Improving Collaboration in Online Learning Groups via Automated Prompting

Von der Fakultät für Ingenieurwissenschaften,

Abteilung Informatik und Angewandte Kognitionswissenschaft

der Universität Duisburg-Essen

zur Erlangung des akademischen Grades

Doktor der Philosophie (Dr. phil.)

genehmigte Dissertation

von

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Tag der mündlichen Prüfung: 29.10.2020

Acknowledgments

Stop waiting… daily for weekends, yearly for holidays, constantly for happiness!?
Start doing! Grab this life, rock it, enjoy it, you only have one! Go for it!
Life is too short to be anything but happy.

Dear destiny, thank you for surrounding me with so many wonderful people. Lieblingsmenschen, thank you for just being there, by my side through good and bad times; for telling me what I need to hear rather than what I want to hear. Thank you for reminding me that falling down is a *part of life* but getting back up *is living*. And finally simply for helping me to do so and for keeping me going.

I thank Nicole Krämer for her supervision and support. Dear Nicole, you trusted me and my ideas, even when I did *not* every now and then. Thank you for widening my horizon in research, for all your advices and for encouraging me on all possible academic and real-life topics.

Further, I would like to thank Ulrich Hoppe for accepting to be *reviewer two*, not an easy task, and providing me with constant critical, constructive, and motivating feedback within the IKARION project.

I wish to thank every single person who contributed to this work. First of all my sister Dr. Ivelina Stoyanova for her endless love and believe in me; for assisting and criticizing, always right and fitting. As well as my parents and my best friend:

Мамо, татко, благодаря за живота, безотказната обич и перфектния личен пример! Роси, благодаря за сърцето и рамото ти, и отворената врата. Пазете се!

Dear SP team, thank you for making me feel like driving home instead of driving to the office. In addition to the dissertation, the friends I found here the last years are the most valuable thing to me. Especially the girls, I shared the office with, Judith, Johanna and Adineh, will stay in my heart forever.

Judith and Johanna, thank you for being there for me. Anytime. Any place. On any topic. Thank you for your time, your energy, your emotional support in tough times, and for making me enjoy this work even more. Thank you for your patience and your love. LE206 4ever!

None of it would have happened without my living motivation: my daughter Nia Amélie. Thank you for accepting me the way I am without any hesitations. I love you! Regrets, I've had a few but then again, too few to mention.. I did it my way*. ***We did it our way!***

*(Frank Sinatra – “My Way”)

TABLE OF CONTENTS

Appendix note

Please contact the author if you are interested to obtain the following material:

Study 1: Questionnaire and stimulus material (visual vignettes of the learning platform)

Study 2: Questionnaire, pretest and stimulus material (personified agent, prompts)

Study 3: Questionnaire, pretest and stimulus material (vicarious punishment, transparency)

LIST OF TABLES

LIST OF FIGURES

Parts of this dissertation have been presented in or accepted for talks and posters at international conferences and summer schools or have been published in peer-reviewed conference proceedings. Please refer to the following publications for more information:

Study 1

Stoyanova, F., & Krämer, N. C. (2018, May). *The Influence of Intelligent Supportive Interventions on Social Group Dynamics in Online Small-Group Collaboration.* Poster presented at 4th International Summer School „Trust in mediated communication", Münster, Germany.

Stoyanova, F., & Krämer, N. C. (2018, September). *The Influence of Intelligent Supportive Interventions on Group Climate and Satisfaction in online learning.* Poster presented at the 51st Congress of the German Psychological Society (DGPs), Frankfurt a. M., Germany.

Stoyanova, F., & Krämer, N. C. (2019). Please don't shoot the messenger! Prompts in online learning groups – Influences of nudging messages' sender and publicness on recipients' perception and attribution. In K. Lund, G. P. Niccolai, E. Lavoué, C. Hmelo-Silver, G. Gweon, & M. Baker (Eds.), *13th international conference on computer supported collaborative learning: Vol. 1. A wide lens: Combining embodied, enactive, extended, and embedded learning in collaborative settings* (pp. 256–263). Lyon, France: International Society of the Learning Sciences. https://doi.dx.org/10.22318/cscl2019.256

Study 2

Stoyanova, F. & Krämer, N. C. (2019, September). *Face it! The influence of system's personification while applying intelligent support in online learning small groups.* Paper presented at the 11th Conference of the Media Psychology Division of the DGPs (German Psychological Society), Chemnitz, Germany.

Study 3

Stoyanova, F., & Krämer, N. C. (2020). Carrot-and-stick procedure without carrots: Vicarious punishment prompts and system transparency in e-learning groups. In P. Kommers, B. Bontchev, & P. Isaías (Eds.), *Proceedings of the 18th international conference: e-Society* (pp. 99–110). International Association for Development of the Information Society. https://doi.org/10.33965/es2020_202005L013

Abstract

The rapidly developing field of e-learning still faces many challenges such as high dropout rates, continuously promoting the need for better understanding of the processes beyond it. Group work is hailed as a solution of typical participation issues, however it is also prone to them too and can easily turn to be a rather frustrating element. To unfold its potential and to be satisfying, group work needs to function properly but barely does by default. Further assistance in terms of nudging others to do their share of the work has demanding conflict potential among group members, thus it should be undertaken by technology. However, the perception of automated support can vary depending on its characteristics and is not systematically examined with regard to the nudging phenomenon so far.

Thus, re-examining the media equation theory, this dissertation investigated how support and especially nudging should be provided to be most beneficial and improve collaboration in terms of participation and satisfaction. Specifically, this work focused on automated prompting – the significance of its source (human vs. system) as well as on its determining characteristics such as appearance and communication manner.

To this aim, three empirical studies including mixed methodological approaches were conducted. The foundations were laid with an online study which investigated the relevance of the prompting source by comparing automated and human prompting, their past proficiency and publicness as a basic message characteristic (Study 1). Results of the online experiment with a between-subject design 2 (prompt publicness: public vs. private) x 2 (source: system vs. human) (x 2 (only human's past proficiency: high vs. low)) showed that public prompts were assessed as more persuasive but also more negative. Moreover, compared to messages from average and low proficient team members, messages from an automated system were assessed as more persuasive and positive but also came along with a higher feeling of guilt for the negative feedback and (potentially linked) with a higher negative emotional affect.

Furthermore, the characteristics of an automated prompting system were addressed within two field studies, combining behavioral and survey data. First, personification of an automated system with the aid of an appearance and a name was investigated (Study 2). The one-factorial between-subjects design in a field study within 6 weeks (abstract vs. personified system with appearance and name) revealed more persuasiveness and satisfaction with an abstract system and that the equal participation predicted higher satisfaction with group work independent of the conditions. Nevertheless, the personification had also a positive effect on satisfaction explicitly when mediated by equal participation.

The third study focused on the communication manner of the more beneficial, abstract system in terms of severity. Therefore, within 4 weeks in a field study by means of a between-subjects design (2 no severity vs. severity (x 2 transparency only of the severe system: high vs. low)), negative consequences for inactive members were variously signaled through vicarious punishment. The transparency of the system was varied to additionally investigate its legitimizing role. Results did not show an effect on contribution as expected – neither with a severe nor with a transparent system, although the latter one induced more fear and higher tendency to imitate inactivity. Additionally, equality of participation was worse both with severity and transparency but changed positively over time with the severe, non-transparent system. Lastly, yet importantly, equal participation once again predicted the higher satisfaction with group work over all conditions.

Having re-examined the media equation theory in terms of nudging in online groups provided by humans and technological entities and having investigated the social-psychological factors related to prompting, this dissertation broadens current knowledge about the nudging phenomenon and its determining characteristics especially within online group work. This systematical investigation of an automated prompting system over time and considering both behavioral and survey-based outcomes, lays important foundations for the endeavor to prevent dropout in e-learning.

Zusammenfassung

Der sich dynamisch entwickelnde Bereich des E-Learning steht noch immer vor vielen Herausforderungen, wie zum Beispiel hohe Abbruchquoten in Online-Kursen, wodurch die Notwendigkeit eines besseren Verständnisses der zugrundeliegenden Prozesse steigt. Obwohl Gruppenarbeit als vielversprechende Lösung typischer Partizipationsprobleme angesehen wird, ist sie ebenso empfänglich dafür und kann somit auch frustrierend sein. Um ihr Potenzial zu entfalten und für Lernende zufriedenstellend zu sein, muss Gruppenarbeit richtig funktionieren, dies gelingt jedoch selten automatisch ohne Weiteres. Zusätzliche Unterstützung im Sinne eines „Anstoßes“ (Nudging), um andere dazu zu bringen, ihren Teil der Arbeit zu erledigen, bringt ein hohes Konfliktpotenzial mit sich, wenn es unter den Gruppenmitgliedern erledigt wird. Daher sollte dieser „Anstoß“ mithilfe einer Technologie übernommen werden. Die Wahrnehmung einer solchen automatisierten Unterstützung kann jedoch je nach ihren Merkmalen variieren und wurde bisher nicht systematisch untersucht.

Daher wurde in dieser Dissertation, die die Media Equation Theory als grundlegende Theorie heranzog, untersucht, wie technische Unterstützung und insbesondere das "Nudging" am nützlichsten sind, um die Zusammenarbeit zwischen Gruppenmitgliedern im Hinblick auf ihre Beteiligung und Zufriedenheit verbessern zu können. Konkret konzentrierte sich diese Arbeit auf automatisiertes „Prompting“ (das Senden von auffordernden Nachrichten), die Bedeutung der Quelle der Prompts (Mensch vs. System) sowie auf die Merkmale Aussehen und Kommunikationsart.

Zu diesem Zweck wurden drei empirische Studien mit verschiedenen methodischen Ansätzen durchgeführt. Der Grundstein wurde mit einem Online-Experiment gelegt, das die Relevanz der Promptquelle durch den Vergleich von einer automatisierten versus menschlichen Quelle sowie das bisherige Engagement der menschlichen Promptsender und die Öffentlichkeit des Prompts als grundlegendes Merkmal der Botschaft analysierte (Studie 1). Die Ergebnisse des 2x2(x2) Between-Subjects Online-Experiments (Prompt: öffentlich vs. privat, Quelle: System vs. Mensch, Engagement ausschließlich des menschlichen Promptsenders: hoch vs. niedrig) zeigten, dass die öffentlichen Prompts als überzeugender, aber auch als negativer bewertet wurden. Darüber hinaus wurden die automatisierten Aufforderungsnachrichten vom System im Vergleich zu Aufforderungsnachrichten von durchschnittlichen und wenig engagierten Teammitgliedern als überzeugender und positiver wahrgenommen, aber gleichzeitig auch mit höherem Schuldgefühl für den Erhalt des negativen

Feedbacks und einem höheren negativen emotionalen Affekt bewertet, jedoch als selbst- und nicht fremdverschuldet.

Weiterhin wurden Merkmale eines automatisierten Prompting-Systems im Rahmen von zwei Feldstudien untersucht, bei denen Verhaltens- und Umfragedaten erhoben und evaluiert wurden. Zunächst wurde die Personifizierung des automatisierten Systems mit Hilfe eines Erscheinungsbildes und eines Namens umgesetzt und untersucht (Studie 2). Die erste Feldstudie wurde anhand eines einfaktoriellen Between-Subjects Designs in einem Zeitraum von 6 Wochen durchgeführt (abstraktes vs. personifiziertes System mit Erscheinungsbild und Namen) und zeigte mehr Überzeugungskraft und Zufriedenheit ausgehend von einem abstrakten System. Die Personifizierung hatte zudem einen positiven Effekt auf die Zufriedenheit, ausschließlich wenn sie durch die gleichmäßige Beteiligung aller Gruppenmitglieder mediiert wurde. Über die experimentellen Bedingungen hinweg, sagte die gleichmäßigere Beteiligung eine höhere Zufriedenheit mit der Gruppenarbeit voraus.

Die dritte Studie konzentrierte sich auf das vorteilhaftere, abstrakte System und seine Kommunikationsart hinsichtlich der Strenge. Hierzu wurde in einer 4-wöchigen Feldstudie getestet, wie sich das auswirkt, wenn negative Konsequenzen für die Inaktivität anderer angekündigt werden im Sinne einer stellvertretenden Bestrafung. Zu diesem Zweck wurden die Strenge der Prompts und zusätzlich die Transparenz (d.h. das Wissen über die Funktionsweise) des Systems als legitimierenden Faktor in einem 2(x2) Between-Subjects Design variiert (2 keine Strenge vs. Strenge (x 2 Transparenz ausschließlich des strengen Systems: hoch vs. niedrig)). Die Ergebnisse zeigten entgegen der Erwartung keinen Effekt auf die Beitragsmenge der Gruppenmitglieder – weder bei einem strengen noch bei einem strengen und transparenten System, obwohl letzteres mehr Angst und eine höhere Tendenz zur Imitation von Inaktivität hervorrief. Darüber hinaus war die Gleichmäßigkeit der Beteiligung sowohl bei der Strenge als auch bei der Transparenz geringer als ohne, änderte sich aber im Laufe der Zeit mit dem strengen, intransparenten System positiv. Des Weiteren sagte die gelichmäßige Beteiligung erneut die höhere Zufriedenheit mit der Gruppenarbeit übergreifend voraus.

Unter Bezugnahme auf die Media Equation Theory und anhand der Untersuchung sozialpsychologischer Faktoren, die mit dem Prompting zusammenhängen, erweitert die vorliegende Dissertation das aktuelle Wissen über das Phänomen des Nudging und seine bestimmenden Charakteristika, insbesondere innerhalb der Online-Gruppenarbeit. Diese systematische Untersuchung eines automatisierten Prompting-Systems im Zeitablauf und die Berücksichtigung von verhaltens- und umfragebasierten Ergebnissen legen wichtige

Grundlagen für das Bestreben, negative E-Learning-Aspekte wie Abbruchquoten zu verhindern und Online-Gruppenarbeit im Umkehrschluss effizient und nutzerfreundlich zu gestalten.

I INTRODUCTION

The rapid evolution of and increasing demand for (lifelong) e-learning are continuously promoting computer-supported collaborative (mass) learning (Zamiri & Camarinha-Matos, 2020). To express this in numbers, according to the summary of various official statistics (Tamm, 2020), the global e-learning industry is projected to reach $243 billion by 2022. Nowadays, 90% of corporations use e-learning, compared to 4% in 1995. Digital learning is the quickest growing market in the education industry, with a 900% growth worldwide since 2000: The annual growth in the German e-learning market is 8.5%, compared to 1.9% annual growth of the German economy.

However, overall, MOOC (massive open online courses) completion rates are low, for instance lying at less than 13% in the UK (Tamm, 2020). Indeed, when German students were asked how motivating and enjoyable different aspects of such courses are, group work was assessed by 21% as highly motivating and by 41% as somewhat motivating, indicating a rather low preference (Schmid, Goertz, Radomski, Thom, & Behrens, 2017). Furthermore, e-learning motivators for employees are individual learning pace (95%) and lack of travel requirements (84%).

Thus, a further understanding of the processes and key affecting factors is necessary in order to implement and develop the CSCL mass communities (Zamiri & Camarinha-Matos, 2020). Keeping in mind that geographical independence, i.e. the desired avoidance of traveling, is genuinely given in online learning settings, the individual learning pace remains the main e-learning motivator for employees (Tamm, 2020), but has the potential for frustration in online group work, for instance, where joint schedules are required. Facilitating the advantages of online learning group work is no longer optional but is rather becoming increasingly crucial and future-oriented, especially in times of lockdowns and exclusively online instead of face-to-face work and education (Favale, Soro, Trevisan, Drago, & Mellia, 2020). Beyond borders, the question was posed, whether the adoption of online learning could continue to persist and impact the global education market since more than 1.2 billion children in 186 countries were affected by school closures until May 2020 due to the pandemic (Li & Lalani, 2020).

In line with the statistics (Tamm, 2020), frustrating online group work has repeatedly been mentioned in student complaints within online courses. Thus, the question arises: How can the benefits of online (group) work be gained without the potential disadvantages?

Research shows that high dropout rates, low levels of participation and course satisfaction are common problems of large online courses (Erdmann et al., 2017). Indeed, on

average, 90 to 98% of the students in massive open online courses (MOOCs) do not finish the course (Henderikx, Kreijns, & Kalz, 2017), i.e. even more than the aforementioned UK statistics. One potential solution is group work within MOOCs as a motivator and as a means against isolation (Bernard et al., 2009). However, in order to be motivating, group work needs to function properly and be satisfying; conversely, it can become demotivating if frustration and dissatisfaction arise. Such disadvantages can occur due to participation issues like free riding and social loafing, which are typical in online groups (Roberts & McInnerney, 2007; Hall & Buzwell, 2012). Unequal or lack of participation and consequently feedback are key for the occurrence of the main problems of online groups (Strauß, Rummel, Stoyanova & Krämer, 2018), like prompting other group members to do their share of the work, i.e. "nudging" others. On the one hand, conflict and negative feedback are needed and potentially useful (Tuckman, 1965; Janssen, Van de Vliert, & Veenstra, 1999), while on the other hand, they can be detrimental if they endure and develop into personal conflicts or reciprocal disliking (Janssen et al. 1999; Ilgen, Mitschell, & Frederickson, 1981). Indeed, in-group conflicts, typical for the early group development stage called "storming", can be beneficial, but the transition to the next stages does not always succeed (Tuckman, 1965) and such conflicts have been found to disrupt further performance and group processing (Ayoko, Konrad, & Boyle, 2012; Doberstein, Hecking, & Hoppe, 2019). Thus, nudging needs to be given effectively rather than constantly reiterated (among group members). Appropriate nudging might facilitate the transition to further group development stages and performance, and thus indirectly also foster satisfaction.

As described, groups (and their individual members) cannot function without additional effort (Kreijns, Kirschner & Jochems, 2003) and need to be assisted. However, the required nudging process can endanger in-group relationships if it takes place personally among group members and is interpreted as intentionally threatening negative feedback (Gabelica, Van den Bossche, Segers & Gijselaers, 2012). Therefore, technology can assume the role of prompting group members to do their share of the work. The media equation theory has been used to explain effects in the realm of human-computer interaction, especially regarding the interaction between humans and agents, postulating their equality with real-life human interactions (Reeves & Nass, 1996). However, results regarding the equal perception of interactions with technology are conflicting (see section 3.1). Due to the ambiguous findings and limitations of the media equation theory (Reeves & Nass, 1996), one might assume an equal, or potentially even more beneficial, perception of automated support (e.g. Lucas, Gratch, King, & Morency, 2014). Indeed, automated support has already been applied as an alternative through the

application of group awareness tools and tutors (Janssen, Erkens, Kanselaar & Jaspers, 2007; Miyazoe & Anderson, 2010). However, the nudging phenomenon is not clearly defined in the realm of e-learning. Moreover, previous research in this realm frequently focused on performance and learning outcomes (e.g. Mayer, 2014), while barely considering the social-psychological group-related variables like satisfaction, even though such variables have been shown to be among the key factors determining dropout, and to be promising for participation and vice versa (Chavez & Romero, 2012; Alavi & Dufner, 2005; Rovai, 2002). The question arises of how support and especially nudging should be delivered in order to be most beneficial – persuasive and effective and yet still group climate-friendly. A sufficient understanding of automated nudging and related characteristics is important in order to bring about a change in attitudes and accordingly the behavior of online learning groups. Therefore, systematic investigations in this realm with real groups participating in real courses can be a promising addition to previous research, which was merely based on individuals instead of groups, subjective or qualitative data.

To contribute to closing these gaps, the present dissertation sheds light on the nudging phenomenon, which has barely been examined in this context. Thus, the main research objective is to answer the question: How can students' satisfaction and participation in online learning groups be enhanced by providing and improving automated nudging?

In the endeavor to identify opportunities to increase the persuasiveness of the means of support, users' satisfaction with group work and, lastly yet importantly, users' participation, further questions arise regarding key characteristics of the nudging process (and content). Primarily, these refer to the nudging source, asking whether technology-based and human-based nudging differ. Furthermore, the characteristics of automated nudging systems are of interest, with regard to personification or a severe manner of communication of the system. By addressing the social-psychological factors related to nudging, this work will broaden current knowledge about nudging and the prevention of dropout in e-learning. Additionally, the media equation theory will be re-examined in the specific case of nudging.

To this end, mixed methodological approaches were applied in three empirical studies within the present thesis. In an online experiment with imaginary group work, the foundations of this research were laid, primarily in order to elaborate the differences and similarities between nudging delivered by an abstract system and nudging delivered by other group members, as well as the impact of their past proficiency and of the publicness of nudging messages (Study 1). Against this background, two field experiments were conducted with

regard to automated nudging under realistic circumstances, each with real groups taking part in real online courses. This method allowed a more systematic investigation by combining objective behavioral data (like contribution quantity, login frequency etc.), as well as subjective survey data regarding the assessment of persuasiveness, satisfaction etc. These methods were employed to examine the impact of a system's personification with the aid of an appearance and a name (Study 2). Consequently, in another field experiment (Study 3), an abstract nudging system was applied and its manner of communication in terms of severity was varied.

The thesis is organized as follows, divided into four main chapters – introduction, theoretical background, empirical approach and general discussion. The chapters include several sections and subsections, which are numbered independently of the four main chapters. The present, first chapter (chapter I), introduced the context, importance and main purpose of our study within a brief summary of the theoretical framework, which is extended in the next main chapter (chapter II) in the form of a detailed overview of the literature. It starts by outlining the theoretical framework of potentials and challenges within online group work (section 1). Therefore, the participation issue is identified through the elaboration of typical challenges of groups collaborating online (section 1.1), and their potential effects and related factors, i.e. the interdependence of isolation, participation and satisfaction (section 1.2). Finally, a step towards automated solutions is taken, elaborating on how to combat participation inequality (section 1.3). The description of participation issues, and the related endangerment of satisfaction and automated support generally as an option, leads to the key concept of nudging (section 2). This section primarily addresses the meaning, role and significance of nudging in the context of group work against the background of relevant classic theories (section 2.1), followed by the review of potential consequences of nudging (section 2.2), which depend particularly on the nudging source and its past proficiency (section 2.2.1), as well as further factors like publicness of the nudging act (section 2.2.2). The third section refers to technology-based nudging as an alternative to the potentially detrimental human source, with a focus on theories regarding the perception of automated support – the media equation theory (section 3.1) and the social agency/cues theory (section 3.2). Differences and limitations of the media equation theory point to both equal and *un*equal perception of technology versus human interactions (section 3.1.1). Some theories recommend that social cues (section 3.1.2) should be extended to achieve a more beneficial and social perception of technological interactions, while others do not. Thus, section 4 discusses the characteristics which can help to beneficially turn an abstract technology into an agent. First, an overview of agents and personification is

given (section 4.1), followed by the elaboration of potentially beneficial but simple personification characteristics like appearance (section 4.1.1) and manner of communication (4.1.2). The theoretical framework closes with a summary of the underlying theories and approaches (section 5). Within this section, the aim of the present study, the research questions and the empirical strategy are derived and finally visualized in a model. The empirical approach of the thesis is described in the next main chapter (chapter III), presenting the three experiments (sections 6, 7 and 8) conducted within this dissertation, each through consecutive subsections regarding derived hypotheses (e.g. 6.1), methods (6.2), results (6.3) and a discussion (6.4). The final main chapter of this thesis (IV) includes the general discussion considering the results of all three studies. Thus, it begins with a synopsis (section 9) and summary (section 10) of the results, followed by the interpretation and reflection on the results (section 11). Finally, theoretical (section 12) and practical (section 13) implications are considered. The dissertation closes with an outline of limitations and future directions (section 14) as well as a conclusion (section 15).

II THEORETICAL FRAMEWORK

1 Potentials and challenges of online group work

Typically, dropout rates are especially high within MOOCs, and as mentioned above, course satisfaction and participation remain on a low level (Erdmann et al., 2017). One reason for dropout lies in the *lack* of required key factors such as support (learning support or social support), sufficient and effective feedback (difficult to provide when there are many students), motivation (decreased due to feeling completely free) and a sense of community and belonging (Aydin & Yazici, 2020). These factors can easily be categorized as isolation- and support-related and might be facilitated by the employment of groups.

Indeed, small-group cooperation is a didactic element that is hailed as a potential solution to both low motivation and low levels of understanding within large online courses. In this regard, "… the interaction process is considered to be a more important element in learning than the outcomes" (Vuopala, Hyvönen, & Järvelä, 2016, p. 26). It has already been demonstrated that small group work is related to higher course satisfaction (Bernard et al., 2009). Conversely, failures in the realm of participation and interaction can increase dropout

rates, especially due to the resulting feelings of isolation (Khalil & Ebner, 2014; Mourad, Tarik, & Pascal, 2015). Isolation during e-learning is in turn linked to efficacy problems and frustration (Rafique, Dou, Hussain, & Ahmed, 2020), while interaction has beneficial effects by reducing the sense of isolation and improving feelings of community and satisfaction (Bernard et al., 2009; Liu, Magjuka, Bonk, & Lee, 2007). Hence, in order to achieve its motivational potential, group work has to function in a satisfying rather than a frustrating manner.

To be successful in terms of performance but also from a socio-emotional perspective, small group work requires participation and is dependent on group development processes (Walther & Bunz, 2005). On the one hand, in line with the Social Information Processing (SIP) theory (Walther, 1992), it takes longer to equip computer-mediated communication (CMC) with either task-related or socioemotional features as compared to face-to-face communication. However, it is these features in particular that enable the satisfying group development and success. In one of their rules for virtual teams, Walther and Bunz (2005) recommended frequent communication, which is only possible if group members' participation is given. Confirming previous research, social messaging, i.e. interactions in virtual teams, was related to both affective states and groups' performance.

Given the interdependency of participation and interaction, however, (effective) interaction does not occur automatically based on the mere existence of interaction tools in the e-learning environment (Kreijns, Kirschner, & Jochems, 2003; Rummel & Spada, 2005). Particularly when small groups consist only of a few members, their development and existence might be endangered by dropout rates and delays of group activities. Groups may be hindered not only by the absence of participation and interaction but also by challenging, regulatory interactions and topics. Thus, in order to develop solutions to avoid "frustrating" group work, it is useful to take a closer look at the problems that may occur in groups collaborating online.

1.1 **Typical challenges for groups**

Strauß et al. (2018) developed a library of typical detrimental CSCL group behaviors, identifying eight common challenges in online group work which might reduce beneficial effects and satisfaction (Strauß et al., 2018). This library is especially suitable for use as a baseline for the present work, primarily because it simultaneously refers to both theory and field data, benefiting from the application of a top-down and a bottom-up analysis. A further

advantage lies in the application of well-fitting, case-specific filters in the realm of CSCL, taking into account the following three key features: (1) course properties (asynchronous communication) (2) relevance for satisfaction with the collaboration, and (3) observability. As shown in Table 1, eight unproductive behaviors were retained, classified into the following five dimensions (Meier, Spada, & Rummel, 2007): communication (lack of feedback), joint information processing (lack of references for new information), coordination (no joint problem-solving plans, long-lasting instead of simultaneous plans and contributions, not signaling task progress or time contingencies), reciprocal interaction (fewer contributions from individual members, "nagging" other members to contribute). As mentioned above, participation is a general prerequisite for the existence of groups, and problems can arise, for instance, regarding the quality of participation, e.g. information pooling *without* references, *un*collaborative planning of task division etc. However, beyond this, it needs to be noted that half of the problems can be assumed to be directly related to or caused by participation problems. For instance, feedback signals themselves (1 within the library) or feedback with timely and progress-related signals (5 & 6) might be lacking due to lack of participation. Similarly, planning instead of substantively contributing (4) might be based on the longer-lasting plans due to a lack of voting or approval by group members who do not regularly participate. Ultimately, in the case of social loafing (7), a lack of participation constitutes the problematic behavior itself, as well as the direct reason for nagging others (8). Accordingly, non-participation or free riding has repeatedly been identified as the greatest concern of online group work even across disciplines (e.g. Hall & Buzwell, 2012).

1.1.1 **Participation issues as a key factor**

Thus, in particular the problematic behaviors regarding lack of feedback, *un*equal participation and consequent "nagging" will be focused on as directly depending on participation and significant for the present thesis. As already noted by Strauß et al. (2018), timely feedback (i.e. the opposite of lacking or delayed feedback) facilitates the sense of community (Sung & Mayer, 2012) and avoids the misinterpretation of non-attendance. Otherwise, even if it is partially or reasonably intentional, non-attendance can easily be mistaken for ignoring other participants' input, thus weakening others' self-belief, as a deliberately reduced participation (social loafing), or even as free riding, i.e. a complete lack of participation (Aggarwal & O'Brien, 2008). In order to identify social loafing and distinguish it from non-attendance, the former is defined as the phenomenon that given the same aim, people contribute less within a group than

they would if they were individually responsible (Karau & Williams, 1993). This reduced effort of individuals within groups is common, and increases with the number of group members and with the lack of assessment of individual performance (Latané, Williams, & Harkins, 1979).

Table 1

Library of typical problems in online collaboration, adopted from Strauß et al., 2018, p. 1046

Aspect	Process dimension	Common unproductive behavior
Communication	Mutual understanding	1. Lack of feedback on forum posts, e.g. questions, suggestions
Joint information processing	Information pooling	2. New information is introduced without a reference to the information already shared
Coordination	Task division	3. Groups do not plan the problem-solving process (collaboratively)
	Structuring the problem-solving process	4. Groups are stuck in planning and neglect to work on the task simultaneously
		5. Group members do not signal their progress towards the tasks
	Time management	6. Group members do not signal individual time contingencies
Reciprocal interaction	Equal engagement	7. Individual group members contribute nothing or very little (social loafing)
		8. 'Nagging' other group members to do their share of the work

However, social loafing is not necessarily intentional (Huguet, Charbonnier, & Monteil, 1999), even though, as mentioned above, it is often mistaken by others as such. In a recent review, Zhu and Wang (2018) also identified a positive type of social loafing, insofar as it is intended in order to achieve strategic group benefits (such as the avoidance of participation dominance). The authors therefore excluded this type from the updated definition of the term, and instead included the evaluation by other group members. In this way, social loafing and free riding should merge, as both refer to an effort reduction, "(…) when an individual is perceived to shirk duties and free ride upon the others' efforts and yet enjoy the benefits of the group in disproportion to his or her contribution." (Zhu & Wang, 2018, p. 8).

1.1.2 **Active and inactive group members**

Active contributors who perceive such behaviors may be positively affected insofar as they try to compensate for them (i.e. social compensation). However, the main consequences are frustration and decreased motivation, which negatively affect the continuous contribution, also known as the sucker effect (Kerr, 1983). Furthermore, the frustration due to passive group

members may ultimately lead to a type of online vigilante justice from the active group members. Finally, yet important and central for the current thesis, this common problem of small groups has been described as nagging or nudging others to do their share of the work (Strauß et al., 2018). In this way, first attempts to regulate social loafers are undertaken. Due to the increasing frustration, individual remarks may be less objective and effective than the regulatory measures from high-level supervisors, and may even be detrimental for many group-related factors such as socioemotional and performance-related factors (e.g. Walther, 1996). As one of the central topics of this work, and at the same time an ambiguous term, nudging will be explicitly expanded on in the second section. At this stage, it is necessary to take into account its direct link to lack of participation, or vice versa, a lack of participation as a direct cause of nagging and conflicts in groups.

However, after the *first* step of identifying an issue, in this case lack of participation, the *second* step should be towards resolving it, potentially by providing the correct support either for the free riders to avoid loafing and activate their participation, or for the already participating group members to reduce their frustration and keep them participating. This choice depends on potential effectiveness of a respective intervention in either direction. To better understand the mechanisms of predicting and changing behaviors, Fishbein and Ajzen (2010) analyzed the positive and negative intentions behind them. Negative intentions *not* to engage in a challenging activity more often translated into actual avoidance behaviors, and people indeed *did not* engage, while positive intentions to engage were more likely to turn into actual engagement. A study examining intentions to exercise found that almost half of participants who intended to exercise actually did so, while 97% of those who intended *not* to exercise ultimately did not (Sheeran & Orbell, 2000). An intention-behavior gap, especially in the case of positively valenced intentions, was demonstrated. In addition to intention-behavior patterns, several studies found that one particular group was mainly responsible for the intention-behavior gap: the group of inclined abstainers, meaning individuals who had positive intentions but failed to act accordingly, i.e. participants who achieved none of or fewer than their individually intended goals or even decided to quit (for a review see Sheeran & Webb, 2016). However, the focus of the present study is not on the additional patterns and personality factors (e.g. goal orientation) related to lack of participation, but rather on the potential measures of support that might be given to reduce frustration due to non-participation, and the most appropriate ways to implement these measures. Given the stable nature of negative intentions, it would be irrational to focus on free riders and attempt to convince them to

participate more. Thus, we focus instead on the potentially endangered students with positive intentions, although 50 % can be assumed to fail to fulfill their intentions (Sheeran & Orbell, 2000).

Before taking the second step towards resolving participation issues in section 1.3, it is important to keep in mind the typical participation-based problems in online small groups as described in this section. Furthermore, it is also important to review the interdependence of participation with other factors which may potentially reduce frustration and to consider the consequences for group work. Thus, the next section (1.2) will shed light on the theoretical background of promising key aspects. The potential of the link between isolation, (equal) participation among group members, their satisfaction and dropout rates will be focused on in order to highlight the significance of participation-based issues and their consequences.

1.2 **The relation of isolation, participation and satisfaction**

The next section explains the link between isolation, participation and satisfaction. This potential relation is first outlined, before describing it further in terms of content with a review of previous research on these topics and the links between them.

So far, it has been discussed that if group members do not participate, they cannot interact with each other and develop as a group. Group members need to first stay in the course or group before they are able to deliver any learning outcome. Moreover, based on the theory of planned behavior (Fishbein & Ajzen, 2010), attitudes constitute one of three factors which determine intentions, and accordingly influence behaviors and ultimately dropout. Students' attitudes, in turn, can be related to their experiences in online courses, as suggested by Roberts and McInnerney (2007), who listed online group learning problems and their solutions. In this line, frustration or dissatisfaction in groups can be linked to dropout, low participation levels and interaction. As such, motivation may be suppressed, either directly or indirectly, through the aforementioned factors. If dissatisfaction and consequently demotivation arise regularly in the long term, they can even bias a higher perception level, namely attitudes towards online courses. Similarly, it has been suggested that antipathy towards group work may lead to members' free riding behaviors and withdrawal (Roberts & McInnerney, 2007). Thus, as a prerequisite for the existence of groups, dissatisfaction-based dropouts should be prevented.

In turn, the question arises whether the opposite of frustration and dissatisfaction, i.e. satisfaction, .can itself prevent dropout. To the best of our knowledge, this question has not yet

been definitively answered. Nevertheless, satisfaction may potentially play the role of a long-term motivator in online courses, and remedy the dropout rates. Thus, the following brief literature review begins with the source of many online group problems –isolation. It then addresses lack of and unequal participation as a potential risk but also as a potential means to combat isolation and dissatisfaction.

Isolation, as a typical aspect of e-learning, is a state in which self-evaluation becomes easily lost, and online learning students thus require additional motivation (Galusha, 1998). As mentioned above, online group work provides a potential solution, aiming to reduce feelings of isolation, but this requires participation in group work. It has been demonstrated that online groups can be superior to face-to-face interactions in terms of quality and quantity (Brewer & Klein, 2006), but it has also been shown that online group members communicate less frequently than in face-to-face groups (Lebie, Rhoades, & McGrath, 1995). Indeed, students identified the biggest challenges of online learning groups, as compared to face-to-face work, as being that communication was more difficult and that group members tend to leave participation and submission to the last minute (Goold, Augar, & Farmer, 2006). The latter aspect, similar to lacking or delayed feedback (see section 1.1), can easily be misinterpreted as non-attendance and cause frustration. Generally, beyond this, without interaction or participation, isolation remains an issue and increases efficacy problems in terms of self-belief (Rafique et al., 2020) or even dropout rates (Khalil & Ebner, 2014). On the one hand, the sense of community might conquer isolation (e.g. Liu et al., 2007). On the other hand, interaction, which is critical to foster the sense of community, does not occur easily in online learning (Phirangee, 2016). Moreover, certain kinds of interaction have been identified as detrimental and may even weaken the sense of community. For instance, if an act of communication goes unanswered, this can be easily mistaken for ignorance or irrelevance of one's own contribution, ultimately having a negative impact on one's self-belief (Phirangee, 2016; Zembylas, 2008). While it may be suggested that interaction and participation are key to combating isolation, they do not occur automatically and are not even necessarily beneficial. Isolation has also been linked to other significant factors, such as higher dropout rates and students' satisfaction with a course (e.g. Wang, Guo, He, & Wu, 2019).

These findings demonstrate the diverse effects of isolation in online learning groups as well as its links to various other aspects such as interaction, self-belief etc.

Before going looking at satisfaction, (equal) participation and dropout in greater detail, it should be noted that *satisfaction* can be defined in various domain-specific ways. Therefore, diverse facets of satisfaction can be taken into account – with regard to performance, team, course, environment, tutor or other issues. The focus of this thesis is on satisfaction with group work, assessed as most promising for students' attitude change.

The relation between participation and satisfaction in online courses has been broadly investigated in past research, with studies highlighting the relevance of participation for satisfaction. For instance, Fulford and Zhang (1993) found that students' perception of interaction was a better predictor of course satisfaction than their actually measured interaction. Thus, the authors recommended providing the potential for interaction, even if students do not actually avail themselves of themselves thereof, and it seems unlikely to bias achievement. Furthermore, in a survey on student attitudes, three main factors explained 53% of the variance in online teamwork satisfaction: team dynamics, team acquaintance, and instructor support (Ku, Tseng, & Akarasriworn, 2013). Communication among team members helps them to facilitate collaboration, team effectiveness and teamwork satisfaction (Lancellotti & Boyd, 2008). Lastly yet importantly, familiarity was found to reduce team member uncertainty, which in turn is associated with behavioral and relationship-related expectations (Stark & Bierly, 2009). Moreover, familiarity significantly predicted team satisfaction.

Although satisfaction-related factors like interaction, team dynamics or familiarity require participation, the direct link between satisfaction and participation is not always clearly identified. In a blended learning environment, for instance, perceptions of collaborative learning were found to be related to perceptions of social presence and satisfaction, i.e. students who perceived high levels of collaborative learning were more satisfied with an online course and similarly perceived high levels of social presence (So & Brush, 2008). However, the positive relationship between social presence and overall satisfaction was not statistically significant. Additionally, an analysis of the qualitative data in the same study revealed that closeness and connectedness with group members affected students' willingness and motivation to engage in the course. Various other studies had already suggested this relationship and the importance of psychological distance and social interaction in online collaborative learning, although they did not investigate this in detail (Moore, 1991; Russo & Benson, 2005; Elliot & Shin, 2002). However, So and Brush (2008) further discussed the link of lower levels of mutual closeness, trust, and interdependence with lower levels of participation in groups. Indeed, in another qualitative study, students reported an aversion to

participation in e-learning groups due to a lack of feelings of connection, which in turn also affected overall motivation (Vrasidas & McIsaac, 1999). Thus, these factors can be seen as results or bases of participation, which seem to interact with one another. Only asmall number of studies have focused in detail on the link between participation and satisfaction as a dropout prevention measure online (for a review see Chavez & Romero, 2012). The authors highlighted a low level of participation as a main difficulty in computer-supported collaborative learning (CSCL), and identified participation as a highly important factorwhich increases group productivity and learning perception, improves grades, and facilitates the evaluation of the quality of results, i.e. even students' perception. Moreover, in individual studies, it has been argued that participation positively influences the perception of satisfaction (Alavi & Dufner, 2005), as well as retention rates (Rovai, 2002).

In sum, a link between participation and satisfaction has been frequently suggested. However, even those studies which investigated this link in detail were mostly qualitative in nature, and found participation to be related to various kinds of satisfaction. To analyze these relations systematically, long-term mixed methods are required. Therefore, to identify methods to facilitate satisfaction with the collaboration process and the course, and to prevent dropouts, further investigation of these factors is necessary. For this purpose, after the identification of the participation issue and its interdependent factors, as mentioned, the step towards automated support solutions is taken in the next section.

1.3 **Combating inequality of participation**

Having addressed the significance of participation, it can be seen as more than a dichotomous dimension described merely by its presence or absence. A recently discussed subdimension of participation on the group level is equality of participation, which describes (mis)distribution or (im)balance of group members' contributions, an important aspect of collaboration. Studies regarding participation equality have suggested that group members' interaction fosters equal involvement/participation and ultimately improves decision-making processes and satisfaction (Zmud, Mejias, Reinig, & Martinez-Martinez, 2001). Moreover, with regard to classic group work, there is correlational evidence that the decreased satisfaction with increased group size is mediated by limited individual participation in larger groups (Patterson & Schaeffer, 1977).

Thus, while some advantages of participation equality have already been identified, the question of how to achieve this, and how to prevent inequality, is of interest. The

aforementioned second step towards resolving the participation issue can be taken directly within small groups, as identified by Strauß et al. (2018). Due to a lack of participation and increasing frustration, actively contributing participants, who are (digitally) "on the spot" often try to provide "first aid", or in this case "first support". To achieve this, certain person(s) (one or more) may "nag" others to do their share of the work. This process of informing group members and nudging them to become more involved in group work is a potentially promising approach. However, as such criticism needs to be executed by a particular member of the group, it can be detrimental, as described in greater detail in the chapter "Nudging and nudging sender" (2). If nagging among group members is interpreted as unbalanced regulatory attempts by single group members, this may result in ineffective regulation (Isohätälä, Järvenoja, & Järvelä, 2017). Moreover, negative feedback might be perceived as intentionally threatening (Gabelica et al., 2012) and the productive influence of task conflicts can easily turn into detrimental, personal conflicts (Janssen et al., 1999). Hence, the group climate and the collaborative decision-making may also suffer due to the personal remarks and consequently arising interpersonal disliking (e.g. Walther, 1996; Ilgen et al., 1981). This raises the question of whether technology could alternatively be employed for this purpose.

Indeed, in terms of achieving beneficial social and educational effects, it has been shown to be advantageous when groups are supervised and supported by tutors (Thorpe, 2002). However, in large online courses (e.g. MOOCs) with a high number of small groups, the required time- and staff-related capacity is unaffordable and yet still superficial with regard to students' engagement and activity (Mapuva, 2009). As mentioned in the previous paragraph (and in detail in Section 2.2), nagging among group members can have a detrimental impact due to the misinterpretation of conflicts and negative feedback (e.g. Gabelica et al., 2012). Moreover, its occurrence is not guaranteed, and rather depends on the group members who are involved in a respective team.

Therefore, one solution might be automated support and warning systems in online environments, which mediate in the case of conflicts in small groups, facilitate the interaction and prevent common unproductive behaviors. Especially in terms of intelligent group support in order to increase effectiveness and save resources, machine solutions such as group awareness tools (GAT) seem reasonable. However, many factors need to be considered before such tools gain acceptance and usage. Indeed, according to the classic Technology Acceptance Model (Davis, 1989), perceived usefulness correlates with current and future usage.

Moreover, with regard to nudging within the GATs, the latest research demonstrates that experienced users evaluate digital nudging more positively and accept nudging messages more compared to new users (Lidynia, Offermann-van Heek, & Ziefle, 2019). One question that needs to be asked with respect to participation, however, is whether the included instructions can also increase or equalize participation, which in turn increases satisfaction. One study reported that online instructions in a blended learning setting, compared to face-to-face, did not improve the quantity of contributions, but instead improved the linguistic quality, interaction quantity and the equality of participation (Miyazoe & Anderson, 2010). However, a study applying a group-awareness tool to visualize conversation participation found that the equality of participation was not facilitated, but that a longer display duration had an impact especially in longer dialogues (Janssen, Erkens, Kanselaar, & Jaspers, 2007). Furthermore, a study by McLeod (1992) revealed a positive effect of group support systems on equality of participation, but a negative effect on satisfaction, i.e. displaying the actual participation may trigger changes in behavior but may also draw attention to inequality and the disadvantages thereof.

Thus, there are some indications of a link between group awareness tool interventions and equality of participation, and a relation of such interventions with satisfaction. However, the respective findings are ambiguous and further research on the topic is needed in order to improve the methods used to combat unequal participation.

So far, this chapter has defined lack of participation as a key challenge of online group work. Satisfaction was shown to be both potentially endangered and simultaneously a means of prevention. Thus, action should be taken against unequal participation and can be easily undertaken by technologies in online environments. In particular, nagging others to assume work is a method which may be demanding if it is applied by other group members, and can instead be employed using group awareness tools. Therefore, in the next chapter, the phenomenon of nagging (i.e. nudging) will be discussed with a focus on its challenging character in groups and potential consequences depending on the sender of the nudging.

2 Nudging and nudging sender

To date, “nagging” or nudging other group members has barely been researched as a social psychological challenge for interpersonal relationships in small group collaboration. Accordingly, it is not yet clearly defined or conceptualized. The term “nudging” has been defined as a form of soft paternalism which helps to combat cognitive or behavioral biases in

decision making, as "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Wang, Leon, Scott, Chen, Acquisti & Cranor, 2013, p. 376). Nudging occurs, for instance, when displaying a driver's current speed instead of forcing him or her to slow down. Such indirect means have been successfully applied in the context of health or nutrition and for the purpose of online privacy (e.g. Acquisti et al., 2017).

In the current study, *nudging* will be synonymously used for nagging or prompting, and refers to hints (prompts) in order to regulate others' activities. In order to support active group members and undertake means against free riders, inactive members need to be prompted to take up work. However, nagging can be challenging if it takes the form of personal remarks, and can instead be addressed by an automated support system. Therefore, the following chapter is divided into two parts. The first section (2.1) primarily considers the general meaning of nudging within online groups and their development. In the second section (2.2), classified into relevant terms such as conflicts and negative feedback, a definition of the currently applied concept of "nudging" will be given. Finally, the characteristics of the nudging source (2.2.1) and the publicness of the nudging messages (2.2.2) are elaborated upon.

2.1 **The meaning and role of "nagging" in group work**

Having discussed nagging as a common detrimental problem in small-group collaboration (Strauß et al., 2018) and mentioned that it might be addressed by an automatic support system (see chapter 1), it is important to consider the role it plays for groups' development. According to Tuckman (1965), five different group phases occur during collaboration, independent of the kind of tasks and members. Figure 1 presents an overview of these phases on the temporal and performance dimensions. Since lack of participation and nagging, respectively, can occur across all phases of group work, a brief overview of all phases will be provided in order to outline the possible consequences of nagging.

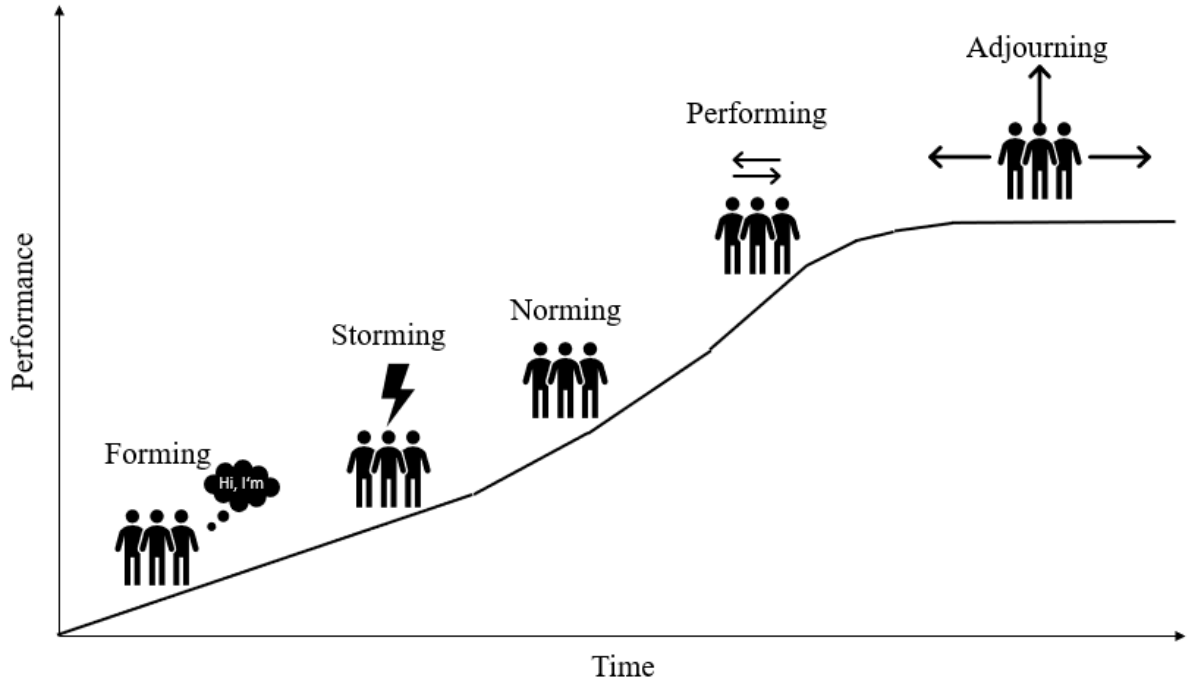


Figure 1. Group development stages according to Tuckman (1965).

First, the team members come together and get to know each other (forming). This is typically associated with uncertainty regarding the acceptance and building of relationships among group members. A lack of participation at the beginning of group work is typical (Walther & Bunz, 2005) and prevents group members from getting to know each other, or at least those who are inactive. If nagging occurs during these very first steps of group formation, the first impression of the sender of nagging can be jeopardized. Indeed, in a previous study, students identified the similar concept of the "keener" in online groups, who responds quickly and constantly to any interaction, always intervenes regardless of who was actually addressed, and can weaken the sense of community (Phirangee, 2016). The over-involvement of such group members was evaluated as frustrating and dominant. However, a qualitative study found that a less engaged group which was unable to overcome the formation stage and had confusing open questions about how to get started at all was also the group with the lowest final performance score (Ayoko et al., 2012).

After this initial uncertain phase, the group members try to define their territory through task and role conflicts (storming) (Tuckman, 1965). This can be particularly critical if dominant characters collide. As the storming phase can influence the entire group work, it is often recommended that it is externally accompanied and moderated or mediated (e.g. by tutors), as

"attacks on individual team members' behaviors are most likely to occur at this stage" (p. 171, Ayoko et al., 2012). Furthermore, it has been demonstrated that the storming stage occurs not only at the beginning of the group phases, but also repeatedly throughout all course sessions (Glowacki-Dudka & Barnett, 2007).

On the one hand, nagging can endanger the whole process if it is interpreted as demanding and is prolonged. Potentially, it may produce increasing conflict, due to continuously lacking answers or contributions, and may shorten the subsequent productive phases of substantial contributions. According to a rule for virtual teams, simultaneously planning and performing instead of postponing is critical both for a group's development and for its performance (Walther & Bunz, 2005). Indeed, according to the qualitative study by Ayoko and colleagues (2012), conflicts and emotional behaviors are typical for the start of storming, but groups which spent too much time in this phase instead of moving on achieved the second-lowest performance level (Ayoko et al., 2012).

On the other hand, if nagging is perceived positively and as constructive instead of threatening, it can be applied, as recommended by Tuckman (1965), as useful mediation in this phase and can optimize the whole group work process. Moreover, the mediation might be even more promising if it is provided externally, for instance by support systems instead of group members, which again demonstrates the importance of the author of the nudging messages. Ayoko et al. (2012) recommended two solutions to overcome interpersonal attacks and consequently to help groups to move through the storming phase successfully – feedback-seeking behaviors, and positive reinforcement of others' contributions, i.e. the opposite of the nagging phenomenon, which is based on criticism of others in order to persuade them to do their share of the work.

Having successfully resolved the power struggles, groups grow together in the following phases by collaboratively setting the group rules and defining the roles (norming) (Tuckman, 1965). Beyond apologies and other strategies, other members play the role of a third-party mediator in order to resolve conflicts and move towards effective work, signaling the need for mediating entities when difficult behaviors occur. However, the norming phase can also be disturbed, hindered and interrupted by a lack of participation and consequently nagging, which seems similar to the behaviors in the storming phase as mentioned above. This can potentially result in failure of the transition to the next stage, in this case performing, and to a disruption of the definition of rules and the assignment of roles. Indeed, Ayoko and colleagues (2012)

identified that not all groups go through all the phases or spend an equal proportion of time on each phase. In particular, the transition after the storming stage was shown to be challenging. The authors argued that this was attributable to a lack of resources of virtual teams compared to face-to-face teams in terms of managing difficulties such as defensiveness, attacking and counter-attacking. Unsolicited feedback given to other group members was highlighted as a particular danger, as it may generate interpersonal conflicts. Teams, which were stuck in the first two phases or spent the majority of their time therein performed worse than teams, which went through all four phases. Furthermore, the importance of early coordination was demonstrated in several learning analytics studies with the aid of interaction sequences (Doberstein, Hecking, & Hoppe, 2017, 2018, 2019). Clustered behavioral data have revealed that it is not the general inactivity, but rather the absence of coordination at the beginning of group work, which is the most crucial *negative* indicator of groups' productivity and participation distribution.

However, according to Tuckman (1965), the norming phase is a prerequisite to ensure the success of the subsequent actual work phase (performing). Additionally, an optional phase was added for teams collaborating on a temporary basis (adjourning); this serves the purpose of replacing members and disconnecting, and ideally also reflecting and learning for future group work. Given a constant change of members, phases can be run on a continuous loop, but regular feedback loops are also needed to redefine the division of roles and tasks and ultimately to work efficiently. Despite the typically occurring lack of participation, nagging is also not novel in these advanced phases; however, no special consequences are expected other than those described above, for instance that the phases cannot be passed through, hindering performance and group development. Under these circumstances, the recommended regular feedback loops can be demanding or even impossible.

In sum, nagging can be significant in all phases, but is potentially most detrimental in the beginning phases, i.e. storming and norming. Several links and similarities to the nagging phenomenon across the model stages, especially storming, suggest that much depends on the transmitter, i.e. sender of nagging. Therefore, a closer examination of this aspect is required.

Nudging and intentional factors

Nagging can also play a significant role regarding individuals' intentions and behavior. As was pointed out in section 1.1, there is a substantial intention-behavior gap between the positive behavioral intentions and the actual behavior, mainly due to members who have

positive intentions but fail to act accordingly. In line with the reasoned action approach (Fishbein & Ajzen, 2010), three factors determine the intention – behavioral control, attitudes, and social norms, as shown in Figure 2. The latter two factors might be affected by acts of nagging for more participation in small online groups.

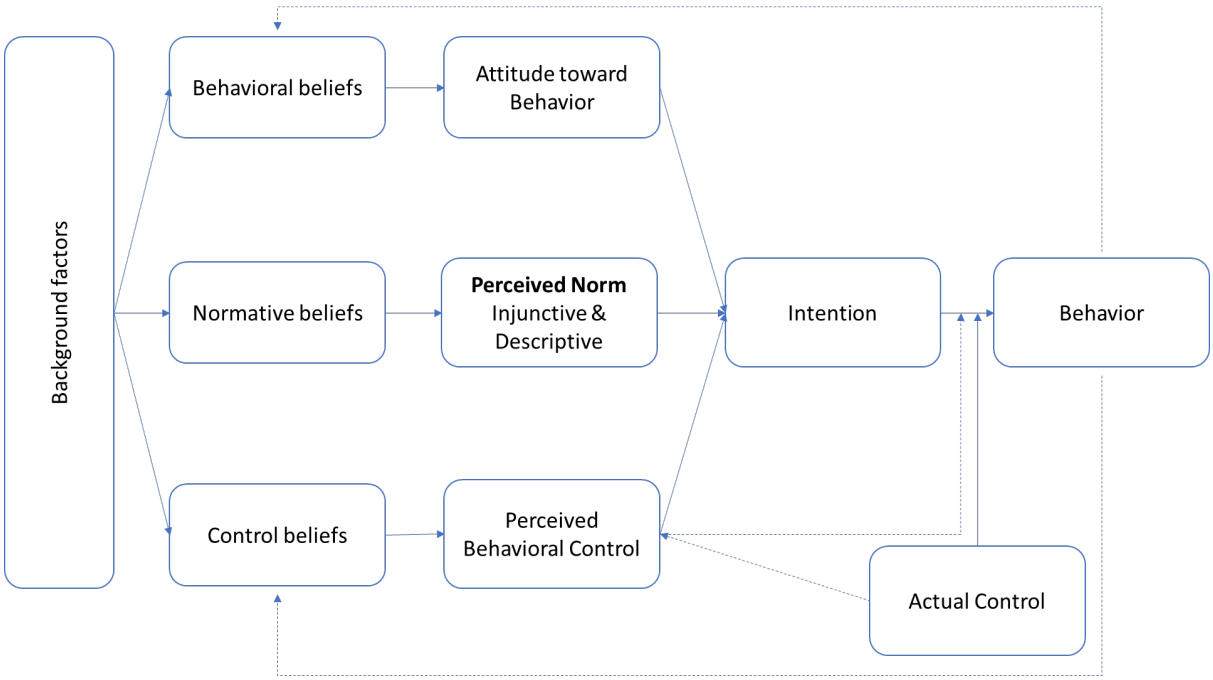


Figure 2. Reasoned action approach (Fishbein and Ajzen, 2010), adopted from Donné, Jansen, & Hoeks, 2018, p. 149.

Generally speaking, individuals' attitudes towards certain behaviors can be related to satisfaction, as mentioned above (e.g. Ku et al., 2013). Unfortunately, nagging might also elicit reactance and exert a negative impact on attitudes, whereas the nagging actor, or "sender", may play an important, beneficial or detrimental role in this process. The model distinguishes two critical aspects of attitudes, postulating that they can be instrumental, defined as the expected consequences, and experiential, referring to perceived experiences, and each of these aspects can have a positive or negative valence. Both aspects can be related to nagging because consequences and experiences can depend on the severity and style of nagging, as well as on the experienced (prior) satisfaction.

Additionally, perceived social norms such as levels of social pressure regarding whether or not to perform a particular behavior can have a determining impact, and can be easily highlighted in groups through the nagging reminders to take up work. A more detailed view on social norms distinguishes between two categories (Fischbein & Ajzen, 2010). Injunctive norms, which refer to the perception that rules should be followed, would definitely result in

participation in the present context. However, descriptive norms such as comparison with others (group members) regarding this behavior might be contradictory during nudging. Due to the act of "reminding" certain inactive group members to contribute, a lack of participation might be perceived as more common if it is part of others' norms. Indeed, injunctive and descriptive norms of in-groups interact and influence attitudes, willingness and behaviors (Smith & Louis, 2008). The highest and lowest levels of attitudes, respectively, were shown when both injunctive and descriptive norms were consistent – i.e. both supportive and both non-supportive, respectively. Furthermore, the second-highest attitudes resulted from a supportive injunctive but a non-supportive descriptive norm, i.e. when the group approved of a behavior even though it did not engage in it. However, the effect disappeared with an out-group source of norms and changed with a less (personally) involving issue – controversial, injunctive norms increased attitudes only when descriptive norms were consistently supportive, i.e. when the group itself also engaged in the behavior. Several studies showed that a conflict between group-level injunctive and descriptive norms weakened behavioral intentions (Smith, Louis, Terry, Greenaway, Clarke & Cheng, 2012). Moreover, the views both of active and inactive group members might differ and should be taken into consideration, especially with respect to their perception of the descriptive norms, for instance when an active group member compares him/herself with less engaged others in a group, or vice versa, an inactive group member compares him/herself with less engaged others. In this sense, the publicness of nagging might also be risky, and is worthy of consideration.

How social the norms are perceived might also vary depending on the sender of the nudging message – i.e. whether it is a group member or an automated system. Indeed, research has found that people are more willing to disclose confidential information to virtual humans than to real humans (e.g. Lucas et al., 2014). Given the suitability of automated support in CSCL due to its beneficial characteristics, a special focus on the sender of nudging might foster the understanding of human in-group interactions and provide a foundation of knowledge for the employment of technology in this realm. Therefore, this is an object of investigation and the topic will be elaborated upon further regarding the nudging source (Section 2.2.1) and human-based versus technology-based nudging (Section 3).

Thus, having discussed the significance of nagging for group work, the phenomenon will be scrutinized in the next section under consideration of several prominent concepts. The section also takes into account characteristics which have been considered crucial so far, such as the source and the previous proficiency of the source, as well as publicness.

2.2 **Negative Feedback, Conflict and Dis-Liking**

As a means to regulate others' activities, in the context of learning groups, *nudges* can be understood as prompting messages which include negative feedback, and as co-regulation or socially shared regulation of learning; they may lead to task and person conflicts and can be assumed to be either beneficial or detrimental.

For instance, effective non-individual regulation of learning, as well as task conflicts, are beneficial due to the facilitation of group discussions, decision making, performance and knowledge building (Janssen et al., 1999), but failures and their effects on interpersonal relationships remain unknown. Furthermore, it was demonstrated that socially shared regulation of learning does not function well in the case of disengagement and unequal participation and contribution (Isohätälä et al, 2017), i.e. nudging can also be defined as *unbalanced* co-regulation or socially shared regulation of learning.

Furthermore, with regard to conflict, specifically, person conflict reduces teams' effective communication and cooperation, tolerance of opposition, and openness to ideas of disliked team members, and simultaneously improves hostile attributions of others' intentions and behaviors (Janssen et al., 1999). Relationship conflict was also found to be linked to lower perceived task performance (Mohammed & Angell, 2004). Under certain circumstances, the more beneficial and desirable task conflicts can facilitate group discussions. However, such conflicts should not automatically be assumed to improve performance and satisfaction, and may instead pose a risk (De Dreu & Weingart, 2003). Benefits are only possible when the conflict is handled constructively, with openness, psychological safety and within-team trust. Moreover, these task conflicts can easily transform into more detrimental person conflicts (e.g., due to the fact that group members can hardly distinguish between the two types of conflict (Janssen et al., 1999)). Tolerance of different viewpoints may prevent task conflicts from being misinterpreted as personal attacks (De Dreu & Weingart, 2003).

As one explanation, task conflicts might be misinterpreted as person conflicts due to the need for consistency, i.e. disliked positions regarding the task can lead to corresponding personal attitudes toward the author. Indeed, according to Weisband and Atwater (1999), liking functions differently in groups face-to-face compared to online communication. The authors suggested that when communicating face to face, more non-rational aspects such as attraction, which are not related to the task, play a role. Online group members, by contrast, showed greater liking for members who more frequently contributed task-related messages.

Furthermore, the longer-term exchange of both social and task-related information also plays a facilitating role, especially in online groups, as it was shown that given enough time to exchange, group members liked each other even more (Walther, Slovacek, & Tidwell, 2001). Furthermore, even justified criticism can generate reciprocal dis-liking and conflicts (Ilgen et al., 1981).

Defining nudging and classifying it into conflicts, negative feedback, or as a dis-liking factor, highlights the importance of its characteristics and of applying it in a beneficial manner. Therefore, especially with regard to conflicts in groups and their consequences, it has been recommended that teams should be provided with help in diagnosing the type of emerging conflicts, and group members should be taught to manage, mitigate and eliminate these conflicts by tolerating differing opinions (De Dreu & Weingart, 2003). Using such strategies, teams can be helped to benefit from disputes. To achieve this, the source and publicness of nudging are especially promising, and are therefore addressed in detail in the next section.

2.2.1 Relevance of feedback source

Feedback can be based on a subjective opinion or an objective measure and can derive from an internal or external source. In the present context, group members might be categorized as an internal feedback source, as well as providing a subjective opinion. Automated mediated feedback, such as messages deriving from a support system as an external source, might be categorized as potentially based on more objective measures. Feedback is more likely to be perceived as accurate if it derives from more credible, powerful or knowledgeable sources (e.g. London & Sessa, 2006). However, this has mainly been demonstrated in the classic teaching context regarding learning processes and outcomes (e.g. Finn, Schrodt, Witt, Elledge, Jernberg, & Larson, 2009).

Gabelica et al. (2012) concluded that the effectiveness of feedback interventions might be improved if feedback is accurate, given in a timely manner, regular, given directly to the teams it targets, *shared*, *non-threatening*, *and when its distribution is fairly equal*. However, these characteristics might vary depending on the source. The latter three factors in particular cannot be ensured or held constant if feedback is given in a subjective manner by group members. They can, however, be explicitly adjusted if feedback is provided by an external system, as described in the next section regarding the media equation theory.

Past proficiency

Regarding the effects of feedback, it is not only important who the sender is; rather, his/her attributes and prior behavior will also play a role. One important aspect is past proficiency of group members, as has been described in group dynamic theories referring to the term of idiosyncrasy (i.e., possessing unique characteristics or showing unique behavior). In order to be allowed to derogate from a group's normative standards, the individual member must have shown high achievement in the past, i.e. must have earned a high level of "idiosyncrasy credit" (Hollander, 1958). In its origin, this considers leaders acquiring credit over time by performing continuously well and following group norms. As a credit of trust, it enables one to deviate from the norms. Applied to learning groups, this credit may be a basic factor in the case of the common problems of unequal contribution, social loafers and free riders.

A recipient of a nudging message may perceive any nudging remarks from a member with low past proficiency as inappropriate. Conversely, high past proficiency, as a credit of trust and an image of being a high contributor being seen as a type of group leader, may translate into special rights to announce feedback within the group. This may be a foundation for the effectiveness of the message, e.g. persuading the recipient to reconsider an act due to higher internal causal attributions.

2.2.2 **Public versus private nudges**

Beyond the source, the way in which the message is presented needs to be scrutinized. One important aspect of presenting nudges in groups is whether these are targeted privately at the deviating person or displayed publicly in the group. The psychologically relevant construct in this context is ego threat. Negative feedback might pose an ego threat to one's self-image or public image (Audia & Locke, 2003). An ego threat of self-image provides information contrary to one's own beliefs about the self, whereas an ego threat to one's public image provides information contrary to one's self-targeted impression conveyed to others. Less contribution, or late contribution, can be reasoned diversely, consciously or unconsciously, i.e. as fitting with or contrary to one's self-image. Accordingly, nudges to hurry up and contribute more can also be in line with or contrary to one's self-image. However, since people generally tend to have a positive self-concept, prompting messages about their lack of contribution may serve as a threat to self-image. Indeed, threats to one's self-image have already been operationalized by providing negative feedback (Leary, Terry, Allen, & Tate, 2009). Regarding the public-private distinction, the mere presence of others during feedback might be sufficient for a public-image threat, since self-presentation is a basic need and ubiquitous. In the present

context, it can emerge as soon as negative feedback is given in public in the group forum, i.e. others will also be informed about the presumable failure. Previous research on public and private feedback recommended that it should be given in both ways in order to activate all potentially positive effects (Alvero, Bucklin, & Austin, 2001), but differences between the two types may occur regarding nudging.

To summarize, this chapter defined nagging, i.e. nudging in the current thesis, in general terms as the act of prompting others to regulate their activities. It went on to describe the potential role of nudging across the different phases of group work and with regard to intentional factors, suggesting it to be a necessary but potentially disruptive group process. Additionally, the term was classified as negative feedback, causing conflict and dis-liking, but also potentially pushing group processes in this way. Indeed, against this background, the literature review demonstrated that nudging can count as both person conflict and the partly beneficial task conflict. However, task conflict can also easily turn into a person conflict and endanger various group dimensions (e.g. Janssen et al., 1999) or cause reciprocal dis-liking (Ilgen et al., 1981). The elaboration of nudging source and publicness identified both characteristics that potentially determine the consequences of nudging – which may be ambiguous given the threatening and persuasive nature of publicness – and even perceived as accurate with a credible, objective and engaged sender (e.g. London & Sessa, 2006; Hollander, 1958, 2006). Having outlined the meaning and the role of nudging as one of the key concepts of the current thesis, as well as the inherent challenges of nudging if it occurs among group members, the question of beneficial alternatives arises. As already highlighted, one such alternative may be machine-based nudging, which may surpass the benefits of human sources due to its characteristics as a source. Accordingly, the next chapter will shed light on the potentials, differences and similarities between these two methods.

3 Technology-based versus human support

Having identified the importance of the nudging source and the potential of automated solutions like group awareness tools as an alternative (see section 1.3), this chapter will address the perception of automated support as compared to support given by humans. The question of whether a nudging system can be perceived similarly or differently between these two types of support will be tackled in accordance with key theories, starting with the classic media equation theory in the next section (3.1), its limitations and resulting perceived *in*equalities (section

3.1.1) and relevant social cues to which the theory refers (section 3.1.2). To conclude the chapter, its distinction from the social agency/cue theory is outlined (section 3.2).

Before proceeding to review these theories, an explanation of the role of a mediator in terms of intelligent support should be provided. Mediation in this realm can be defined as simple transmission, as the process of information delivery, e.g. message conveyance. Additionally, mediation is also the act of a neutral third party in a conflict. Mediators help the conflicting parties to reach an agreement by managing the interaction and facilitating discussions, focusing on the parties' needs, rights, and interests and aiming for an optimal solution for all (Harvard Law School, 2019). To this end, they guide the process by applying different techniques. Within the scope of this dissertation, both meanings of mediation are relevant for the investigation of automated mediation and the question of how to provide it most beneficially in the specific case of nudging, as outlined earlier (see section 2).

3.1 **Media equation theory**

As described in the previous sections (especially 2.2), nudging among the members of online learning groups can be misinterpreted as intentionally threatening negative feedback or as a task and person conflict. Hence, it might be more beneficial if nudging others to provide their share of the work is accomplished by an automated system instead of by the fellow group members. This raises the question of which factors determine beneficial perception of automated support and how it functions. Automated support is not simply an accurate and financially effective method to support a large number of groups in online learning settings (see section 1.3 for GATs and section 2.2.2). In the sense of a mediator, it might be perceived as more impartial, and can potentially prevent the occurrence of interpersonal conflicts caused by nudging. Accordingly, if negative feedback is sent by the system, it can be less frustrating. As postulated in the media equation theory, interactions with computers and media can be perceived as real-life interactions (Reeves & Nass, 1996). As such, media and real-life interactions are identified as equal, e.g. people respond to technologies as if they were social actors, to which they ascribe personalities and stereotypes and with which they interact politely (Nass, Moon, & Carney, 1999). The authors demonstrated that people treat computers similarly to other humans, e.g. they avoid delivering directly negative feedback.

3.1.1 ***In*equalities within the media equation theory**

However, research in the area of information communication technology and human-robot interaction has already shown some differences and limitations of the media equation theory. For instance, in an adaptation of the Milgram experiment, participants were more likely to abuse a robot compared to a human (Bartneck, Rosalia, Menges, & Deckers, 2005). In an fMRI study, participants showed different emotional reactions when watching a robot or a human being treated in either an affectionate or a violent way (Rosenthal-von der Pütten et al., 2014). Moreover, abusive behavior towards robots elicited different neural activity, i.e. less emotional distress and less negative empathetic concern, compared to abusive behavior towards humans. In another study, participants showed a greater willingness to disclose confidential information to a virtual human when they were led to believe that it was controlled by a computer as opposed to by a human (Lucas et al., 2014). A recent study even proposed that the media equation theory needs a general extension because people, technology, and the interactions between the two have changed over the last decades, resulting in deeper and broader experiences and knowledge (Gambino, Fox, & Ratan, 2020). Thus, the authors argued that while humans indeed interact mindlessly with technologies, they have developed specific scripts for interactions with media entities and apply these instead of the social human interaction scripts referred to in the media equation theory.

Hence, against the background of nudging and nudging source, it can be suggested that negative feedback from an automated system might be perceived differentially, e.g., as more impartial. This might be attributable to the fact that message recipients cannot blame the system and its *personal* reasons for presenting feedback. Recipients might indeed still perceive the system as another human and interact with it equally, as the media equation theory postulates. However, the knowledge that "the system" has no past proficiency (either high or low) or any personal intentions can be significant for triggering a different perception. We assume that even if people blame the system, it would be on a lower level, in line with the neutral past proficiency, instead of high or low past proficiency, as in the case of other members' feedback.

3.1.2 **Relevant social cues**

Furthermore, with regard to the human-like manner which may be included or excluded in an automated system, the effects of the media equation theory have repeatedly been shown to be independent of the physical form and design of a particular communication partner or object and instead to depend on the social cues which it applies (Nass & Moon, 2000). The computers in the studies by Nass and Moon were not completely human-like, but possessed social cues

like *speech*, *interactivity*, or the performance of *roles* conventionally filled by humans – of a tutor for instance (Krämer, von der Pütten, & Hoffmann, 2015).

Indeed, a complete list of the social cues was proposed, which trigger users' social responses to technology, including human and synthetic voice, face, emotion, interactivity, social roles and *language use* (Nass, 2004). According to Fogg (2003), the social cues of computers as persuasive actors responsible for the activation of psychological processes can be organized into five categories: physical cues (e.g. body parts), psychological cues (e.g. personality, feelings), social dynamics (e.g., turn taking), social roles (e.g. teacher, guide) and *language cues* (e.g. interactive language, language recognition). In a more recent taxonomy regarding especially conversational agents, cues were categorized as invisible, auditory, visual and *verbal,* whereby the latter can be distinguished regarding content and style (Feine, Gnewuch, Morana & Maedche, 2019). *Content* verbal cues refer to *what* is said, i.e. to the strict and literal meaning of a message, whereas *style* verbal cues refer to *how* it is said, i.e. to the meaningful deployment of language variations. Conversational agents using natural language can be voice- or text-based, expressed with spoken or written words. Beyond speech (language or verbal cues), further important basic cues are appearance (visual cues) and social roles, which are included in several taxonomies of social cues (Xu, 2020). These will be focused on in the current thesis as optional characteristics of the online learning system. Particular consideration should be given to *verbal cues*, as easily adjustable and yet critical. Accordingly, they are adopted on multiple websites, for instance as chatbots, and are considered to have great potential in various domains, including the domain of education (Følstad & Brandtzæg, 2017).

Thus, even simple human-like behaviors elicit social responses, regardless of the number of social cues. Rather than multiple cues, only a simple cue is required to perceive computers as social actors (CASA) and respond socially. However, being an autonomous source of interaction and possessing social cues have been defined as boundary conditions for the application of the CASA principle (Nass & Moon, 2000). The minimum quantity of both criteria which technology should possess is not clearly defined, but it should be a source instead of just a channel of communication that merely transmits. Regarding social cues, "individuals must be presented with an object that has enough cues to lead the person to categorize it as worthy of social responses" (p. 83).

In this line, however, even *only computers*, i.e. systems which have a low degree of personification but perform a human role, facilitate human-like communication and interaction.

This was also shown regarding ingroup-outgroup behavior with human-computer interaction dyads, which were merely marked with team colors. Participants who were told that they were interdependent with a computer showed more loyalty to the computer, were more likely to agree and cooperate with it, and perceived it as friendlier, more intelligent, and as more similar to themselves (Nass, Fogg, & Moon, 1996). It should be noted that in this study. the computer interaction also was conducted through text-based verbal cues, even though the effects were elicited with the addition of a human role (team member). In particular, language is conceptualized as crucial, and will be implemented in the present dissertation via written words in order to address the participants.

Thus, according to the media equation theory, the interaction with a support system with basic social cues, e.g. language, might function similarly to human interaction. Nevertheless, it may also function differently, being less or even more beneficial than human tutors, based on the studies showing differences and limitations of the media equation theory, i.e. *in*equality for instance in the realm of human-robot and human-computer interaction.

3.2 **Social agency/cues theory**

Furthermore, focusing on multimedia learning and based on the media equation theory, the social agency / cues theory (Moreno & Mayer, 2000, Mayer 2005) postulates that humans respond more socially to human-like features, with another explanation of the effect being related to the presence of basic social cues and consequently social responses. Accordingly, multimedia instructional messages with stronger social cues prime a social response in learners similarly to human interaction, leading to deeper cognitive processing and better learning outcomes. Conversely, actors with weaker social cues are perceived as information senders that are "not worthy" of social responses, such as text interaction without enhancement of learning outcomes. For instance, according to Lester et al. (1997), due to the persona effect, the mere presence of pedagogical agents motivates and promotes learners. However, according to the image principle, while the effects of animated agents are facilitated by the extension of social cues, the presentation of a mere static image in addition to multimedia lessons shows mixed results and does not necessarily improve learning (Mayer, 2014).

In sum, the media equation theory argues that even simple social cues can elicit social responses, while the social agency / cues theory posits that the addition of human-like social cues might be more beneficial and elicit more social responses, especially facilitating learning. However, both theories have also shown limitations, suggesting that the interaction with

technology can also turn out differently to interaction with humans. The question remains whether more human-like features are needed or whether merely a few simple social cues are sufficiently effective and perceived as even more persuasive. Moreover, it is of interest how their application for nudging could bias the satisfaction with group work and participation equality.

Due to the difference between the two theories, it might be suggested that a system's beneficial effects might be increased by optimizing the source of nudging, replacing the human sender not only with technology but also with further social cues in order to increase its human-likeness, i.e. its personification level. Promising effective and simultaneously less complex means to achieve this will be elaborated upon in the next chapter.

4 Characteristics of agents lending support

As discussed so far, recipients of nudging messages react in a socially desirable way to technology-based support and may trust its prompts just as much as, or even more than, those from humans. Beyond the question of whether nudging by humans or by an automated system can be more beneficial, the personification of the system and system characteristics, which can turn the system into an agent, should be taken into account. Certain social cues, including the communication behavior of the system, can be employed for this purpose and will be addressed in the current chapter. With the aim of elaborating on effective but also efficient means within learning environments, particular less complex personification methods will be focused upon. Therefore, the chapter will begin by providing definitions of and a short literature review on personification and support agents (4.1), before focusing on promising, easily adjustable characteristics of the system, like appearance (4.1.1) and manner of communication (4.1.2). Regarding the latter topic, especially the severity of the system in terms of vicarious punishment will be discussed.

4.1 **Personification**

Keeping in mind that (equal) participation does not occur automatically in online groups and that students need to be prompted/nudged to participate more and generally stay in the course, the question of *how* this should be organized remains unanswered. Beyond the suggestion for *who* or *what* could deliver prompts, i.e. technology, it needs to be identified *how* nudges could be most beneficial and whether they should be provided by a human-like entity.

Unlike traditional classrooms, online courses are prone to a lack of teacher immediacy, i.e. the behaviors which reduce the physical and psychological distance between (even) human teachers and their students (Andersen, 1979). Teacher immediacy, the psychological closeness through nonverbal (smiling, eye contact, body posture) and verbal signals (praise, humor, tone of voice) is a basic characteristic of learning, but it is reduced online due to the physical separation, even when human teachers are also online (de la Varre, Irvin, Jordan, Hannum & Farmer, 2014). The resulting feelings of isolation experienced more in online courses may be a salient factor for high rates of dropout (Rovai, 2002), and the display of more teacher immediacy behaviors was shown to increase students' sense of learning community (Shea, 2006). Lack of motivation and the lack of teacher immediacy are among the reasons why school students drop out of online courses (further reasons are time constraints, technology problems and parental influences) (de la Varre et al., 2014). Thus, it may be promising to reduce feelings of isolation by maximizing teacher immediacy regardless of the teaching (or here support-providing) entity. Regarding a prompting system with static social cues (i.e. low embodiment level), the addition of even minimal human-like cues like static image and name might likewise be promising. In this way, the system cannot (and should not) replace teachers, but may still help to establish and strengthen the bond of the students to the system and perhaps even to the course.

In sum, if support is given by a system rather than a human, immediacy might be signaled by the means of *personification*. By definition, personification specifies the application of human traits to non-human objects, for instance the addition of visual social cues like a name or an appearance. Indeed, Feine et al. (2019) categorized both the appearance and a name as visual cues, noting that the name can be displayed as a tag or a badge, or even within the interface system. When it comes to the system itself, which provides intelligent support, several questions remained unanswered regarding its appearance. In a taxonomy of CSCL support dimensions, Rummel (2018) differentiated between three possibilities regarding the way support is provided, i.e. the delivery agent. This function might be fulfilled by a human; by a digital persona, which is commonly a pedagogical agent appearing "as a 'simulated human'" (p. 3); or by a digital system delivering support features without persona appearance. Despite a reasonable amount of research in this area, results distinguishing between the latter two possibilities are contradictory, and only handle the question of what to choose for very specific cases, as it will be described in the next sections regarding the personification characteristics which are specifically focused on. A review on MOOCs highlighted that also simpler, not

necessarily intelligent agents, can increase the effectiveness of the environment for a minimum of cost and effort (Daradoumis, Bassi, Xhafa, & Caballe, 2013). More generally, with regard to agents in MOOCs, the authors concluded that agents could be used to analyze data produced by the users in the online learning environment and use it in order to improve design, support delivery and assessment. However, field studies as well as combined subjective and objective measures are needed to systematically investigate whether the mere personification of the system, combined with a group awareness tool, is recommendable in order to increase group members' participation, satisfaction or even both. Moreover, since personification can be applied in various ways through several characteristics, it is important *how* the entities should look (appearance) and behave (manner of communication) in order to increase their persuasiveness and acceptance as advantageously as possible.

4.1.1 **Appearance (visual cues)**

But is the personification, applied for educational aims, automatically a pedagogical agent even in the case of simple visual cues like a static agent with a name tag? This is not always the case, because pedagogical agents are defined as both animated or not animated. For instance, they have been defined as lifelike characters that guide users through multimedia learning environments (Clarebout & Heidig, 2012) or more recently simply as any kind of on-screen character facilitating instruction (Schroeder, Adesope, & Gilbert, 2013). Hence, differing terminology is used and a personified group awareness tool with the aid of a static agent or even without an appearance can count as a pedagogical agent, guiding the learners with feedback. However, in our case, the support system displays information rather than interacting with the participants, i.e. the complexity of instructions and the interaction level are low. Therefore, the following findings in the realm of (pedagogical) agents, their design and personification should be considered, but should only be transferred with caution.

Although the present study focuses on the framing of personification vs. machine, the linked realm of agents' (social cues) design might be useful in order to gain insights into the potentials and establishment of personification. Ever since the first animated delivery agents were applied, e.g. Clippy by Microsoft, personification and design have been upgraded continuously and have shown many contradictory results. Highly personified, dynamic agents (animated, conversational etc.) with a high interaction level were identified as beneficial, depending on the circumstances (Schroeder et al., 2013 for a review). Applied to conversational agents, personification predicted satisfaction with the system even after controlling for the

satisfaction with technical aspects (Purington, Taft, Sannon, Bazarova, & Taylor, 2017). However, agents like these are barely comparable with those that feature a few simple visual social cues like a static appearance and a name tag. Research in the area has also mainly focused on learning outcomes. Mayer (2014) focused on agents' image and embodiment effects on learning. According to the mixed results of studies applying the image principle, people do not necessarily learn more effectively with multimedia when the speaker's static image is on the screen rather than not on the screen. A boundary condition is the embodiment level, showing static agents to be less beneficial for learning, but improving when animated with human-like movement, eye contact, or facial expression (Mayer, 2014).

In sum, personification through appearance has already been applied in several studies regarding pedagogical agents, although the agents interacted with the participants actively, which makes a difference compared to a static appearance. The studies did not focus in detail on basic solutions which may be promising due to the mere static personification. Moreover, when distinguishing between the support-delivering agents – (animated) pedagogical agents and digital systems – the research mainly referred to learning outcomes or exclusive design (Baylor & Kim, 2004; Gamage & Ennis, 2018; Wang, Mayer, & Liu, 2018). While variables other than satisfaction have been targeted, studies in field settings with real groups are rare (Kulik & Fletcher, 2016; van Lehn, 2011), and long-term effects have not been investigated. Furthermore, the results of previous studies are contradictory, depending on the context, the audience or the agents' properties. Agents were found to foster motivation and learning outcomes, to make no difference or even to detrimentally distract users, to increase users' effort, to lower performance, and to lead to heightened expectations (Heidig & Clarebout, 2011).

One possible explanation for these mixed results may lie in the violation of certain expectations of the users. As mentioned above, recommendations for the application of agents in specific cases and their appropriate appearance options are diverse. For instance, previous research has mainly delivered single solutions linked to different roles in distant education (Schroeder & Adesope, 2014), attractive design-enhancing learning and their tutor functions (Wang & Yeh, 2013), serious games (Gamage & Ennis, 2018) or gambling games (Koda & Maes, 1996). Unfortunately, these solutions can barely be employed for broader target groups and in an interdisciplinary context, i.e. can easily lead to expectation violations in more heterogeneous use cases and user groups. In this realm, acceptance and disappointment might be further determining factors. Hence, the expectancy violations theory and potential effects

thereof will be outlined additionally in Chapter III (Empirical approach) when deriving the hypotheses regarding personification (see Study 2, section 7.1).

Moreover, the key impacting factors of support agents (also able to violate or meet expectations) are their social cues. As already outlined, diverse categories beyond the visual ones can be significant. According to the focus of this section to clarify the characteristics of agents lending support, the manner of communication, as another easily adjustable and powerful social cue, will be discussed in the next section.

4.1.2 **Manner of communication**

According to the CASA approach and the media equation, not only how entities look, but also their attributes and behavior, can be classified as a social cue, e.g. playing conventional human-like roles (Nass & Moon, 2000). Indeed, roles in real life are defined by the manner and content of communication. However, as a combination of attributes and behavior, the manner of communication is not included in a concrete social cue in the taxonomies mentioned above (see section 3.1.2). Alternatively, it can be defined in various categories. It can correspond to Feine et al.'s subcategories of content or style (strength) of language or text-based verbal cues, respectively (Feine et al, 2019). Furthermore, within the basic taxonomies of social cues (Fogg, 2003; Nass, 2004), the manner of communication can be defined as a psychological cue determining an agent's personality or fulfilling social dynamics and social roles. In this way, agents can signal interactivity and affiliation, gaining the influence associated with a certain role – of a peer, a teacher or a guide etc. Even though it can be defined in various ways, the manner of communication remains one of the main characteristics of support agents, and is focused on next as a key factor for the prevention of group problems.

Since the participation issue might need stronger support, the automated support system could communicate in a certain way to induce more pressure, achieving a level of minimal fear, and finally of success. In parallel, keeping in mind relevant characteristics of a nudging source and past proficiency, as described in section 2.2.1, a severe manner of communication might be accepted better depending on the combination with other social cues and further attributes of the system such as transparency, for instance. Indeed, since an automated entity does not have other prior engagements, its transparency can be seen as a central attribute, possibly even signaling idiosyncrasy credit, legitimizing a severe manner of communication.

Severity through vicarious punishment

When punishing unacceptable behaviors, opposites are rewarded by the simple absence of a punishment for them. "(…) When we fail or are unable to punish a difficult employee, we are, in effect, punishing those employees who have not engaged in deviant behaviors and rewarding those individuals who have" (McCallister in Schnake, 1987, p. 379). According to the concept of vicarious punishment, the demonstration of negative consequences for inactivity may be an effective warning, with rewarding effects among the remaining (active) teammates.

Vicarious punishment has mostly been studied in terms of classic offline laboratory experiments, as simulation of work-related or classroom settings or with younger participants. Ina meta-analysis of 21 studies (Malouff, Thorsteinsson, Schutte, & Rooke, 2009), observing others getting punished for a certain behavior led to lower levels of the same behavior by the observers. According to Malouff et al.'s (2009) characteristics of the analyzed studies, the present study could be categorized as follows, highlighting the differences and gaps of previous literature in this realm: The key difference is with regard to the observation of a punishment model. The present study takes place in an online learning environment and the punishment of the model is neither filmed nor live, in contrast to all of the studies analyzed by Malouff and colleagues (2009). In Study 3 within this dissertation, the model is another confederate teammate from the online course, and the observation of its "punishment", i.e. the public criticism by name, takes place online in real time. "A public reprimand for cheating (…) or publicly criticizing" (Malouff et al., 2009, p. 274) as severe punishments are similar to highlighting inactive teammates in teamwork, where the punishment type corresponds to a solely positive one, i.e. the addition of an undesirable stimulus.

In the case of e-learning, both detrimental and beneficial effects on students' behavior and the perception of the system can be assumed. Beneficial effects might arise, such as motivation to avoid the black sheep role, increased satisfaction with group work due to perception of fairness and justice, or even increases in regulatory interactions as an imitation of the regulatory acts of the system. On the other hand, participants may decide to imitate the inactive teammates if negative consequences are lacking (O'Fallon & Butterfield, 2012). Hence, prompts could directly address an inactive teammate in order to investigate whether a system is allowed to intervene in a more severe way. However, due to ethical considerations, artificial inactive confederates could be easier to punish without risks. As such, real students

would not be involved in the "threatening" scenario but would still be aware of the consequences for others.

It is important to examine whether participants would rather focus on negative behaviors, imitate or quit them due to automated mediation. Further attributes of the intervening system, such as transparency, could offer an answer to these questions and help to find automated means to increase satisfaction and prevent dropout. As a secondary aspect, transparency, i.e. the detailed information about the system's functionality, will be elaborated on within the Empirical approach (Chapter III), in the course of deriving the specific hypotheses of Study 3 (see section 8.1).

This chapter shed light on the agents lending support, arguing that personification towards more human-like support-delivering entities can be beneficial in online learning environments. Against the background of conflicting results in the literature, there are several hints that even simple, easily employable means are effective (e.g. Daradoumis et al., 2013). The addition of social cues like appearance and a name, as well as a severe manner of communication of the system and further attributes like transparency (section 8.1) can be employed to make the system more human-like and simultaneously more effective and credible while nudging especially the inactive group members. However, the application of concrete social cues also bears risks that users' expectations may not be effectively met (section 7.1). This issue, along with ambiguous results of previous research on personification, can be taken into account when investigating the topic either directly or through the employment of non-personified control conditions.

After the foundations have been laid and discussed against the theoretical background of the academic research conducted to date, the next chapter serves as a summary of the pivotal aspects and a basis for the research questions in this thesis. Additionally, an overview of the methods within the three studies, applied for the investigation of these questions, will be provided for a better understanding and guidance through the following main part of the thesis regarding the empirical approach.

5 Summary of Underlying Theories and Approaches

Based on the theoretical background discussed in the last chapters, the aim of this thesis is to investigate automated support for online learning in small groups with a focus on the nudging phenomenon and its specific affordances when it is provided automatically. As discussed in the first chapter of this work, group work bears several potentials and challenges, as have been

identified in students' complaints and well documented in prior research (e.g. Erdmann et al., 2017), indicating high dropout rates, low motivation and engagement, as well as negative experiences from past teamwork and generally less successful group work. While it has been demonstrated that small group work is related to higher course satisfaction (Bernard et al., 2009), in order to be successful, it requires participation and is dependent on group development processes (Walther & Bunz, 2005). Especially when only consisting of a few members, the development and endurance of small groups might be endangered by dropout rates and delays of group activities (Strauß et al., 2018). Hence, rewarding experiences of group members based on a positive group climate and satisfaction seem to be particularly promising in order to improve basic personal attitudes, future engagement and participation in online courses. Pedagogical psychologists focus mainly on learning outcomes, while more social-psychological aspects such as satisfaction are neglected, even though they theoretically may be interdependent with participation and other group climate factors. Therefore, this thesis investigates potential improving effects of automated support for small groups in educational online courses beyond the learning outcomes, and sheds light on how to approve and adjust automated support such that it has as enhancing an effect as possible.

Group work is needed because it can motivate students, but to achieve this, it needs to run satisfactorily, which can be put at risk by several factors. Even if methods are provided, effective online group work is not a matter of course (Kreijns et al., 2003), and common participation issues like free riding can prevail (Hall & Buzwell, 2012). As discussed, such issues are detrimental for groups working online, and are also related to isolation and low satisfaction (see section 1.2). Thus, peers need to be prompted to do their share of the work, which can be demanding if such prompts are provided by group members and interpreted as negative feedback, conflict or even disliking (e.g. Janssen et al., 1999), as described in detail in section 2.2. In order to reap the benefits of group conflict without the costs, this work focuses on the common but barely researched nudging in groups. "Nagging" or nudging others to do their share of the work has already been identified as one of eight common problems in small-group collaboration (Strauß et al., 2018). As mentioned above, this process can be potentially detrimental if it is carried out by group members, and could be easily addressed by an automated tutor system. Therefore, section 2.2 discussed common concepts like negative feedback and task conflict, which can turn into personal conflict and reciprocal disliking, respectively (e.g. Ilgen et al., 1981).

Beyond the disadvantages for the personal relationships among group members, the nudging phenomenon, as described according to Tuckman's group work stages (1965), can hinder the collaborative process at several points, but it also has the potential to positively impact intentions and behaviors according to Fishbein and Ajzen's reasoned action approach (2010). Publicness and source have been discussed as important determining characteristics of nudging (section 2.2). Thus, in order to avoid the drawbacks for a human nudging sender within the group while still providing the required group work support to combat participation inequality, nudging can alternatively be adopted by technology (e.g. Janssen et al., 2007; Zmud et al., 2001). In this case, the technology undertakes the role of a mediator in group work, either simply transmitting messages or acting as a neutral third party in a conflict. This could be conducted within GATs, but related research focused the display of information and its consequences for group awareness – frequently on the cognitive but also on the social one, indeed but disregarding satisfaction with group work. However, especially in the case of nudging, socio-emotional effects often are hidden due to the fact, that peers do not share their frustration in order to spare their peers or protect group dynamics, i.e. complains in this case barely can be collected, displayed or fought by GATs, consequently studies on the topic are rare. Finally, GAT-Research did not address the comparison of a human and automated nudging source or the optimization of its perception (section 1.3). However, in order to motivate rather than demotivate students, automated nudging, similar to group work, has to run satisfactorily and not be frustrating. This can be achieved by providing nudging in the most beneficial way possible but there is still much uncertainty regarding users' perception in this realm.

As postulated in the media equation theory (section 3.1), interactions with computers and media can be perceived as real-life interactions (Reeves & Nass, 1996). It has been demonstrated that people treat computers similarly to humans, e.g. they avoid delivering directly negative feedback (Nass et al., 1999). However, research in the area of information communication technology and human-robot interaction has already shown some differences and limitations of the media equation theory, for instance regarding the likelihood of abuse and self-disclosure (Bartneck et al., 2005; Lucas et al., 2014). Hence, it can be assumed that negative feedback from an automated system might be perceived differentially, e.g., as more impartial, since message recipients cannot blame the system and its personal reasons for presenting feedback. Recipients might perceive the system as non-human, indeed as a machine, but nevertheless interact with it as an equal due to its social cues, as the media equation theory

postulates. As a mediator, a system could be perceived to be more objective and potentially prevent the occurrence of interpersonal conflicts in the case of nudging among group members. If negative feedback is sent by the system, it may be less frustrating.

Hence, the question arises whether human-based and technology-based nudging differ, and which is more beneficial. To answer this, further source-determining factors will be taken into account, since the knowledge that "the system" has no past proficiency (either high or low) or any personal intentions can be crucial for different perceptions. A significant question is therefore whether certain characteristics could replace or complete past proficiency and legitimize the provision of negative feedback as well as the nudging source by signaling its expertise and credibility, be it a human or a system. Furthermore, the characteristics of the nudging messages themselves could impact users' assessment. For instance, key properties like publicness of the prompting messages (see section 2.2.2)will be investigated with respect to whether they are perceived as more or less threatening and persuasive. However, message characteristics do not exhaust all customization possibilities of an automated support-providing entity. Beyond these, further characteristics of automated support, in terms of the entity providing the support, can have a determining impact, such as the appearance and "behavior" in the sense of guiding techniques.

Thus, having investigated the role of message publicness and whether mediation by humans and machines differ, it is of interest whether human-like properties and skills should be transferred to make the process more facilitative. According to the social cues/agency theory, the more social the system appears to be, the more social responses it earns (Moreno & Mayer, 2000, Mayer 2005). Thus, personification can be applied to extend the beneficial effects of an automated nudging system, as detailed in section 4.1. Indeed, prior research distinguished the support-lending entities – agent or a digital system – but it targeted variables other than satisfaction, mainly learning outcomes or exclusive design in appearance-related studies (e.g. Baylor & Kim, 2004). Barely any studies have applied field settings with real groups (e.g. Kulik & Fletcher, 2016), and long-term effects have not yet been explored, meaning that a systematic investigation thereof is necessary.

Additionally, with regard to entity-related characteristics, conventional human-like roles applied by machines also serve as further personification factors and social cues according to the CASA principle (Nass & Moon, 2000). Accordingly, instead of modifications of the whole behavior of the system, the manner of communication as a key behavioral aspect can be adjusted, for instance, in terms of severity. In order to combat participation issues, the

application of vicarious punishment, i.e. negative consequences for others (see section 4.1.2), can be promising as a severe means to increase observers' contribution; this has been demonstrated in offline settings but has not yet been investigated either in online learning or when being provided by a system (Malouff et al., 2009). Hence, the manner of communication will be investigated in terms of a system's severity (via vicarious punishment) as well as transparency as an additional, hostility-legitimizing factor (section 8.1). This should shed light on the question of the extent to which automated systems are allowed to communicate in a threatening way.

Against the theoretical framework elaborated so far, there is still considerable controversy surrounding the nudging phenomenon in online learning groups, the application and effects of automated support in this realm, as well as students' perception. Thus, the central research objective of this dissertation is to ask:

- ***How can students' satisfaction and participation in online learning be enhanced by providing and improving automated nudging?***

This leads to three specific research questions on the characteristics of the automated mediation.

First, regarding the nature of the mediator as a prompt sender (Study 1), the following question arises:

- ***Do automated and human nudging differ regarding users' perception?***

Additionally, the sub-question is considered: *What impact do past proficiency of the source as well as publicness of the messages have?*

Second, the personification of automated support is addressed (Study 2):

- ***Can personification improve automated nudging? Is an abstract or a human-like nudging system perceived more beneficially?***

Third, regarding the manner of communication of automated support entities (Study 3), this thesis seeks to answer how severe the nudging system is allowed to be in terms of its communication:

- ***How does a nudging system's severity influence participation and satisfaction?***

In addition to the latter research question, the role of further factors in terms of transparency of the system is addressed, considering the question: *Can transparency improve the severe manner of communication of a system*?

The empirical approach consists of three empirical studies, as outlined in the following overview including the investigated variables (*Figure 3*).

As outlined in this model, in order to lay the foundation for this investigation, the primary focus was on the comparison of mediation by humans and machines (chapter 6). Support systems' and team members' prompts in online learning groups were varied in an online study with visual vignettes. The influences of nudging messages' sender and publicness on persuasiveness, recipients' perception and attribution were explored.

The second study (chapter 7) aims to enhance the system, configuring it more advantageously and focusing on the influence of a system's personification while applying intelligent support in online learning small groups. Objective behavioral data and subjective survey data were collected in a long-term field experiment while varying the personification of the system – with or without a name and a static appearance.

In the final, third study (chapter 8), the manner of communication of automated systems was examined. Therefore, severity and transparency were varied in a field experiment with combined repeated questionnaires and behavioral data collection. To this aim, over the course of four weeks, inactive teammate confederates were publicly addressed in a more or less severe manner by a system, which participants knew more or less about in advance.

In the following main chapter (III. Empirical approach), each of the aforementioned three empirical studies is outlined, starting with the derivation of hypotheses, methods, results and their discussion.

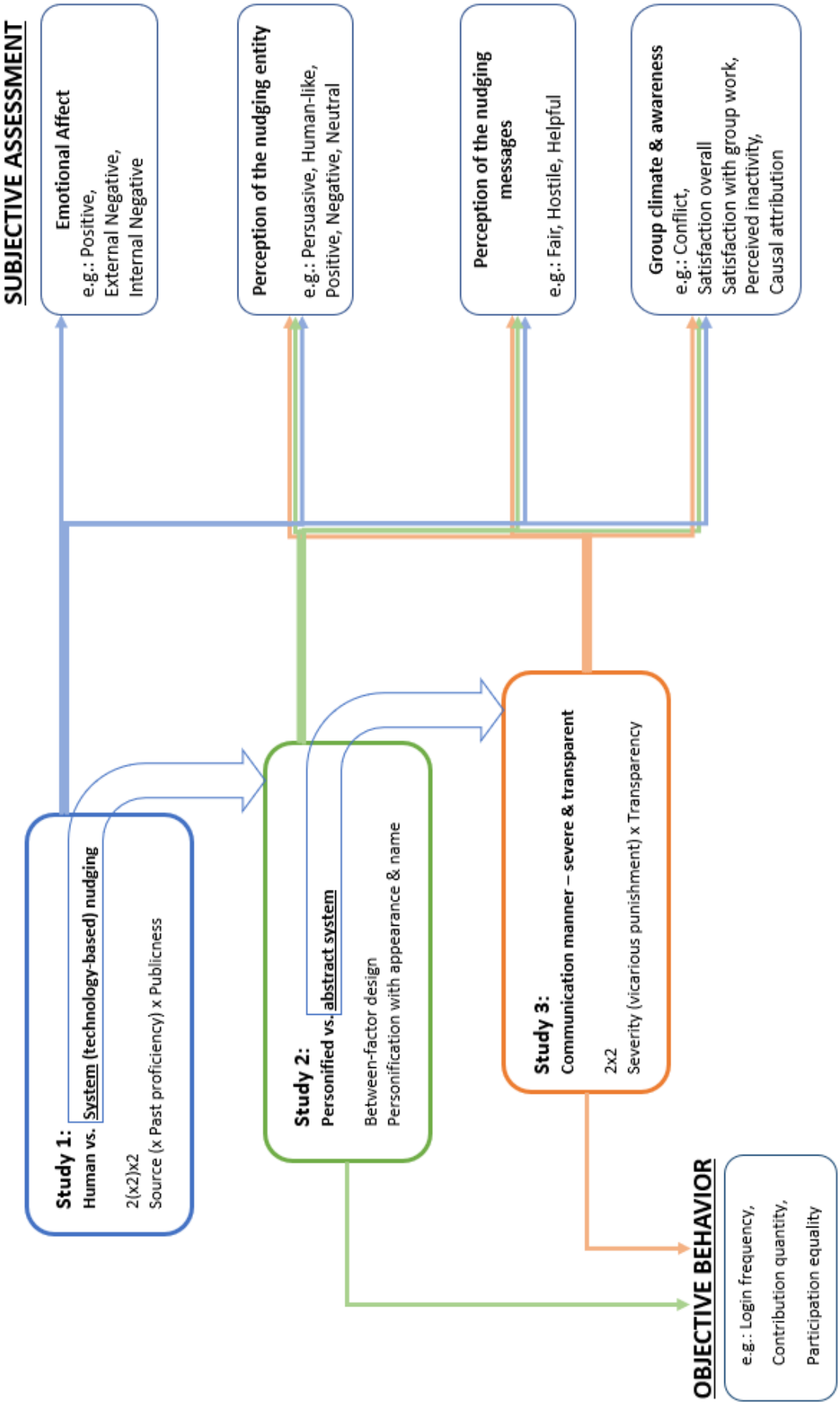


Figure 3. Overview of the hypothesized effects and the empirical approach.

III EMPIRICAL APPROACH

6 Study 1: Please don't shoot the messenger! Prompts in online learning groups - influences of nudging messages' sender and publicness on recipients' perception and attribution

6.1 Objective, Research questions, and Hypotheses

Typical problems within MOOCs such as isolation, low motivation and low satisfaction, and high dropout rates (Erdmann et al., 2017), could be hailed by small group work, which, however, also faces common challenges like dropout and participation issues (Strauß et al., 2018). Group work can turn to be rather frustrating than motivating and can barely unfold its advantages due to such unpleasant and ineffective development (see section 1). Moreover, group work does not function automatically without the additional effort from a tutor or other group members, who address others (free riders, social loafers or just belated group members) to do their share of the work, also defined as soft paternalism or nudging. Such regulative acts are needed (section 2.1) and yet could be ineffective if one-sided (Isohätälä et al., 2017) and generally demanding if undertaken among group members due to involved negative feedback, task conflict easily turning to personal conflict and other interpersonal challenges (see section 2.2). A role reversal could be reached by the application of automated support for groups. However, support also needs to be given in a favorable manner to avoid frustration and persuade instead. Moreover, in the case of nudging, automated support would criticize group members like other group members would. The question appears – could this change of roles between nagging group members and a technology really help in the specific case of nudging?

As stated in the media equation theory (Section 3.1), interactions with computers and media are perceived as real-life interactions (Reeves & Nass, 1996), for instance people treat computers similarly to people, e.g. they avoid delivering directly negative feedback (Nass et al., 1999). However, research on information communication technology and human-robot-interaction has already shown some differences and limitations of the media equation theory as outlined in section 3.1.1. As an example of different perception of interactions with technology – people were more likely to abuse or self-disclose than when interacting with humans (Bartneck et al., 2005; Lucas et al., 2014).

Hence, it can be assumed, that negative feedback from an automated system might be perceived differentially, for instance, as more impartial due to the lack of past proficiency, which humans naturally possess. In the case of an automated nudging source, message recipients could not blame the system to threat intentionally, by criticizing for purpose or personal dislikes. A nudging system could be perceived by the recipients as non-human or even as a machine. However, due to social cues of the system, as the media equation theory postulates (Reeves & Nass, 1996), the interaction can be fulfilled and perceived as equal to real life human interaction. In the role of a mediating third party, a system could be perceived as more objective and can potentially prevent the occurrence of conflicts and personal disliking among group members due to nudging.

Thus, to lay the foundations of this dissertation, the question is asked, whether nudging differs depending on its source, and which is more beneficial – human-based or technology-based. Therefore, further source determining factors are considered, since the automated system does not have any past proficiency – neither high nor low as well as any personal intentions to influence students and therefore result in different perceptions. Hence, it is of interest whether further characteristics could replace or complete past proficiency and serve as a legitimization for the provision of negative feedback. Such signals for the expertise or credibility for instance, be it of a human or of a system, might be crucial for the persuasiveness of the prompting messages as well as for the perception of the nudging source. Beyond source-related factors, characteristics of the prompting messages could impact users' assessment, such as key properties like publicness of the prompting messages (e.g. Leary et al., 2009, see Section 2.2.2), as potentially more or less threatening and persuasive, are investigated.

Based on the reported theories and findings it was aimed to primarily explore which factors influence the perception of nudging and secondary, whether automated mediation (e.g. prompts sent by the system) can reduce potentially detrimental effects of nudging for interpersonal relationships and group climate. In an online study, in an artificial learning environment, prompt messages from the system as well as from team members will be conceptualized. Participants will imaginarily collaborate in small groups and receive prompting messages by means of visual mock-ups. The nudging sender (group member vs. system), his proficiency (high vs. low engaged) and the publicness level (nudge in a private vs. group forum message) will be varied as independent variables.

As summarized so far, based on prior research, the existence of differences between the experimental groups was assumed regarding causal attribution, emotional affect, sender

impression and message perception. The media equation theory postulates that people interact with machines like they do with humans. However, limitations of the theory already demonstrated different, partially more confidential interactions with machines. Hence, it is assumed that system nudges will be perceived differently than nudges from human team members – independent of proficiency and publicness:

H1: Compared to prompts from a team member, system prompts improve a) emotional affect, b) sender impression, c) message perception and d) internal causal attribution.

Beyond this assumption, it cannot be derived whether interaction with the system is still beneficial when contrasted to humans who showed relevant prior engagement and therefore earned idiosyncrasy credit. Therefore, the following research questions is posed:

RQ1.1: Compared to prompts from a low proficient team member, do system prompts improve a) emotional affect, b) sender impression, c) message perception and d) internal causal attribution?

RQ1.2: Compared to prompts from a high proficient team member, do system prompts improve a) emotional affect, b) sender impression, c) message perception and d) internal causal attribution?

Concerning the publicness of negative feedback and public ego-threat as hostile acts, I state that publicness has an impact on the negative emotional affect, on sender impression and message perception among all experimental groups:

H2: Publicness has an effect among all experimental groups, that increases a) negative emotional affect and b) negative message perception, but decreases c) persuasive message perception and d) sender impression.

However, the main effect among all groups does not deliver details to scrutinize which publicness level of system nudges is perceived as less threatening. Therefore, I explore the effect of publicness in system treatment groups, exclude further influences, and state the research question:

RQ2: Among system treatment conditions, is there an impact of publicness on a) negative emotional affect, b) negative message perception, c) persuasive message perception and d) sender impression?

6.2 **Method**

6.2.1 **Sample**

Regarding the *sample*, the study was approved by the ethics committee of the University of Duisburg-Essen. A total of 444 participants were randomly assigned to one of the six conditions. They were mainly recruited through advertisements in Facebook groups and incentivized in a lottery. Additionally, used a crowdsourcing website with postpaid incentives was used. Ninety-two persons were excluded from further analyses as they spent less than 10 seconds at the stimulus material pages (vignettes), their (nick)names were shorter than three letters and due to missing data. The remaining 352 participants (235 female, 117 male (33.2%)) ranged in age from 18 to 69 years (M = 29.40, SD = 10.46). Most of the participants had a university entrance degree (40.9%) or a higher degree (46.1%) and were predominantly students (228, 64.8%) with a medium attitude towards group work participation (M = 2.95, SD = 1.04, 1-5).

6.2.2 **Procedure and Stimulus material**

Participants were instructed to imagine that they participate in an online learning group, did not provide their contribution shortly before the deadline and therefore received a prompting message. The nudging sender (group member vs. system), past proficiency of sender (high vs. low engaged) and the publicness level (nudge in a private vs. group forum message) were varied as independent variables. The design is not fully crossed as the proficiency of the sender can only be varied in the team member conditions, not in the system conditions. To immerse the participants, I created visual vignettes based on the view of a group member account in the learning environment Moodle and adapted them to the specific conditions (Figure 4). The group context was described in advance by short texts and charts on the past progress of the group and group members' past proficiency regarding contributions' quantity and timeliness. Participants were presented a prompt message in form of a visual mock-up either from the system or from a high or low proficient teammate, and either as a private (inbox) or public (forum) message. The use of an artificial learning environment allowed to remind participants of the group context in the main message with the aid of a Moodle tool presenting group members' past online activities.

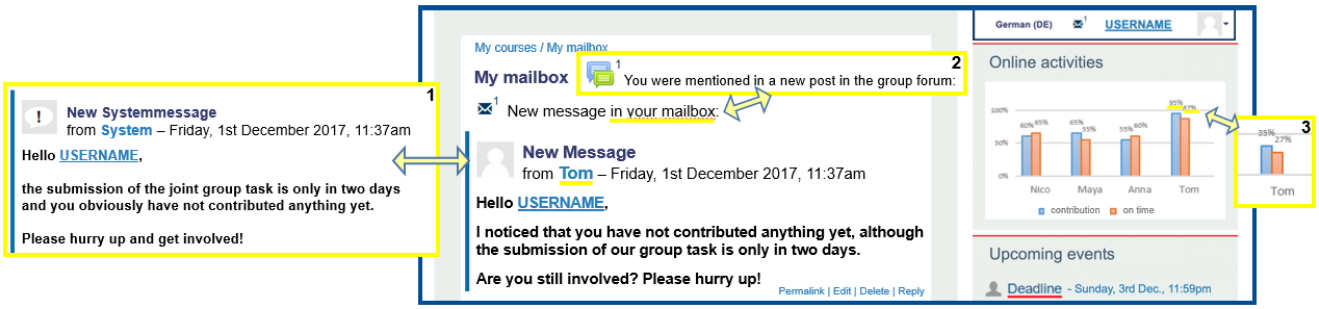


Figure 4. Exemplary vignette with variable conditions (1 = sender, 2 = publicness, 3 = proficiency).

6.2.3 **Measures**

Regarding *measures*, adjective item lists were adapted from various affective scales and lists for emotional affect, message perception and sender impression. Finally, for each measure, an explorative factor analysis according to Horn (1965) was conducted and the recommended factor solution was chosen.

Emotional Affect was measured with a list of 23 adjective items, all employing a 5-point Likert scale (1 to 5 = strongly agree). Factor analysis revealed a 3-factor solution: *Positive* affect (α = .841, 8 items, e.g. "inspired"), *negative external* affect (α = .907, 10 items, "humiliated"), and *negative internal* affect (α = .786, 5 items, "guilty").

Message Perception was measured by 18 single items, employing a 5-point Likert scale (1 to 5 = strongly agree) and divided into 3 factors revealed by factor analyses: *Negative* (α = .841, 5 items, "hostile"), *positive* (α = .894, 7 items, "needed") and *fair* (α = .827, 6 items, "impartial"). Additionally, as a further perception dimension, persuasiveness of the message was measured with an adapted version of the perceived persuasiveness scale from Orji, Vassileva and Mandryk (2014), employing a 7-point Likert scale (1 to 7 = strongly agree). An additional self-generated item regarding reluctant behavior was included. One-factor solution was applied – persuasive (α = .840, 5 items, "The prompt would persuade me").

Positive Sender Impression. Semantic differentials were applied (e.g. 1 = unfriendly to 5 = friendly) to measure impression from the sender and taken according to factorial analysis as one-factor solution (α = .905, 9 items).

Causal Attribution. I measured how participants attribute why they received the nudging message, whether it was their fault (internal) or others' (external). Based on Lefcourt (1981), 8 items with daily internal and external reasons were generated on a 5-point Likert

scale (1 to 5 = strongly agree). After a factor analysis, the dimensions were combined in an overall factor *Internal causal attribution* (α = .726, 5 items, “Because I was lazy”).

Other Measures. One item measures were employed to assess socio-demographics (e.g. age, education, gender), past group work experiences (both quantity and valence), and attitude towards group work. Additionally, self-esteem, perfectionism, and causal attribution style were measured as traits, as well as further personality traits, which are not relevant for the analyses presented here.

6.3 **Results**

Regarding *hypothesis 1*, after inspecting descriptive values (Table 2Table 2), a planned comparison was conducted to test whether the system as a nudging agent compared to team members improves a) emotional affect, b) sender impression, c) message perception and d) internal causal attribution. Therefore, both system-message-conditions (groups 1 & 2) were compared in planned contrasts to all the team-member-conditions (groups 3, 4, 5 & 6) as shown in Figure 5. The contrast revealed significant differences, indicating increased levels in the system conditions regarding internal negative emotional affect, $t(346) = -2.20$, $p = .029$, $r = .12$, but also message perception positive, $t(346) = -2.99$, $p = .003$, $r = .16$, and persuasive, $t(346) = -3.35$, $p = .001$, $r = .18$, generally positive sender impression, $t(263.12) = -2.76$, $p = .006$, $r = .17$, and internal causal attribution, $t(346) = -4.03$, $p < .001$, $r = .13$. *Hypothesis 1* is partially supported since the general comparison of all treatment groups divided by sender showed significant differences and an improvement of the positive and persuasive message perception, sender impression, as well as higher levels of internal causal attribution, whereas, contradicting to *hypothesis 1*, the internal negative emotional affect was higher. However, the system as a sender, compared to the groups with a team member sender, did not reveal significant differences regarding fair and negative message perception.

Research question 1.1 and *1.2* investigate whether compared to a message sent by a team member with high or low past proficiency, a message sent by the system improves a) emotional affect, b) sender impression, c) message perception and d) internal causal attribution. Therefore, to measure these, planned contrasts were conducted. Due to the factor proficiency which was varied in all experimental groups with a team member as a sender, the analyses had to be splitted to avoid conflicting high and low proficiency to be summarized. Thus, the system-message-conditions (1 & 2) were compared in planned contrasts to the team-member-group

Table 2

Descriptive values of dependent variables across treatment groups

Variables	1. SYpr		2. SYpu		3. TMpr-		4. TMpr+		5. TMpu-		6. TMpu+		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Emotional Affect														
Negative internal	3.75	0.77	3.72	0.81	3.72	0.90	3.72	0.77	3.36	0.86	3.78	0.80	3.95	0.84
Negative external	2.47	0.96	2.66	0.82	2.57	0.80	2.62	0.92	2.82	0.94	2.88	0.97	2.67	0.91
Positive	2.22	0.73	2.34	0.75	2.05	0.75	2.32	0.76	2.16	0.72	2.23	0.79	2.22	0.75
Message Perception														
Negative	2.46	1.05	2.78	0.86	2.82	0.90	2.57	0.98	2.90	0.95	2.78	0.89	2.72	0.95
Positive	3.00	0.90	2.95	0.77	2.41	0.90	2.97	0.98	2.52	0.94	2.77	0.83	2.77	0.92
Fair	3.19	0.85	2.96	0.81	2.68	0.90	3.29	0.91	2.77	0.84	3.12	0.71	3.00	0.86
Persuasive	5.15	1.41	5.32	1.13	4.28	1.39	4.76	1.45	4.83	1.06	5.10	1.34	4.90	1.33
Positive Sender Impression	3.38	0.66	3.21	0.69	2.86	0.85	3.35	0.80	2.84	0.90	3.23	0.70	3.14	0.80
Internal Causal Attribution	3.86	0.55	3.88	0.63	3.34	0.77	3.68	0.72	3.41	0.66	3.85	0.57	3.66	0.69

Note. Treatment groups:
1. SYpr = System private prompts
2. SYpu = System public prompts
3. TMPr- = Private prompts form a low-proficient team member
4. TMPr+ = Private prompts form a high-proficient team member
5. TMPu- = Public prompts form a low-proficient team member
6. TMPu+ = Public prompts form a high-proficient team member

conditions divided by proficiency. For *RQ1.1* I compared them to those with low past proficiency (exp. groups 3 & 5). Contrasts revealed that a system message, compared to one from a low proficient team member increased internal negative emotional affect, $t(346) = 3.97$, $p < .001$, $r = .21$, message perception, (fair, $t(346) = 3.19$, $p = .002$, $r = .17$, positive, $t(346) = 4.38$, $p < .001$, $r = .23$, and persuasive, $t(346) = 4.04$, $p < .001$, $r = .21$), positive sender impression, $t(223.46) = 4.41$, $p < .001$, $r = .23$, as well as internal causal attribution, $t(346) = 5.81$, $p < .001$, $r = .22$ (see Figure 5). There were no significant effects on external negative emotional affect and negative perception of the message. Except for these two subscales, the system-message-condition, compared to low proficient team-member-conditions, had an improving effect. For *RQ1.2* both system-message-conditions (1 & 2) were compared to those with high past proficiency team-member-conditions (exp. groups 4 & 6). However, there was no significant difference compared to high proficient team members. *Research question 1.1* revealed that messages from the system compared to those from low proficient team members improved internal causal attribution, positive sender impression, as well as fair, positive and persuasive message perception. On the other hand, the system had detrimental effects regarding increased internal negative emotional affect. *Research question 1.2* did not reveal significant differences between the system and high proficient members.

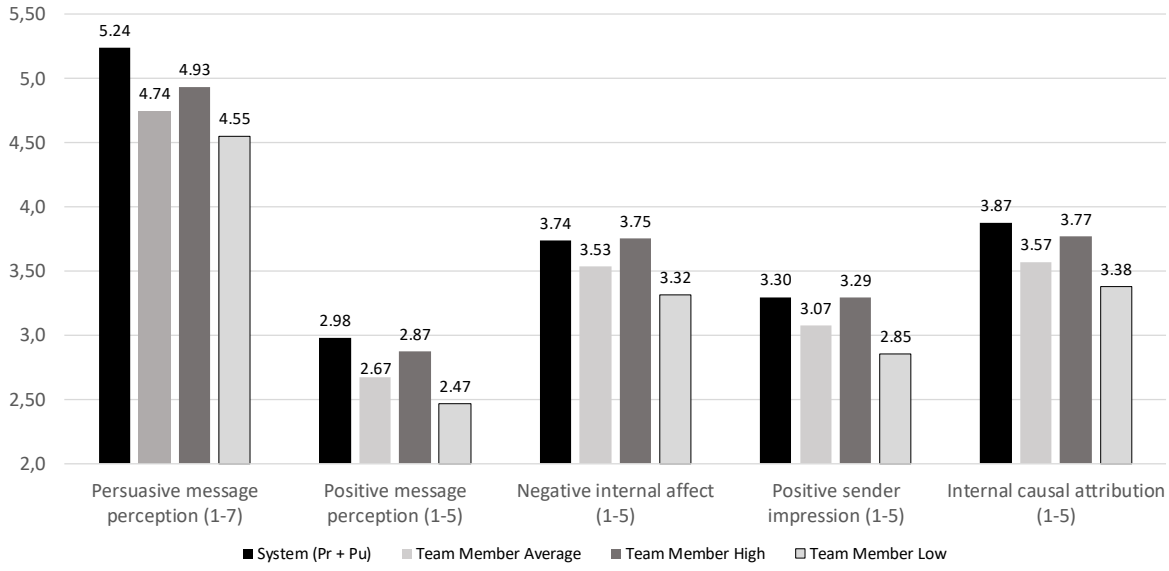


Figure 5. System vs. group members (average, high and low proficient) by means.

Hypothesis 2 was tested in a MANOVA, conducted among all treatment groups to test the influence of publicness on the experimental groups regarding increasing a)

negative emotional affect and b) negative message perception, but decreasing c) persuasive message perception and d) sender impression. There was a significant effect of publicness, $V = 0.64$, $F(5, 346) = 4.77$, $p < .000$. Further separate univariate ANOVAs revealed significant effects on a) external negative emotional affect, $F(1, 350) = 5.69$, $p = .018$, $\eta^2 = .016$, b) negative message perception, $F(1, 350) = 4.44$, $p = .036$, $\eta^2 = .013$ and c) persuasive message perception, $F(1, 350) = 5.66$, $p = .018$, $\eta^2 = .016$. However, there was no significant effect on d) sender impression. All significant effects indicated higher levels in public, rather than in private nudges, i.e. more negative emotional affect and more negative, but also more persuasive message perception. Therefore *H2* is partly supported as in the public condition a) negative emotional affect, b) negative message perception and c) persuasive message perception increased, but there was no significant effect on d) sender impression.

Research Question 2 addressed the publicness of a system message and whether public and private system prompts differ regarding a) negative emotional affect, b) sender impression and c) negative and persuasive message perception. Therefore a MANOVA was conducted, by comparing solely the experimental conditions with a system sender. No significant differences were revealed, $V = 0.12$, $F(15, 99) = .893$, $p = .574$.

6.4 **Discussion**

In order to gain the benefits of group conflict without the costs, I focused on the common but barely researched nudging in groups. In an online experiment, I addressed the social psychological dynamics in online learning groups and explored potentially influential factors for the perception of nudging, i.e. the sender, sender's past proficiency, as well as the publicness of the message. The data indicated that nudging messages sent not by a team member but by the system, were perceived as more positive and persuasive, improved sender impression and internal causal attribution. In line with prior research (Lucas et al., 2014), this indicates that a message from a human is not always equal to a message from the system and that it can be beneficial if a system instead of a fellow human delivers unpleasant messages. Contradicting my assumptions, however, internal negative emotional affect was also higher, potentially due to the fact that participants were more likely to blame themselves when the system confronted them with negative feedback. Also against my assumptions, the system messages were not perceived more impartial. Future research will need to show whether this – in the sense of the media

equation (Reeves & Nass, 1996) – actually indicates that humans and machines are subject to the same person perception mechanisms or whether this result is due to different expectations towards machines and humans.

While there was no difference between highly proficient team members and the system, the system was perceived as more positive compared to low proficient team members. Keeping the idiosyncrasy credit and the media equation theory in mind, participants may think of the system differently and still attribute a level of past proficiency to the system or at least attribute sufficient competences to the system to accept that it judges oneself. Alternatively, the system might have been accepted as a truly neutral evaluator who is allowed to utter feedback just as much as a proficient peer is. In order to address these open questions, systems' error rates should be taken into account in future studies demonstrating the systems' past proficiency. The findings here further affirm some studies in educational artificial intelligence and tutoring systems. Compared to human-tutors, intelligent computer-tutoring was shown as equally and more effective independent of time and context (for review Kulik & Fletcher, 2016) and concluded as needed only if beneficial for performance and learning (Ostrander et al., 2019). However, the mere system perception and social-psychological group dynamics were disregarded.

Regarding limitations, this study so far only elucidates the effect of system nudging in the artificial context of imaginary groups. Future field studies are needed in a field setting and real groups to replicate the findings. A survey analysis was applied that primarily focused on perception, but behavioral data may be more promising to investigate the topic and its links to students' learning processes and outcomes. Finally, it has to be noted that all effect sizes were small.

In conclusion, having the tutor-system deliver nudges seems to be a promising solution for a specific form of group conflicts. Future research should also include and consider the system´s potential embodiment and other cues such as natural language output. The more we learn about the conditions under which negative feedback can unfold positive effects (and the messenger does not have to be shot), the better can tutoring systems be improved to support group dynamics.

7 Study 2: Face it! The influence of personification of a prompting system on users' behavior and satisfaction in online learning groups

7.1 Objective, research questions, and hypotheses

Having investigated the nudging source in the first study of this dissertation, how a technology-based and a human-based source are perceived, their differences, similarities and significant determining characteristics (section 6), the overarching aim of this dissertation remains partly unanswered. In order to learn more about the improvement of online learning groups through automated prompting, further investigations are needed. Beyond the insights about the advantages of an automated prompting system as more persuasive and more positive (against low and average proficient team members), the publicness of the prompting messages mattered as more persuasive but also as more negative. However, these source and message characteristics do not exhaust all possibilities to customize an automated support providing entity. Further characteristics can be determining such as appearance and "behavior" in the sense of guiding techniques.

Thus, considering the results of the first study, next it is of interest whether human likeness in terms of properties and skills, should be transferred to make the process of nudging more facilitative. The social cues/agency theory postulated that the more social the system appears, the more social responses it earns (Moreno & Mayer, 2000; Mayer 2005, see section 3.2). Hence, generally personification can be proposed to serve as an extension of the beneficial effects of an automated nudging system (see section 4.1). Researchers already distinguished between the support lending entities in terms of agents and digital systems, but satisfaction was barely investigated. Moreover, the variables of interest varied, depending on the purpose and realm the support was provided for. For instance, mainly learning outcomes were focused regarding pedagogical agents or exclusive design in appearance related studies (e.g. Baylor & Kim, 2004 and section 4.1.1). Nevertheless, even though systematic investigations are required, field settings with real groups were barely applied (e.g. Kulik & Fletcher, 2016), and even if so, long term effects were not explored yet, however they are crucial for group dynamics especially in the case of nudging. Moreover, beyond merely subjective assessments like

survey data or only behavioral data, potentially disregarding a holistic view on groups, a combination of different data types could be explicitly helpful when it comes to collaborative interactions. Last but not least, especially the static display, respectively interaction with an automated support entity can develop and differ over-time, potentially violating students' expectancies.

7.1.1 **Expectancy violation**

As aforementioned, diverse recommendations exist for the application of agents in special cases and their fitting appearance options. Unfortunately, they can barely be employed for broader target groups and in an interdisciplinary context, i.e. can easily lead to expectation violations in more heterogeneous use cases and user groups. In this realm, acceptance and disappointment could be key factors.

The Expectancy Violations Theory (Burgoon & Hale, 1988) initially regarded the violations of distancing during interaction. It defined humans' subliminal expectations to avoid uncertainty and the deviations from them as "expectancy violations" – positive if better, or negative if worse than expected. The extended theory is showed even virtual agents to provoke expectancy violations (Burgoon et al., 2016). The authors compared communication with either humans or embodied agents – graduating human likeness and media richness – from text only up to animation and voice. Indeed, positively violated expectations made the interaction most desirable regarding communication partner (with an agent instead of a human) and regarding expectedness (positive violation were most effective compared to confirmation of expectations and their negative violation). Even though negative confirmation and violation did not differ regarding outcomes, in sum they showed worse outcomes than positively evaluated interactions regarding dependability, connectedness and being understood/receptivity. Lastly, yet importantly, in this study (Burgoon et al., 2016) the interaction scripts were equal in all agent conditions, however interactions were rated differently: with highly embodied agents (text, voice and animation) as positive violations, with medium embodied (voice and animation; text, voice and static image) as negative violations, while low or not embodied ones (text with voice or text only) were rated as slightly negative confirmations. Although the ratings depend on the individual expectations, these results identify that medium human-like agents (text, voice and static image) can provoke even more negative violations than those without appearance, potentially due to the disappointing, contrary

to expectations, lacking agent skills. It needs to be mentioned, that the medium human-like agent in this case had a voice, i.e. a high-level social cue. However, even other, weaker embodiment can still trigger higher expectations and more negative violations especially in the long term, as users could easily notice the lower interactivity of the agent and the persistent content of prompt messages regarding participation.

Thus, in order to facilitate the acceptance of system interventions, prevention of wrong expectations and their potential violation is needed. Undefined agent cues can be beneficial and offer universal solutions, allowing imaginary personalization (Silverarg, Haake, & Gulz, 2013). They could provoke lower expectations and help prevent expectancy violations. Furthermore, even though focused on teaching instead of informing, most recent research in the realm of Intelligent Tutoring Systems (ITS) and especially focused on collaborative dyad problems, recommended tutors to be applied only when beneficial for learning and performance in order to prevent overloading (Ostrander et al., 2019). Additionally, the need for an *interdisciplinary* discussion was identified, aiming to find out what is relevant for intelligent tutoring (Johnston, Sottilare, Sinatra, & Burke, 2018). From this point of view, aiming to reduce potential expectancy violation and overload, it might be assumed to refuse of any appearance or social cues of the system, like it often is the case with ITS. However, we need to keep in mind that tutoring systems aim to teach instead of simply inform or nudge participants and focus, just like pedagogical agents, mainly on learning and performance. The necessity of personification and amount of social cues can change with the support aim. Searching for the optimal solution in the case of prompt messages, the question remains, whether they could gain higher acceptancy and persuasiveness when being sent by machine-like or by human-like entities, moreover how it develops over time.

7.1.2 Hypotheses

Based on the theoretical background and findings of prior academic research outlined so far, in the recent, second study of this dissertation participation, satisfaction and personification, as well as their interdependencies were investigated in detail by several hypotheses. Keeping in mind the importance of participation (equality) and satisfaction, group members have to be prompted to contribute more. To this aim, the acceptance of system prompts has to be facilitated, potentially by the addition of simple social cues like static appearance and a name.

First, considering on the significant role of participation (equality) for online group work, and partly hints for the connection between participation and satisfaction (e.g. Alavi & Dufner, 2005; Zmud et al., 2001) or retention rates (Rovai, 2002), it can be assumed that the equality of participation positively influences the satisfaction with group work:

H1: The higher equality of user participation facilitates satisfaction with group work.

Regarding the provider of prompt messages and its personification, the question remains whether an abstract support giving system can gain advantages by the addition of basic social cues such as an appearance and a name. An answer is still missing due to partly conversed assumptions of the Media Equation Theory (Reeves & Nass, 1996) but also its limitations pointing out *in*equalities and advantages of human-computer interaction. Moreover, as the Social Agency/Cue Theory (Moreno & Mayer, 2000) postulates, the more social the interaction gets, the more social the information sender was perceived. However, based on some related findings from the realm of pedagogical agents (even though as more interactive entities) (e.g. Baylor & Ryu, 2003; Heidig & Clarebout, 2011), I hypothesize that personification facilitates the subjective user perception of the system, of the prompt messages in detail and of the satisfaction with group work:

H2: The mere static personification of the system has a positive impact on the subjective user perception and assessment of the system (2.1), the prompt messages (2.2) and the satisfaction with group work (2.3).

Similarly, apart from the subjective perception or potentially even based on it, I assume that participation based prompts by a personified system impact the way users behave within the course, with or without awareness of their perception of the system. Thus, it is hypothesized that personification triggers them to login more frequently and contribute more, resulting in more equal participation within the groups, as prompted by the system:

H3: The mere static personification of the system has a positive impact on the objective user behavior such as login frequency (3.1), contribution quantity (3.2) and equality of participation (3.3).

More precisely, the relation between personification and subjective satisfaction might be mediated by the equality of user participation, i.e. prompts given by a

personified system increase the equality of participation, increasing this way users' satisfaction:

H4: The influence of system personification on subjective satisfaction is mediated by the equality of user participation.

Regarding the interaction with the system in the long term, it is possible that users become accustomed to the personification over time, which can result in an attrition of the primary positive impressions and effects. I assume the personified, yet not interactive system to cause decreases in the facilitating effects due to expectancy violations (Burgoon et al., 2016). Thus, the hypotheses are stated, that the duration of three group tasks will weaken students' positive perception and behavior due to the monotonous feedback from the personified system. Opposite to the effects of non-repetitive interactions (see H2 and H3), the abstract system could be less disappointing over time, i.e. more beneficial. Thus, long-term effects opposed to those in the short term are assumed:

H5: Due to repeated usage, the abstract system, compared to the personified one, facilitates in the long term users' subjective assessment of the prompt messages (5.1), perceived group awareness (5.2) and satisfaction with group work (5.3) as well as users' objective behavior in the course (i.e. login frequency, amount of contribution, equality of user participation)(5.4).

7.2 **Method**

7.2.1 **Experimental field setting**

This study was conducted in the winter semester of 2018/2019, within an online course at a large German university. The course was implemented in the online learning environment Moodle and comprised a total of eight topic blocks, six of which were combined with group tasks of two weeks each and used for accompanying research. Besides, the course started and ended with one-week individual tasks, one as an introduction of basic knowledge at the beginning and one as a repetition week at the end. This schedule granted that the particularly expected high dropout rates at the beginning of the course are passed before group formation, i.e. before the start of the accompanying research, and additionally this way there was no interruption by the semester breaks during the two-week topic blocks.

The course materials included a video to introduce the topic as well as up to two articles that served as related basic or extended literature. A central component of each topic block was a two-weeks group task, which had to be completed in small groups of three to five students. Active participation in the group tasks was a mandatory prerequisite for participation in the final exam in order to promote increased activity.

The course participants were randomly assigned to groups at the beginning of each topic block. During this process, participants were categorized so that always new group member constellations were assured. This way habituation effects in the groups were avoided and new coordination as well as exchange processes during the group work were stimulated. For the purpose of processing the group task, groups had their own group forum for communication purposes and a wiki as a text production tool available for each topic block.

The teaching team listed basic recommendations for the structuring and division of the task parts in each task description, which should promote the collaborative processes. However, no regulations about preferred working methods within the groups were set, so that the course participants needed to communicate in the group forum in order to coordinate and develop the group contribution. A minimum of 600 words per group was required. The solutions were stored and automatically submitted at the end of each topic block.

In order to promote active and dynamic group work, course participants should indicate at the end of each topic block, i.e. before the compilation of the new working groups, whether they are still actively participating in the course. This obligatory opt-in was used as a prerequisite for the new group assignment at the beginning of the following week. In order to reduce the lack of activity of individual group members, further features such as e-mails, received individually and simultaneously by all participants, were used to remind the participants to explicitly opt-in for the next week. At the same time, the e-mails also served as a reminder of the upcoming deadlines for the group tasks and as a hint for the participants to complete the questionnaires. Further help options were presented through the general discussion and announcement forum.

7.2.2 **Procedure and Design**

This study was placed in the second half of the course[1] in order to investigate the influence of system personification while applying intelligent support. The field study employed an experimental one factorial between-subjects design (personification vs. no personification).

The independence of the accompanying research and the course was clearly communicated. In the beginning, written informed consent was obtained by the course participants, who agreed to participate in the accompanying research voluntarily. Participation could have been cancelled any time without justification or consequences for the further running course.

With their consent to participate, the participants agreed to the storage of their objective data like Moodle activities and subjective data like online questionnaires – one before the start of the course, one at the end of the course, and one after each topic block with group work. After group task 6 an additional final questionnaire was added to the short questionnaire. The course activities were stored as log files. They included contributions made in the group forums and wikis, as well as activity data on click behavior and registration times. As an incentive for the continuous participation in the accompanying research, participants were awarded a lump sum of 5 Euro each and 8x50 Euro were raffled. Further additional raffles were advertised for the completion of selected questionnaires in order to promote participation – at half time or within the entire second half of the course.

7.2.3 **Sample**

In total, 123 university students registered at the beginning of the course, 94 (76.4%) of them agreed to participate in the accompanying research. Due to high dropout rates in total during the whole course (47.1%), 65 students retained in the second half of the course, before the study started. Despite reminders per e-mail questionnaires were not completed intentionally every two weeks as needed (see Table 3). In sum, 35 participants completed all four questionnaires ($N = 35$, 23 females, $M_{age} = 23.17$, $SD = 4.62$).

[1] An independent study was conducted in the first half of the course, followed by a complete replacement of the experimental manipulation, which was announced as a system upgrade to avoid confusion. Participants were completely randomized and evenly assigned to the conditions of the this study in order to prevent side effects.

Table 3
Number of participants and completed questionnaires in each task

	Pre-questionnaire	Task 4	Task 5	Task 6	All
Participants (log files)	94	52	49	48	46
Completed questionnaires	70	42	40	39	35

All participants were university students from diverse disciplines, 29% “Applied cognitive and media sciences”, 17% “Business administration”, 11% “Political sciences” and many others. The most significant reasons for the choice of this course was flexible, independent time and place (M = 4.77, SD = .65), interest in online collaboration (M = 4.17, SD = .82), followed by interest in the topic (M = 4.14, SD = .69) and joy of online collaboration (M = 3.86, SD = .81). Participants indicated that they already used the learning platform Moodle (M = 12.89, SD = 13.65) and had positive previous experiences with it (M = 75.91, SD = 26.27), had little knowledge in the course topic in advance (M = 2.60, SD = .74) and generally enjoy group work moderately (M = 3.03, SD = .95). Since leaving school the participants already experienced group work (M = 11.43, SD = 11.24), but they have barely participated in online courses with group work before (M = .51, SD = 1.20). However (or even due to this fact) participants stated to have positive previous experiences with online courses (M = 68.83, SD = 26.43). Participants also stated in their daily life to be less conventional (M = 2.30, SD = .70) and subservient (M = 2.56, SD = .80), but highly innovative regarding readiness for technology (M = 3.66, SD = .77). With regard to virtual agents and assistants (e.g. Siri, Alexa, etc.) participants were moderately familiar with them (M = 3.09, SD = .78) and 65.7% already used some before. In sum, previous experiences were moderate, neither positive nor negative (M = 47.80, SD = 24.39, 1 - 100) but general attitudes towards virtual agents and assistants were positive. Participant find them helpful (M = 3.54, SD = .98), but not very necessary (M = 2.09, SD = .89), and moderately annoying (M = 2.89, SD = 1.05).

7.2.4 **Materials**

The awareness tool provided a mixed guiding strategy (a combination of mirroring and guiding). The accompanying personification of the system was experimentally manipulated with the presence or absence of a static virtual agent with a name (*Figure 6*).

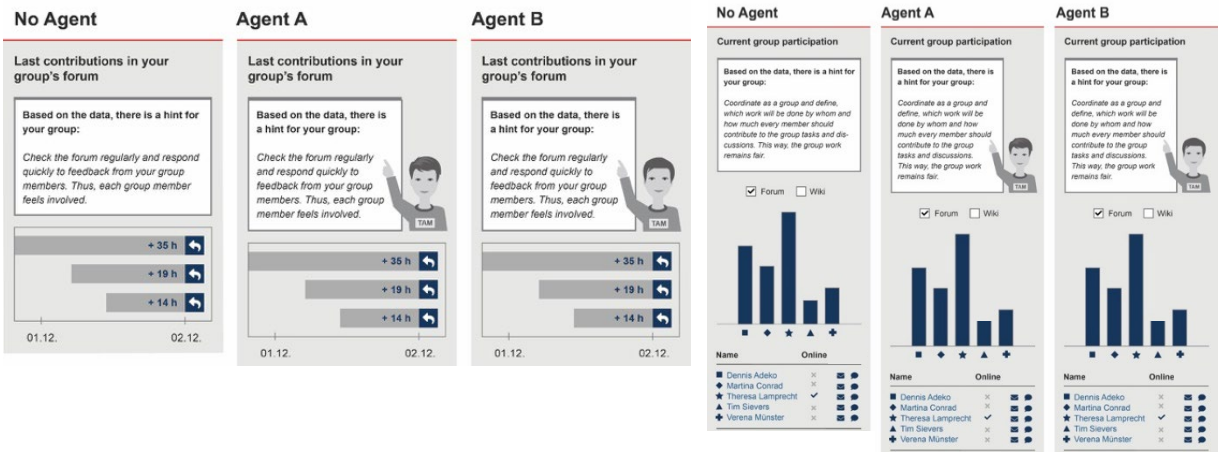


Figure 6. Interventions regarding forum latency (left) and participation (right) in both conditions: no personification vs. personification (appearance A/B collapsed for the analysis).

For the purpose of personification an agent, named Tam, visually represented the underlying system and was placed as the transmitter of the guiding messages within the awareness tool. Two pre-tests were used to evaluate potential agents' names ($N_{pretest1}$ = 30) and appearances ($N_{pretest2}$ = 40) to generate an agent which is neither unfavourable, nor extremely feminine or masculine. Gender neutrality was applied to avoid gender-specific effects since research in this area yielded contradicting results (e.g. Baylor & Kim, 2004). Especially regarding education, pedagogical agents delivered contradicting results depending on context, audience or agents' properties (Heidig & Clarebout, 2011). Thus, I aimed to test the effects of a more universal, generalizable personification.

In the first pre-test ($N_{pretest1}$ = 30, 23 females, M_{age} = 26.40) 18 names were evaluated. After reducing the extreme cases among them with regard to being extremely masculine or feminine, unsuitable for an agent and highly prominent, 8 names were retained (Simi, Tam, Lucky, Eli, Alexis, Momo, Dany, and Charlie). Among them, the name Tam showed the best results according to the demands regarding compatibility for a virtual agent, high androgyny, low name recognition, as well as perception as less authoritarian, medium likable, trustworthy, intelligent and helpful.

In the second pre-test ($N_{pretest1}$ = 40, 22 females, M_{age} = 26.08) six design drafts (Figure 7) were tested regarding the same components. Agents 1 and 5 showed the best results. In order to foster generalizability of results, not just one specific appearance, but instead the two most androgynous and agent-suitable appearances were chosen for the

personified condition, both with medium perceived character attributes (Figure 7). Later on, the groups were compared and collapsed in one condition for the analysis.

Figure 7. Agents' design drafts. Finally applied in the personified condition: agent A (5) and agent B (1).

Additionally, *expertise signalling attributes* like glasses and a necktie were not highly preferred and varied the gender perception inconsistently, therefore none of them were applied in the study.

Ultimately, 14 more general *hints of the week*, their likeability, helpfulness and severity were evaluated. For the application in the course, the weekly hints were finally selected, which were independently rated as not highly negative but simultaneously as highly prompting.

The tips of the week were displayed for all groups (e.g., "Notifications off: Every beeping, every red number in your field of view induces stress. Turn it off."), according to the experimental condition, with or without personification. This ensured the inevitable confrontation with prompting messages from the system, even in case of an absence of the diagnosed "problematic" behaviors in the groups.

In sum, based on the results of the pre-tests the name Tam and both appearances were chosen after their evaluation as suitable, neutral and compatible. Both agents were given the same name for two reasons. On the one hand, in order to maximize the number and variety of variable participants in the groups, allowing me to combine team members with the personification of both appearances (for instance a group could contain participants in the personified condition, but some with agent A and some with agent B). On the other hand, this method would minimize possible misunderstandings and conspicuities within the groups in case of discussions about the agent, as the agent's name was indeed the same. Half of the volunteers were equally divided between the two agent conditions, while the other half of the volunteers had no agent displayed as a system representation.

7.2.5 **Measures**

This systematic field setting and the agreement of the participants guaranteed the access to objective data (behavioral data) and subjective data (questionnaires assessing emotions and perceptions after each group task). Both types of data collection were combined in order to deliver applicable solutions for a beneficial configuration of the intervening system.

Objective measures

Students' behaviors in the platform (click behavior, frequency of logins, quantity of contributions in forum and wiki, and the level of equality of participation) were logged as objective measures. The system could log the quantity but not the quality of the behaviors, i.e. whether students clicked on certain materials or not, however not their scrolling behavior. Furthermore, there is no information about how students processed materials or proceeded after accessing the platform and the materials. Log files were stored per topic, ordered by time and assigned to the platform ID of each participant, which were also transmitted to the surveys of subjective measures. This method provided the opportunity to relate self-reported data and log files.

Contribution quantity in forum and wikis was measured as a simple word count.

Login frequency was filtered by the time difference between logins. This way it did not count as several login actions in case the same user logged in more than once within 30 minutes.

Level of participation equality was measured with the Gini coefficient, which is commonly applied as a coefficient of group members' participation at the group process, e.g. as an inequality coefficient already successfully applied for bug prediction in programming IT-groups (Giger, Pinzger, & Gall, 2011). If the desirable state is true and all members contribute in a perfectly equal manner, the Gini coefficient has the minimum value of zero. On the contrary, when the value reaches the maximum value of one, the inequality of participation is achieved. In this study, based on adopted data from prior online courses, a threshold value of 0.5 was set as "problematic" on a group level and activated the delivery of participation related prompts. Nevertheless, this coefficient was calculated as a cumulated value, on several days of the group work, for instance, a value of 0.75 at the last day of group work is not the result of group members' participation at

the 14th day but rather their participation regarding the sum of their participation in the last 13 days calculated proportionately.

Subjective measures

For all questionnaires, items needed to be as short as possible to enhance the willingness of the students to complete them after each group work. Therefore, adjective item lists and single items were applied, which were adapted from various affective scales and lists measuring emotional affect, message perception and impression of the system. Finally, for each measure with diverse adjectives, an explorative factor analysis according to Horn (1965) was conducted and the recommended factor solution was chosen.

Pre-Questionnaire

Students were asked about socio-demographic parameters, such as age and sex, as well as about their study program.

Course-related characteristics and how relevant they were for choosing this course were asked employing a 5-point Likert scale (1 to 5 = strongly agree, 9 items): as a personal challenge, for new knowledge (without any in this topic), to refresh basic knowledge, due to interest in online/virtual collaboration or in the topic, enjoyment of online/virtual collaboration or the topic, due to flexible, independent time and place or due to the study plan.

Additionally, *topic knowledge* was assessed on a 5-point Likert scale (1 to 5 = a lot) as well as general *enjoyment of group work* (1 to 5 = very much) and the total number of participation in Moodle courses, generally group works and online courses with group work since leaving school (all input fields). *Previous experiences with online courses* and with the *Moodle platform* (slider 1 = highly negative to 100 = highly positive) were also assessed.

Others: Additionally, however not from interest in this study, *causal attribution, conventionalism*, *authoritarian subservience*, *innovativeness, experiences and attitudes towards virtual agents/assistants* were also measured with adopted single items.

Short-Questionnaire

As this was completed repeatedly after each group task, it was intentionally set as the shortest questionnaire, therefore mainly one-item solutions and a total of 14 items were applied.

Primarily, the manipulation was checked by questions about the hints – how many were *noticed* and/or *closer observed* in the last group task. Except for these two input fields, the following items of the short-questionnaires employed a 5-point Likert scale (1 to 5 = strongly agree).

Satisfaction with group work was measured employing two items combined to a factor (α = .77; 2 items): willingness to solve a task in this group again as well as general satisfaction with the group work.

Prompt message perception was measured by 4 single items: *helpful, relevant, motivating,* and *good willing*.

With regard to *group awareness,* perceived group usage of the shown hints for collaboration optimization, other members' helpful participation and observability of their participation were measured as single items.

Additionally, potentially varying *task characteristics* were measured with single items: *interest in the task, degree of freedom while solving it* and *group conflict*.

Final-Questionnaire

Immediately after the items of the last short questionnaire participants were explicitly instructed to recall the last three group tasks. In this part of the questionnaire students were asked more specifically about their perception of the system and the prompt messages sent by it. The more general formulation of the questions allowed to apply these items in both conditions, independent of the appearance and name of the system or its abstract being. Additionally, in the personification condition the perception of the agent was measured explicitly.

Perception of the system was measured with an adapted shortened version of the Agent Persona Instrument (API) from Baylor and Ryu (2003). Subscales were employed on a 5-point Likert scale (1 to 5 = strongly agree): *human-like* (α = .74; 3 items; e.g., "The system had personality") and *facilitating learning* (α = .86; 3 items; e.g., "The system shifted my focus on the relevant information").

Perception of the prompt messages was measured with a list of adjectives and short sentences, employing a 5-point Likert scale (1 to 5 = strongly agree), partially adapted from the perceived persuasiveness scale from Orji et al. (2014). 15 items were divided in 4 factors revealed by factor analyses: *persuasiveness* (α = .83; 4 items; e.g., "motivating"), *hostility* (α = .80; 5 items; e.g., "hostile"), *fairness* (α = .76; 3 items; e.g., "impartial") and *relevance* (α = .80; 3 items; e.g., "necessary").

Perception of the agent was measured only in the personification condition. Attitudes to agents' appearances were employed on a 5-point Likert scale (1 to 5 = strongly agree) regarding compatibility with the name Tam as a virtual agent and single item characteristics such as authoritarian, likeable, trustworthy, intelligent and helpful. Additionally, agents' androgyny (slider 1 masculine to 100 feminine) was measured.

After these items the final instruction in the questionnaire asked participants to answer the following items regarding the complete course in general.

General course characteristics were measured with 11 items on a 6-point Likert scale (school grades 1 = excellent to 6 = insufficient): overall course evaluation, satisfaction with the topics, satisfaction with group work (all topic blocks), successful collaboration within the group (all topic blocks) and further course didactic items.

Finally, *intra-group conflicts*, i.e. the overall perceived level of conflict between group members in the whole course was measured by adapting a standardized scale (Saavedra, Earley, & Van Dyne, 1993) on a 5-point Likert (1 to 5 = strongly agree; α = .84; 7 items; e.g., "I was often unhappy and in conflict with the members of my groups.").

Other Measures. Additionally, causal attribution style as a trait, as well as further common problems of online collaboration were measured, which are not relevant for the analyses in this study.

7.3 **Results**

Before the analysis of the main hypothesis, the manipulation regarding the perception of the agents was checked. Attitudes to both appearances did not differ significantly as shown in Table 4. Thus, based on the comparison between agent A and B as well as on the missing significant differences, participants in both subgroups were collapsed for the analysis as a personification condition.

Table 4
Differences between agents' characteristics all non-significant, p > *.05*

	compatible	authority	likable	trustworthy	intelligent	helpful	androgyny
A/B	3.00/3.14	2.50/2.57	3.38/3.86	3.38/3.43	3.38/4.00	3.75/3.71	51.50/24.00

Depending on data collection's point in time and the group task variables refer to, they are employed in the analysis with an abbreviation (e.g. participation equality "T6 d14" means equality measured in group task 6, day 14). Lastly, yet importantly, due to the drop-out and varying willingness to complete surveys, the sample as well as the distribution changes for each point of data collection, respectively also for the calculations.

Participation and satisfaction

To investigate whether higher equality of user participation facilitates satisfaction with group work (H1), a linear regression was conducted (n = 40) using the index of equality of user participation in the final group task (last day of the last group task - T6 d14) as predictor and satisfaction with the group work in this task as an outcome variable. Results revealed a statistically significant relationship between the factor equality of participation and group task satisfaction, F (1,38) = 8.41, p = .006, R^2 = .181. Equality of participation increased participant's satisfaction with the group work. Therefore, hypothesis H1 is supported.

Impact of personification on subjective user perception

Several univariate ANOVAs with the experimental condition as the independent variable were computed to test the next two hypotheses regarding the effects of personification (H2 with n = 40, 18 in the personification condition; H3 with n = 46, 22 in the personification condition).

To test personification effects on the subjective user perception of the system (H2.1), *human-likeness* and *learning facilitation* were added as dependent variables, however, no significant effects were revealed (see Table 5). Therefore, user perception of the system did not differ, i.e. H2.1 is not supported.

Table 5

Results of H2 regarding personification and subjective user perceptions

	personified		abstract		*F*	*p*	η^2
	M	*SD*	*M*	*SD*			
H2.1 system's							
human-likeness	2.44	0.71	2.27	0.87	0.45	.506	.012
learning facilitation	3.04	0.97	3.35	0.85	1.18	.285	.030
H2.2 prompt messages'							
hostility	2.14	0.71	1.88	0.58	1.66	.205	.04
fairness	3.54	0.54	3.62	0.79	0.15	.702	<.01
relevance	3.26	0.74	3.65	0.83	2.43	.127	.06
persuasiveness	2.76	.59	3.50	.77	11.13	**.002**	.23
H2.3 group work satisfaction R							
overall satisfaction	3.89	1.41	2.81	1.12	6.29	**.017**	.15
successful collaboration	3.72	1.41	2.71	1.10	7.08	**.011**	.16

A similar analysis strategy was chosen to investigate personification effects on the perception of the prompt messages (H2.2, $n = 40$) with the dependent variables *hostility*, *fairness*, *relevance* and *persuasiveness*. Results revealed no statistically significant effects on the first three variables, but on *persuasiveness,* $F(1,40) = 11.13$, $p = .002$, $\eta^2 = .23$ (see Figure 8). Personification decreased perceived *persuasiveness* of the prompt messages ($M_{personified} = 2.76$, $SD = .59$; $M = 3.50$, $SD = .77$). H2.2 is not supported, because the results are contrary to my assumptions. Compared to the system without appearance, the personified system is perceived as less persuasive.

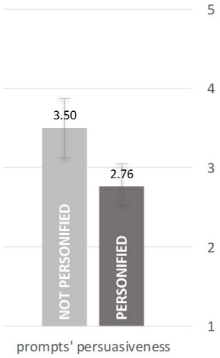


Figure 8. Prompts' persuasiveness improved by an abstract system against H2.2.

Personification effects on the satisfaction with group work (H2.3) were tested similarly with ANOVAs with *overall satisfaction* as the dependent variable. Results revealed significant effects on *overall satisfaction with group work,* $F(1,39) = 6.29$, $p = .017$, $\eta^2 = .15$ ($M_{personified} = 3.72$, $SD = 1.41$; $M = 2.71$, $SD = 1.10$) as well as on *overall successful collaborations* $F(1,39) = 7.08$, $p = .011$, $\eta^2 = .16$ ($M_{personified} = 3.89$, $SD = 1.41$; $M = 2.81$, $SD = 1.12$). Keeping in mind that this scale was based on German school grades for higher motivation to evaluate the course at its end (1 = excellent to 6 = insufficient), participants in the personification condition were overall less satisfied than participants in the condition with an abstract, not personified system (see Figure 9). However, these results are opposite to the assumptions, therefore H2.3 is not supported.

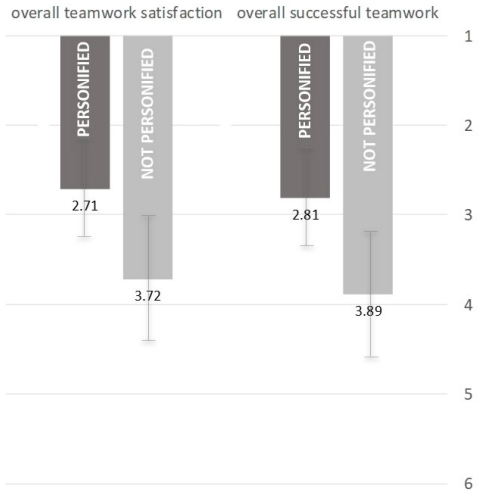


Figure 9. Overall satisfaction improved by an abstract system against H2.3.

Impact of personification on objective user behavior

In order to test whether the mere static personification of the system has a positive impact on the objective user behavior further ANOVAs were computed with the experimental condition as a dependent variable and objective measures as dependent variables (login frequency in H3.1, contribution quantity in H3.2, and equality of participation in H3.3). Results revealed no significant effect of personification on login frequency (H3.1) and on contribution quantity in terms of the number of written words (H3.2) (see Table 6). Thus, both hypotheses H3.1 and H3.2 are not supported.

Table 6

Results of H3 regarding personification and objective user behavior

	personified		Abstract				
	M	*SD*	*M*	*SD*	*F*	*p*	η^2
H3.1 login frequency	35.13	16.21	30.58	13.44	1.10	.300	.024
H3.2 contribution quantity							
Forum	354.36	286.40	366.17	427.97	0.01	.920	<.01
Wiki	808.55	426.50	697.79	386.70	0.85	.361	.019
H3.3 participation equality	.40	.20	.53	.15	10.21	**.003**	.19

Regarding H3.3, there was a significant effect of personification on the equality of participation in group task T6, $F(1,46) = 10.21$, $p = .003$, $\eta^2 = .19$. In the experimental condition with personification the index of equal participation was lower, i.e. participation was more equally distributed ($M_{personified} = .40$, $SD = .20$, $M = .53$, $SD = .15$). Therefore, H3.3 is supported, showing significant effects confirming my assumption, that personification facilitates the equality of participation.

Mediated impact of personification

In order to test the link between objective behavior, subjective perception and the experimental condition (H4), a mediation analysis was conducted ($n = 40$) applying the PROCESS macro for SPSS (see, for example, Hayes, 2018). Here, system personification served as the predictor, satisfaction with group work T6 as the outcome and equality of participation T6 d14 as the mediator (see Figure 10). The overall model was statistically significant, $F(1,38) = 5.13$, $p = .029$, $R^2 = .119$. Results revealed a non-significant total effect, $p_c = .153$, B = -.49, but a significant direct effect, $p_{c'} = .005$, b = -.92, and a significant indirect effect of personification on satisfaction via participation equality, b = .42, 95% CI [0.045, .954]. The fully standardized indirect effect was 0.19.

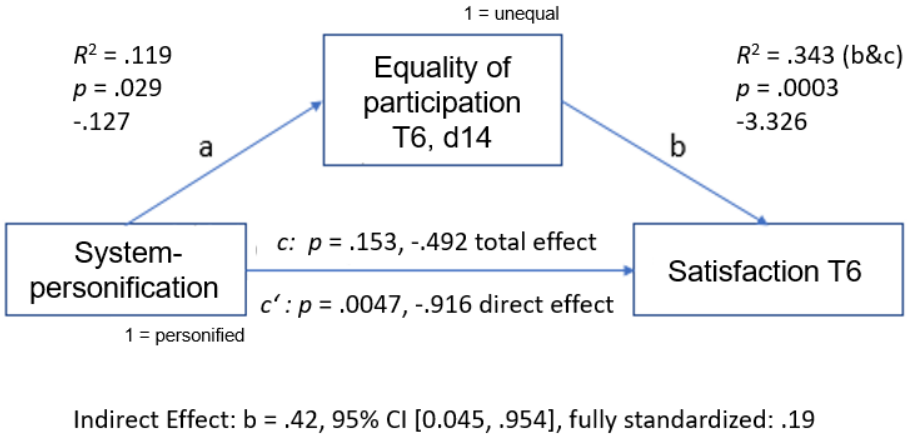


Figure 10. Mediated impact of personification (H4).

Therefore, regarding the last group task, a mediating effect of participation equality on the interaction between system personification and group satisfaction was found. System personification's influence on subjective satisfaction was mediated by the objective user behavior on a group level (i.e. equality of user participation) – the less personification, the more unequal the task participation and dissatisfied the participants, i.e. the more personification, the more equal distributed participation and the more satisfaction. Therefore, H4 is supported.

Long-term effects of personification

To test whether the personification has a negative long-term effect, i.e. whether the interaction with the abstract system differs from the personified one, repeated measure analyses were conducted. Specifically, it was assumed, that the interaction with the abstract system over time facilitates subjective and objective user components (H5, n = 35). Thus several mixed ANOVAs were conducted with a between-subjects factor personification (the experimental groups) and within-subjects variable the repeated measures of interest: assessment of the prompt messages (H5.1), group awareness (H5.2), satisfaction with group work (H5.3), objective behavior (H5.4). These analyses were conducted to compare the effects of repetition during all three tasks. Due to the sample size and its potential risk for the function of the Mauchly's test, Greenhouse-Geisser correction values are reported (for details and all values see Table 7). Additionally, in the over time analysis main between-subject effects will not be reported, due to the main

analysis of personification effects in H2 and H3, which were conducted with larger group sizes and has to be considered instead regarding personification effects.

Table 7

Results of H5 regarding over time effects of personification

	Over time			Personification		Overtime x Personification		
	F	*p*	*r*	*F*	*p*	*F*	*p*	*r*
H5.1 prompt messages								
goodwilling	3.58	**.036**	0.31	0.0	.988	0.03	.966	
motivating	0.43	.651		1.34	.255	1.11	.335	
helpful	0.99	.374		0.23	.638	2.73	.076	
relevant	0.98	.378		0.27	.607	0.74	.479	
noticed prompts	1.77	.180		0.13	.720	0.06	.931	
focused prompts	1.53	.225		0.15	.704	0.14	.845	
H5.2 group awareness								
Transparency of tool	3.83	**.036**	.32	0.0	.947	0.99	.364	
Used by own group	3.91	**.028**	.32	2.77	.105	2.98	.063	
H5.3 Satisfaction with group work								
Satisfaction	0.28	.755		1.40	.246	0.31	.736	
Task interest	0.54	.579		0.11	.744	0.46	.624	
Degree of autonomy	0.59	.557		0.0	.941	0.44	.644	
Group conflict	1.21	.305		0.69	.411	1.97	.149	
H5.4 Objective behavior								
Wiki contribution	1.86	.164		0.85	.361	0.48	.611	
Forum contribution	0.47	.602		0.01	.920	2.14	.130	
Participation equality	1.64	.199		2.31	.136	3.48	**.040**	.20
Login frequency	54.49	**< .001**	.74	1.10	.300	0.95	.389	

First, to test the repetition effects on perception of the prompt messages (H5.1), the repeated measures from the short-questionnaire were added solely, which refer to perceived prompt characteristics, as within-subjects variables. There was a significant over-time effect on the perception of the system as *goodwilling* (M_{T4}= 3.78, M_{T6} = 3.33),

indicating that the system was perceived significantly less goodwilling after the sixth compared to the fourth task. However, there was no significant interaction of goodwilling with the between-subject factor, personification. This indicates that the decreasing goodwilling perception of the system did not differ with or without personification. Non-significant main effects and interactions indicated that users perceived the system unchanged *motivating, helpful* and *relevant* over time and independent of personification. Likewise, the tests with the *number of noticed and specifically focused prompts* did not reveal any significant differences. Therefore H5.1 is not supported.

Regarding the perception of group awareness during the tasks, the following relevant short-questionnaire items were applied as within-subjects variables to test H5.2, i.e. the repetition effects on group awareness depending on personification. Results revealed no significant interactions with personification over time. However, time effects were indicated with regard to the *transparency of the group awareness tool* in terms of how well participants knew, who did what and how much, paired samples t-tests identified a marginal significant decrease over time (M_{T4}= 4.52, M_{T6} = 3.82, p = .069). Likewise, significant over time effects were found regarding the perception, whether the prompts from the system were *used by the own group for optimization* with post hoc comparisons indicating a significant decrease towards the last task (M_{T4} = 2.74, M_{T6} = 2.24, p = .041). Thus, H5.2 is not supported.

To test time effects on satisfaction, i.e. H5.3, another mixed ANOVAs with repeated measures on one factor was computed applying personification as a between-subjects variable and the mean score *satisfaction* (2 items), as well as potentially satisfying characteristics such as *task interest*, *degree of autonomy in tasks*, and *group conflict*. Results revealed no significant effects or interactions over time, thus H5.3 is not supported.

Similarly, regarding behavioral course data over time and the personification in a mixed ANOVA, conducted with the within-subjects variables *contribution amount* (forum and wiki solely) did not show significant long term or interaction effects. However, *login frequency* differed in the repeated measurements. Paired post hoc comparisons indicated highly significant differences between tasks four and five, and task four and six (M_{T4} = 15.90, M_{T5} = 8.45, M_{T6} = 8.51, p < .001), indicating that participants logged in more often during the first task compared to the following tasks, however independent of personification, as the non-significant interaction showed. Finally,

regarding *participation equality*, there was a significant interaction effect between it and the personification, $F(2,88) = 3.48$, $p = .04$, $r = .20$. This indicates that different levels of participation equality across the three tasks differed between groups with the personification and with the abstract system. To break down this interaction, contrasts were performed comparing each equality measurement time to the final one ($equality_{T6}$) across the experimental groups (with and without personification). These revealed significant interactions when comparing the participation equality of participants in the personified and not personified condition in T4 compared to T6, $F(1,44) = 5.69$, $p = .02$, $r = .27$, and to T5 compared to T6, $F(1,44) = 5.05$, $p = .03$, $r = .18$. Looking at the interaction graph (Figure *11*), this suggests that equality across the experimental groups is very similar in T4 and T5, but in the last task, T6, in the personified condition the gini coefficient decreased, i.e. participation got more equal, while in the not personified condition the coefficient increased, i.e. participation got less equal. Therefore, H5.4 is partially opposed to the assumptions of facilitation through the abstract system over time and therefore not supported.

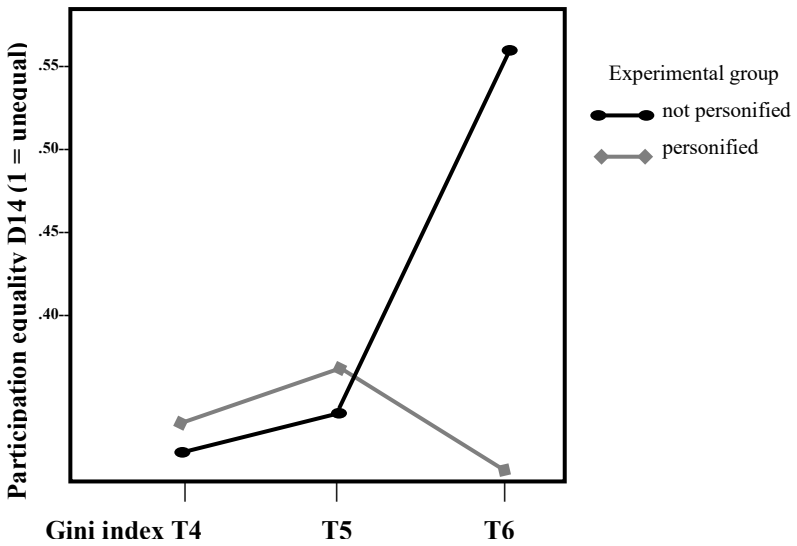


Figure 11. Long-term interaction of personification and participation equality (H5.4).

7.4 **Discussion**

Participation struggles (lack and inequality) are among the main problems faced by online learning groups (Strauß et al., 2018) and yet equivocally related to many crucial factors like performance, dropout rates and satisfaction. Support is needed to prompt students and avoid interpersonal conflicts arising through nudging among group members.

However, undertaken by technology, it should be provided in the best possible way to be motivating and persuasive rather than frustrating. The personification through social cues of the automated system can be promising but revealed ambiguous results so far and needs further examination especially on over-time effects in real groups. For this purpose, a between-subjects field experiment in an online learning platform was conducted, whereas the prompting system was manipulated (abstract vs. static appearance and a name). Within six weeks, both behavioral and survey data were collected.

Hypothesis 1 stated that equality of participation will facilitate the satisfaction with group work. The assumption was supported for the participation equality in the last group task. This is in line with prior research identifying not only the general link between participation and satisfaction (Alavi & Dufner, 2005), but especially focusing on the subdimension equality improving satisfaction. Likewise facilitated satisfaction was also shown through more interaction and consequently more equality (Zmud et al., 2001). Additionally, according to Lancellotti and Boyd (2008), communication among teammates facilitates their collaboration, team effectiveness and teamwork satisfaction. However, active participation can be seen as a precondition for the existence and development of communication. Contrary, unequal participation, can also be an indicator of completely inactive group members, whose occurrence automatically hinders communication and respectively satisfaction.

In hypothesis 2 the positive impact of personification on users' subjective perception of the system (H2.1), of the prompt messages (H2.2) and of satisfaction (H2.3) was assumed. No differences were found regarding human-likeness and learning facilitation (H2.1). Even though non-significant, the abstract system is perceived tendencially as less humanlike, but more learning-facilitating. Likewise, prompt messages did not differ regarding perceived hostility, fairness, and relevance, but those from a personified system were assessed as less persuasive, and non-significantly tended to be less relevant and fair, but more hostile (H2.2). These results affirm and extend the persuasive advantages of an abstract system compared to nudging group members (Stoyanova & Krämer, 2019). Indeed, the design of persuasive technology was already recommended to be best when boring, i.e. as familiar and mundane as possible (Wai & Mortensen, 2007), which cannot be ensured for all, as soon as an appearance is given. The findings are opposed to prior research regarding the beneficial effects of graduating human-likeness (e.g. Burgoon et al., 2016), which, however, mostly includes animation

– barely comparable with static social cues. On the other hand, the results of this study confirm the missing effects of an image added to an agent with a name (Baylor & Ryu, 2003), as the addition of an image did not make a difference regarding person-likeness and instructor-likeness. In the same study, an agent with a name and no image let participants mention fewer things they disliked, according to the recommended undefined agent cues as a beneficial universal solution in order to allow imaginary personalization (Silvervarg, Haake, & Gulz, 2013) and refusing of tutors to prevent overload (Ostrander et al., 2019).

Regarding the overall group work satisfaction (H2.3) at the end of the course, contrary to my assumptions, users in the abstract system condition perceived higher overall satisfaction with group work and the collaboration as more successful. However, as aforementioned, satisfaction potentially depends on various co-factors, objective and subjective, which are investigated in the following hypotheses.

Taken together, as the abstract system improved the persuasiveness and overall satisfaction, this can be interpreted as a confirmation of the media equation theory (Reeves & Nass, 1996) and the CASA principle (Nass & Moon, 2000), which postulate that even minimum social cues are sufficient for technology to induce social responses and for the perception of the entities as human-like.

Hypothesis 3 stated the positive impact of personification on students' behavior regarding login frequency (H3.1), contribution quantity (H3.2) and participation equality (H3.3). Contrary to the assumptions, students did not login more frequently nor contributed more (in forum and wiki), thus H3.1 and H3.2 were not supported. Solely the participation was distributed more equally in the personified condition as assumed, thus H3.3 was supported. This is in line with prior research on GATs, partially showing the potential of a tool as a persuasive mean against problematic behaviors (Miyazoe & Anderson, 2010), where contribution quantity likewise did not, but participation equality differed.

Referring to the link between participation equality and satisfaction (H1 supported), additional related factors are of interest beyond the mere participation-based factors which facilitate interaction. As already identified in a survey, team dynamics, acquaintance and *instructor support* are significant for teamwork satisfaction (Ku et al., 2013). Due to the ambiguous results of personification so far, in hypothesis 4 the relationship of objective and subjective data was focused, stating that the influence of

personification on group work satisfaction will be mediated by the equality of participation. Results revealed the mediation, identifying that personification does not bias satisfaction directly, but only via increased equality of participation which respectively increases satisfaction and, in this case, negatively on the direct path to satisfaction. Although the findings in hypothesis 2 showed that personification was perceived as less persuasive, through equal participation it still seems to predict higher satisfaction with group work. This indicates the significance of equally distributed participation and its powerful influence on other relevant variables, in the case of personification, even despite the direct, generally negative effect on satisfaction. Apparently, compared to the personified system, the abstract system was perceived as more persuasive and the group work as more satisfying. Slightly opposed to it, personification as a solely negative predictor of satisfaction, however, turn to a positive predictor of satisfaction through equal participation. This demonstrates repeatedly the importance of this behavioral dimension on a group level and the need for further investigations in order to find techniques to improve it continuously.

Regarding the long-term effects of personification, hypothesis 5 stated the abstract system to facilitate subjective assessment and objective behavior. Independent of the personification condition over time, the system was perceived as less goodwilling, less transparent regarding others' participation and less applied for optimization in the own group. Additionally, login frequency was lower in the following two tasks compared to the first one. However, over time, the personified and abstract experimental groups differed regarding the participation equality, identifying controversial development in the last task. The participation was more equal in the personified condition and more unequal in the abstract condition. These findings are opposed to my assumptions according to potential attrition of the effects and expectancy violations of virtual agents (Burgoon et al., 2016). A less human-like agent did not show any facilitation over time, although it was assumed that it may provoke less expectations and respectively violate them less negatively over time. Keeping the media equation theory in mind (Reeves & Nass, 1996), which postulates that even minimum social cues elicit social responses to computers, the simple abstract system may be perceived already as human-like due to the human-like prompting function. This way expectations of various prompt content and violations over time due to the contrary monotonous prompt-content can arise, finally being less motivating to participate constantly over time.

Limitations

Several limitations of this study have to be acknowledged regarding the generalizability of the results. Since the topic refers to online learning, it is appropriate that the participants are merely students and of the same age. However, due to the particular course and topics, results are not broadly generalizable as results from courses in various realms and organizations could be. The long-term measurements were within three group tasks instead of the whole course, a longer period could be beneficial especially to better prevent dropout. Additionally, an unavoidable limitation was the small sample size, which underpowered the statistical tests. Educational field experiments are typically facing such challenges and still delivering authentic behavioral data, which makes them worthwhile. Large sample sizes within MOOCs can be a solution in the future. Regarding the dependent variables, it needs to be taken into account that the equality of participation is a variable on the group-level, calculated equally for each member of the same group and it also refers to a certain day of the task. However, the small sample size allows neither multilevel analysis nor a control group for study, and both should be considered next.

Conclusions

This study provides novel long-term insights from real online learning groups, their objective behavior and subjective assessment of a prompting system – abstract vs. personified (static appearance and name). Equality of participation generally predicts higher satisfaction with group work and mediates the influence of personification on satisfaction, from negative on the direct path to positive through participation equality. However, the abstract and not the personified system facilitates the assessment of prompt persuasiveness, collaboration satisfaction and perceived collaboration success. These results affirm the media equation theory (Reeves & Nass, 1996) and extend the advantages of abstract prompting systems (Stoyanova & Krämer, 2019). Regarding behavior in the course, participation was more equally distributed with the personified system. Additionally, in the long term, equality of participation develops differently depending on the personification. In the last task, in the personified condition, participation is more equally distributed and less equally in the non-personified condition. Summarized, an abstract system may be even more persuasive than a personified one. However, personification is beneficial for the equal distribution of participation equality. Moreover, mediated through it, personification also increases the satisfaction with group

work. Having indicated the powerful potential of the equality of participation, further investigations are needed on this, so far disregarded dimension of participation.

8 Study 3: Carrot-and-stick procedure without carrots: vicarious punishment prompts and system transparency in e-learning groups

8.1 Objective, research questions, and hypotheses

Considering the overarching aim of this dissertation to improve collaboration of online learning groups through prompting, first two studies paved the basic directions for the third experiment – the advantages of an automated prompting system compared to human nudging sources; the mixed but predominantly negative influence of the system's visual personification and the significant influence of participation equality towards students' satisfaction with group work. Moreover, Study 2 barely revealed an influence on students' behavior in the course although complains and dissatisfaction were further reported by the students. Therefore, the focus was redirected to more explicit nudging means in order to obtain behavioral changes. Both the inactive members and the negative consequences for them were neglected so far in this dissertation but they might have a reassuring and rewarding effect for the actively contributing group members. Thus, solutions in this direction are considered for the third study.

With regard to the characteristics of automated prompting entities, according to the CASA principle the application of conventional human-like roles also serves as further personification and social cue (Nass & Moon, 2000). Respectively, the communication manner as a key behavioral aspect and its severity can be modified instead of the whole behavior of the system. To this end, in order to combat participation issues, the demonstration of negative consequences for others, i.e. the application of vicarious punishment (see section 4.1.2) can be promising as a severe means to increase observers' contribution. However, vicarious punishment was shown beneficial in offline settings, but it was barely examined in online learning and not provided by an automated system (Malouff et al., 2009 and section 4.1.2). Hence, the communication manner of an abstract prompting system is explored in terms of system's severity via vicarious punishment.

Furthermore, users' knowledge about the system in terms of transparency might legitimize the severe system and minimize its hostile perception. Therefore, this concept is elaborated next and considered in Study 3 in order to shed light on the question, how severe an automated system is allowed to communicate, and which additional characteristics play a role for users' system perception.

8.1.1 **Transparency**

Detailed information about the system's functionality will be addressed as system transparency. Users' knowledge about algorithms, i.e. the way a system actually functions, could induce positive or negative attitudes toward it (Kizilcec, 2016). A simple common example of daily algorithms are those in social networking sites, for instance, the facebook news feed used by millions. Many users are unaware of it (Eslami et al., 2015) and develop personal beliefs (Rader & Gray, 2015). The so-called mental models of how the system works are based on analogues of the physical world (Payne, 2003) and do not correspond to the real algorithms or how the system really functions. Better understanding of systems' algorithms could increase trust in the system (DeVito, Gergle, & Birnholtz, 2017).

In research literature transparency has already been shown as beneficial in the specific case of recommender systems – by increasing confidence and liking (Sinha & Swearingen, 2002). However, another study regarding a financial advisory system does not show positive effects of revealing the system's functionality, which is interpreted as an effect of disappointed expectations (Nussbaumer & Matter, 2011). Further, in the realm of human-robot interaction, within a group task, when the delivery robot was more transparent, less blame and credit was attributed to other teammates, however, transparency did not affect credit or blame to the robot (Kim & Hinds, 2006). Another study regarding trust and transparency recommended balanced interface transparency – neither too little, nor too much (Kizilcec, 2016). Individuals whose expectations were violated (by receiving a lower grade than expected) trusted the peer assessment system less, unless the grading algorithm was made more transparent. However, too much information eroded this trust and attitudes did not vary with transparency, when expectations were met.

So far it was discussed that personification is possible with simple characteristics, especially through appearance and communication manner of the system. Although

research result on this topic is ambiguous, personification can be helpful and facilitate the support delivering system, and certain characteristics like transparency could replace system's proficiency, signal expertise and credibility, and finally enhance system's legitimacy to even handle more severe and highlight inactive teammates. However, the addition of specific social cues to an automated support entity bears also some risks to violate users' expectations, which will be described in the next section.

Thus, in Study 3, the conventional human-like role of a severe communicating tutor highlighting the negative consequences of inactivity for single group members is considered as a personification factor (Nass & Moon, 2000). The manner of communication of the automated system could be a promising, entity-related characteristic especially with reinforced severity and transparency, in order to modify to some extent system's behavior in order to explore the beneficial severity level of the nudging system towards a stronger impact on students' participation and satisfaction with group work.

8.1.2 **Hypotheses**

Based on the theories and findings so far regarding participation issues and satisfaction as well as regarding the findings of the second study, the participation equality is assumed further as a predictor of satisfaction with group work and a precondition for any further interactions. Hence, the assumption is met:

H1: The higher equality of user participation increases satisfaction with group work.

Furthermore, as elaborated earlier in section 4.1.2 and in the brief overview of this chapter (section 8.1), in terms of vicarious punishment beneficial effects on the activity and contribution are assumed, as a result of the observation of public criticism from the system against other inactive group members. Thus, it is hypothesized:

H2: Vicarious punishment has a positive impact on the subjective user perception of inactive teammates (2.1), group awareness (2.2) and satisfaction with group work (2.3), as well as on the objective user behavior such as login frequency (2.4), contribution quantity in forum (2.5) and wiki (2.6), and equality of participation (2.7).

H3: Vicarious punishment has a negative impact on the subjective user perception of the system (3.1) and the prompt messages (3.2).

Based on the contradicting results regarding the system transparency (section 8.1.2), in an explorative approach its effects are investigated by formulating the research questions:

RQ1: What influence does transparency have on the subjective user perception of the system (1.1), and the prompt messages (1.2), group awareness (1.3) and satisfaction with teamwork (1.4)?

RQ2: What influence does transparency have on the objective user behavior?

E-learning is mostly conducted in the long term, i.e. within a longer period of time instead of a single lesson. Interacting with the prompting system repeatedly can influence the perception of the system in various ways. Potential repetition effects could weaken or strengthen the effects of vicarious punishment and transparency. Thus, the development over time is of additional interest:

RQ3: Is there a difference between first and second group task regarding stress, fear, tendency to imitate inactive teammates, and equality of participation depending on vicarious punishment and transparency?

Additionally, based on inconsistent results within research on transparency and on the research gap regarding vicarious punishment in e-learning groups, it is necessary and important to examine the influence of subjective variables like system and prompts' perception (objectivity, faultiness, comprehensiveness, etc.), as well as perceived in-group variables (stress, conflict, trust) on satisfaction, fear and, lastly but importantly, on behavioral outcomes (contribution amount, login frequency). Thus, the research questions are stated:

RQ4.1: What relevant factors influence users' objective behavior? Is there a correlation between fear, login frequency and contribution?

RQ4.2: What relevant factors influence users' subjective in-group experiences? Is there a correlation between the perception of the prompts with the perception of conflict and in-group trust?

RQ4.3: What relevant factors influence users' subjective perception of satisfaction and fear? Is there a correlation between satisfaction, the tendency to imitate inactivity and fear?

Further, it would be interesting to examine whether vicarious punishment could predict the contribution amount, as it influenced productivity in offline experiments (Malouff et al., 2009), and whether it depends on the perceived fear. The fear to get

publicly criticized might increase the motivation to log in more frequently or, vice versa, the fear to get criticized might lead to rare login actions to avoid the criticizing. On the other hand, the more frequent login might result in more contributions in forum and wiki. These thoughts lead to the following research question:

RQ5: Will vicarious punishment increase the fear and login frequency, resulting in more total contribution?

8.2 **Method**

The study was conducted at a German university in the winter semester of 2019/2020 within an online course addressing the psychological basics of computer-mediated communication. The course was implemented in the online learning environment Moodle and comprised six topic blocks combined with group tasks. The course materials included a video as a topic introduction as well as basic literature and short optional quizzes. Each group task had to be completed in small groups of three to five students within 14 days. The course participants were randomly assigned to groups at the beginning of each topic block, so that always new teammate constellations were assured. This way habituation effects in the groups were avoided and new coordination as well as exchange processes were stimulated. The teams had their own group forum and a wiki as a text production tool in order to coordinate and develop the group contribution.

8.2.1 **Field experimental design and procedure**

The present study was placed in the first half of the course, over a period of two topic blocks (4 weeks in total). The field study employed a 2(x2) experimental between-subjects design. Vicarious punishment and system transparency were varied as independent variables. The design is not fully crossed as system transparency was only varied in the vicarious punishment conditions.

A group awareness tool visualized the quantity of forum and wiki contributions within the team in a bar graph. The system signaled when a teammate has not been participating actively by displaying prompt messages on a group level regarding the potential for improvement and coordination hints. In the vicarious punishment condition, inactive teammates (confederates) were addressed by name. A pre-test was used to evaluate potential formulations (N_{pretest} = 40) and choose neither unfavorable nor extremely severe ones.

In order to apply vicarious punishment, profiles of confederate course participants were generated, left inactive and assigned to each group. From the participants' point of view, the confederate profiles did not differ from the others. Teamwork was assessed as passed or failed on a group level and did not influence the individual course grade, so that the confederates' inactivity was not a disadvantage for the real course participants. Severe vicarious punishment was varied by publicly criticizing an inactive confederate teammate (vicarious punishment condition) (Figure 12). Criticizing was placed in the prompting message from the system in the group awareness tool. The prompting message occurred on the fourth day and was kept visible until the end of the task in a team tool on the platform.

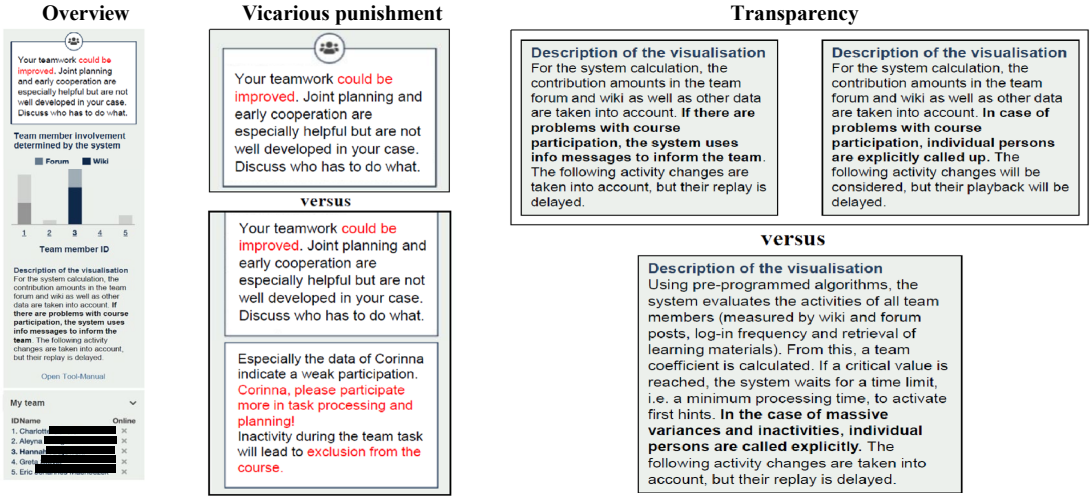


Figure 12. Left to right: Group awareness tool overview, varying vicarious punishment and transparency in the conditions.

Additionally, the system transparency was varied by informing the participants in advance more or less detailed about the system's functionality (high vs. low transparency condition). At the beginning of the first topic block, a more or less detailed briefing about the functionality of the system was sent per e-mail and applied on the platform as an obligatory pop-up text and as a visible short version within the tool (Figure 12). In the high transparency condition, it included a list of all possible sources for the inactivity calculation and an explanation of the thresholds before activity changes are displayed. The transparency manipulation was only applied within the vicarious punishment condition.

The independence of the accompanying research and the course was clearly communicated. Written informed consent was obtained by the course participants, who

agreed to participate in the accompanying research voluntarily. Participation could have been cancelled any time without justification or consequences for the further running course.

With their consent to attend, the participants agreed to the storage of their objective data like Moodle activities and subjective data from the online surveys. These were due before the start of the course and after each two-week teamwork. The course activities were stored as log files. As an incentive for the continuous participation in the accompanying research, participants who filled all surveys were awarded a postpaid incentive of 10 Euro and 2x50 Euro were raffled. The procedure of the study was approved by the ethics committee of the university.

8.2.2 **Sample**

In total, 107 university students registered at the beginning of the course and 97 retained after the first week. Eighty-one (82.5%) of them agreed to participate in the accompanying research. For the first topic block with a team task, a total of 72 participants were randomly assigned to one of the three conditions (n = 24) and to teams, including four teammates and an inactive confederate. This way, six teams per condition were assigned. Due to high course drop-out rates (31%), a total of 67 students retained in the second topic block of the course, of whom 57 study participants were assigned to the experimental conditions ($n_{\text{no vicarious pun.}}$ = 19, $n_{\text{vicarious pun.}}$ = 21, $n_{\text{vicarious pun. transparent}}$ = 17). The log file data of all 81 study participants were stored ($n_{\text{log files}}$ = 81). Most of them completed the pre-survey before teamwork ($n_{\text{pre-survey}}$ = 80, 51 females, $M_{\text{age pre-survey}}$ = 23.47, SD = 3.11). Additionally, the same survey needed to be completed twice - after each teamwork block every two weeks, so that irregular participation was identified ($n_{\text{survey-t1}}$ = 52, $n_{\text{survey-t2}}$ = 44) and in sum 42 participants completed all three surveys (N = 42, 28 females; $n_{\text{no vicarious pun.}}$ = 15, $n_{\text{vicarious pun.}}$ = 14, $n_{\text{vicarious pun. transparent}}$ = 13). Data from drop-out students was used partly, depending on the short-survey they completed.

All participants were students, mostly of the Human sciences (42%), Engineering sciences (20%), Communication and Media (15%) or Economics (14%). They identified flexibility (M = 4.55, SD = 0.75, 1-5) and interest for the topic (M = 4.13, SD = .90, 1-5) as the most important reasons to choose this course. On average, participants had a neutral attitude towards online teamwork participation (M = 3.22, SD = 0.60, 1-5) and neither negative nor positive prior experiences with group work (M = 48.91, SD = 24.20, 1-100).

8.2.3 **Measures**

The systematic field setting guaranteed access to objective behavioral data and subjective data (assessed in online surveys after each group task). Students' behaviors on the platform (click behavior, frequency of logins, quantity of contributions in forum and wiki, and the level of equality of participation) were logged as objective measures. The system could log the quantity, but not the quality of the behaviors. There is no information about how students processed materials or proceeded after accessing the platform and the materials. Log files were stored per topic, ordered by time and assigned to the platform ID of each participant, which were also transmitted to the online surveys. This method provided the opportunity to relate self-reported data and log files.

In the first, "pre-survey" that was administered at the beginning of the four weeks, students were asked about socio-demographic parameters (*age*, *sex*, *study program*). *Course-related characteristics* and their relevance for choosing this course were asked employing a 5-point Likert scale (1 to 5 = strongly agree, 9 items, e.g. "as a personal challenge"). Additionally, I assessed *topic knowledge* and *enjoyment of group work* on a 5-point Likert scale (1 to 5 = a lot), as well as number of participation in Moodle courses and in online courses with group work (both input fields), *previous experiences with online courses* and with *Moodle* (slider 1 to 100 = highly positive). Additionally, personality traits with the short version of the big-five, goal orientation (other-approach, other-avoidance), self-efficacy, social comparison, innovativeness, social comparison orientation, schadenfreude, resignation and competitive learning attitude were measured, which are not relevant for the analyses presented here.

After each of the two group tasks, a questionnaire with 39 items was employed (for an overview of detailed example items, reliability and descriptive statistics of all dependent variables, see Table 8). Primarily, the frequency of *noticed system prompts*, a recall of their *content* and the *consequences of inactivity* were asked as a manipulation check. Input fields were applied for these and for a final item regarding personal reactions and means in case of inactivity to foster collaboration. The rest of the questionnaire employed a 5-point Likert scale (1 to 5 = strongly agree). I assessed the *system perception* and *prompt message perception*. For the factor analysis of prompt perception, means of both measurement times per item were applied. The recommended three-factorial solution was applied with *objective, motivating, hostile*. Regarding collaboration, the *stressfulness* of the last teamwork, *satisfaction* with group work, *in-group trust*, *group conflict*, *stressful*

coordination and *perception of inactive team members* were assessed. I also measured *group awareness*, as well as an additional item on potentially varying task characteristics – *degree of freedom* during task processing. Questionnaires are available in an open science platform (see link* below the references).

Table 8
Measures with example items, reliability and descriptive statistics

Variable	Item example	Items in total	α	Total	
				M_{t1}	SD_{t1}
System					
Fact-based character	Participation graph and prompts corresponded to reality	1		3.78	1.05
Emphasis calming	I'm reassured that action is taken against inactive members	1		3.62	1.26
Commiseration	I feel pity when a person is flagged as inactive	1		2.42	1.23
Fear of emphasis	I'm afraid I might get emphasized soon too	1		2.33	1.04
Prompts					
Noticed prompts	How often did you notice system hints system last 14 days	1		5.09	3.80
Objective	faulty(r), objective, comprehensible, appropriate	4	.90	3.83	0.69
Motivating	constructive, helpful, motivating, reassuring	4	.80	3.28	0.70
Hostile	hostile, humiliating, threatening	3	.79	2.19	0.83
Collaboration					
Stress	How stressful was your teamwork in the last 14 days	2	.59	3.17	1.15
Satisfaction	Overall I'm satisfied with teamwork in the last 14 days	2	.87	2.76	1.09
In-group trust	I trusted my teammates to work on our task	1		3.02	1.10

Conflict	There was much tension among the members of our team	1	2.10	0.98
Coordination stress	Task division and workflows were not clear and precise	1	3.25	1.23
Inactive members				
Existence and presence	I was very aware that there were inactive team members	1	4.24	1.12
Disliked peers	Such teammates are unpleasant co-workers	1	3.73	1.17
Disliked compensation	It was annoying to compensate for what others didn't do	1	3.31	1.19
Imitation tendency	When I see others' inactivity, I feel like quitting work too	1	2.57	1.25
Awareness				
Hints used to optimize	We as a team used the prompts to change our collaboration	1	2.18	1.11
Others helpful	My teammates contributed to a successful task completion	1	3.39	1.17
Others' observability	I was able to estimate who contributed how much or little	1	4.04	1.00
Observability gainful	Its good that everyone can see who contributes how much	1	3.94	1.04
Freedom during task	I could work the way I wanted to during task processing	1	3.29	1.15
Behavior				
Login frequency	Total login times with minimum		13.30	9.33
Contribution Forum	Word count of forum contributions per topic block		173	200
Contribution Wiki	Word count of wiki contributions per topic block		277	272
Participation Equality	Gini coefficient, 0 = perfectly equal participation		0.74	0.14

8.3 **Results**

To test the hypothesis H1, a linear regression (n = 41) was conducted using the index of equality of user participation in the final group task (day 12 of the second teamwork) as the predictor and satisfaction with the group work in this task as the outcome variable. Results revealed a statistically significant relationship between the factor equality of participation and group task satisfaction. A significant regression equation was found F (1,40) = 12.30, p = .001, with an R^2 of .235. A strong negative correlation could be detected (b = -.49, SE = 1.05, p = .001). However, the regression analysis was not significant regarding the first teamwork block. Equality of participation (0 = perfectly equal) increased the participants' satisfaction in the second task. Hypothesis H1 is partly supported.

To test the hypotheses H2 and H3, multivariate analyses of variance (MANOVA) were computed with the vicarious punishment as a fixed factor and the corresponding dependent variables (see Table 9).

Regarding H2, vicarious punishment had no significant effects on the subjective user perception *of inactive teammates* (2.1) *and satisfaction with group work* (2.3), but it influenced, contradicting to my assumption, the *observability of others' contribution* (2.2) negatively (for an overview see *Figure 13*). This means that *group awareness* was higher in the condition without vicarious punishment. Regarding objective user behavior, vicarious punishment had no significant effects on *login frequency* (2.4), *contribution quantity in forum* (2.5) *and wiki* (2.6). However, it influenced *equality of participation* (2.7), differently than hypothesized, as the participation was more equal in the condition without vicarious punishment (Table 9 and Figure 14). Thus, H2.1, H2.3, H2.4, H2.5, H2.6 are not supported, while H2.2 and H2.7 yielded significant differences between vicarious punishment conditions, which are contrary to my assumptions.

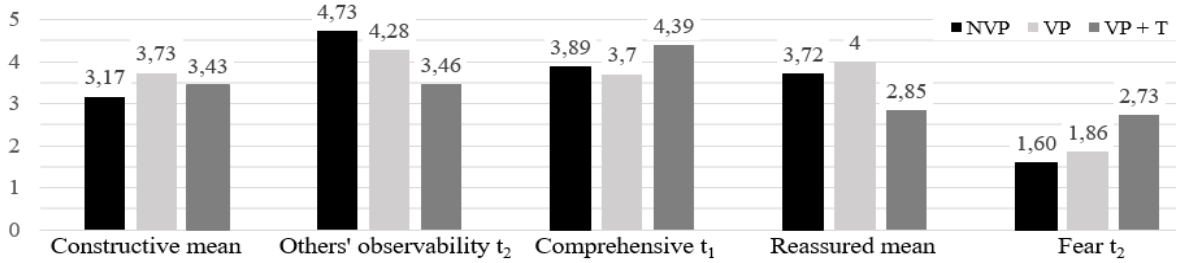


Figure 13. Differences between conditions vicarious punishment (VP), transparency (VP + T) and none (NVP).

Regarding H3 and the perception of the system and the prompting messages, vicarious punishment had no effect on the *perception of the system* (3.1), but, contrary to my assumption, had a significant positive effect on *the perception of the prompt messages* (3.2) – i.e., they were perceived as more constructive in the vicarious punishment condition (Table 9 & *Figure 13*). Thus, H3.1 and H3.2 are not supported, whereby H3.2 showed positive instead of negative effects of vicarious punishment on the perceived constructiveness of the prompt messages.

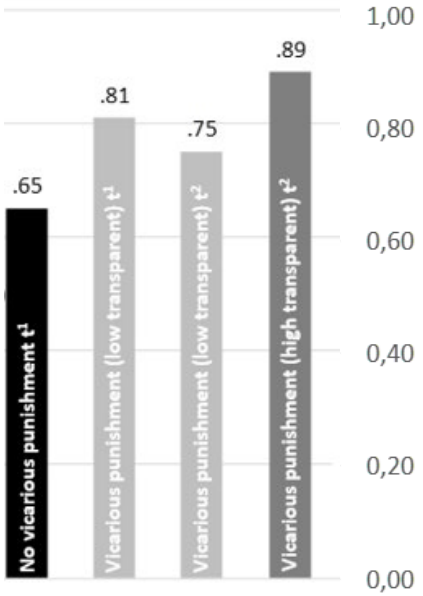


Figure 14. Differences regarding the equality of participation within the first and second group task.

Further MANOVA analyses were computed to explore research questions RQ1 and RQ2, with transparency of the system (transparency) as a fixed factor and as the corresponding dependent variables (Table 9). Regarding RQ1, transparency had no significant effects on the *satisfaction with teamwork* (RQ1.4). However, there were significant effects on the perception of *the system* (RQ1.1), *the prompt messages* (RQ1.2), *and the group awareness* (RQ1.3). When participants knew more about the functionality of the system, i.e. in the high transparency condition, they perceived it less *reassuring that action is taken* against inactive members and they were more *afraid to get publicly criticized*, too (*Figure 13*). In this condition with high transparency participants perceived the *prompt messages* as more *comprehensive* (*Figure 13*) but reported to have noticed a lower number of prompt messages. However, transparency showed a negative effect on

Table 9
Results of the hypotheses (H2 and H3) and research questions (RQ1, RQ2, RQ3)

Variable	Vicarious Punishment (H2, H3)				VP + Transparency (RQ1, RQ2)				Long term (RQ3)		
	$F^{(df1,df2)}$	p	η	$M_{\text{none / one}}$	$F^{(df1,df2)}$	p	η	$M_{\text{low / high}}$	$F^{(df1,df2)}$	p	η
constructive mean	$5.25^{(1,36)}$	.028	.13	3.17 / 3.73							
equal participation d_{12}, t_1	$22.69^{(1,46)}$	<.001	.33	.645 / .807							
others' observability t_2	$5.03^{(1,27)}$	.033	.16	4.73 / 4.28	$5.08^{(1,26)}$	.033	.16	4.28 / 3.46			
comprehensive t_1, 1 item					$7.49^{(1,31)}$	.01	.20	3.70 / 4.39			
reassured mean					$7.51^{(1,33)}$	.01	.19	4.00 / 2.85			
hints noticed t_2					$6.09^{(1,26)}$	.021	.19	5.64 / 3.29			
equal participation d_{12}, t_2					$15.21^{(1,37)}$	<.001	.29	.747 / .898			
fear t_2					$7.11^{(1,26)}$	.013	.22	1.86 / 2.73			
transparency x fear t_1 ⇨ t_2									$6.32^{(1,24)}$	.019	.21
transparency x inactive imitation t_1 ⇨ t_2									$4.25^{(1,24)}$	.05	.15
transparency x stress t_1 ⇨ t_2									$3.29^{(1,24)}$	.082	.12
transparency x equal participation d_{12} t_1 ⇨ t_2									$14.11^{(1,37)}$	.001	.28
vicarious punishment x equal participation d12 t_1 ⇨ t_2									$21.78^{(1,38)}$	.001	.36
vicarious punishment x stress t_1 ⇨ t_2									$4.73^{(1,27)}$	.039	.15

Note. $t_{1 \text{ or } 2}$ = after 1st or 2nd teamtask; mean = mean across t_1 and t_2; d_{12} = day 12 of 14 in a teamtask; VP = Vicarious Punishment.

group awareness as *observability of others*' participation was lower (Table 9). Regarding *influence of transparency on users' behavior* (RQ2), there was a significant negative effect on equality of participation – it was less equal in the high transparent condition as shown in Figure 14.

To explore *differences between first and second group task depending on vicarious punishment and transparency* (RQ3), two-factorial repeated measures ANOVAs were conducted with repeated measure on one factor to compare the effects of task participation repetition for each dependent variable among conditions (as a non-repeated between-subject factor). Due to the sample size and its potential risk for the function of the Mauchly's test, multivariate tests are reported. Main differences between the conditions have been reported in the prior result section and are disregarded with the smaller sample of the repeated measure analysis.

Transparency showed a significant difference over time (first vs. second teamwork) on stress, fear to also get publicly criticized and the tendency to imitate inactive teammates, as well as on equality of participation. When people knew more about the functioning of the system, participants' stress was higher in the first task and lower in the second task, while in the condition where they knew less, stress was lower in the first group work but higher during the second group work. Similarly, fear to get criticized was higher in the second group task in the transparency condition, while it was lower in the second group task compared to the first group task in the non-transparent condition. However, reported tendency to imitate the behavior of the inactive teammates was lower in the first task and increased when knowing more about the system, while in the low transparency condition, imitation tendency was lower in the second task (see Table 9 & Figure 15).

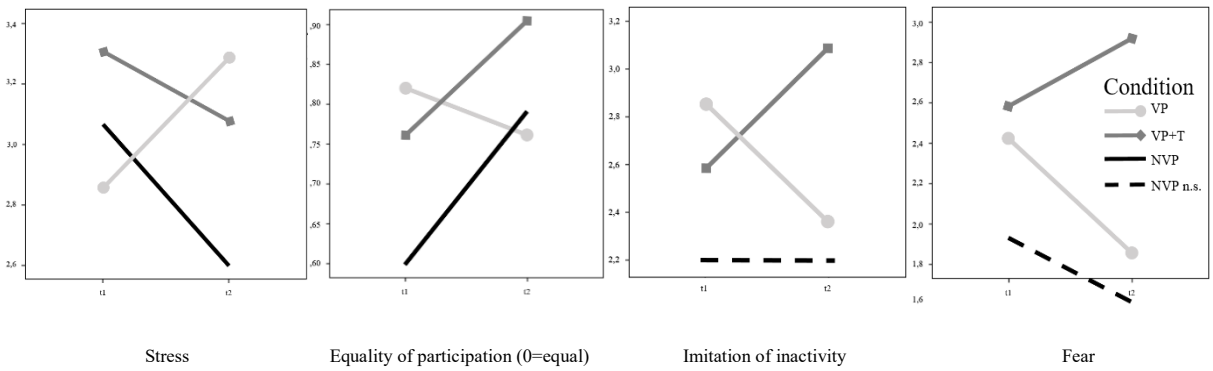


Figure 15. Effects over time (after first/second teamwork): vicarious punishment (VP), transparency (VPT) or none (NVP).

Vicarious punishment showed a significantly different impact over time on stress and a marginally significant effect on perceived objectivity of the prompt messages (see Table 9 & Figure 15). Without vicarious punishment participants' stress was already low after the first task but was even lower after the second task, while in the condition with vicarious punishment, stress was initially lower and increasing over time.

Both transparency and vicarious punishment showed a significantly different impact on equality of participation over time (see Table 9 & Figure 15). Two days before the deadline, participation was getting more equal over time (first vs. second topic block) in the vicarious punishment condition, while without it, it was getting less equal. Regarding transparency, equality of participation increased over time in the low transparent condition, but it decreased in the high transparent condition.

In order to examine potentially influencing factors of users' objective behavior (RQ4), Pearson correlations with the mean values among the first and the second task were conducted. I analyzed the relationship of subjective data perception of prompts and inner group stress, conflict, and trust, on satisfaction, fear and, lastly yet importantly, on the objective behavior such as forum and wiki contribution amount, and login frequency. Results show several significant relationships among them.

Regarding user's behavior (RQ4.1), for instance, login frequency correlates significantly negatively with fear but positively with both kinds of contributions – in forum and wiki, indicating a link between more frequent logins, more contribution and less fear. Furthermore, for the contribution in forum and wiki a significant negative correlation was found with hostility of prompts. Thus, there is a link between the higher amount of contribution and the perception of prompts as less hostile (see Table 10 for an overview of the values). For research question 4.1 it can be concluded that higher login frequency relates to higher amount of contribution and less fear.

Regarding subjective data (RQ4.2 and 4.3), several relevant factors were found. Fear correlates negatively with the perceived objectivity of prompts, but positively with their faultiness ($p = .054$, marginally significant) (Table 10), indicating a link between higher fear to get publicly criticized and the perception of prompts as less objective and more faulty. Perceived in-group conflict also correlates significantly positively with the perception of prompts faultiness, i.e. the faultier the prompts, the more conflict was perceived. Satisfaction with teamwork correlates significantly positively with others' helpful contribution and negatively with coordination stress, in-group conflict and the

perception of inactive members as disliked peers, disliked compensation of their inactivity and the tendency to imitate them. This indicates a relationship between higher satisfaction with teamwork and more helpful teammates' contributions, as well as relationships between lower satisfaction and conflict, coordination stress, disliked inactive members, the compensation of their inactivity and lower tendency to imitate inactivity. Similarly, in-group trust correlates significantly positively with satisfaction and helpful contributions of other teammates, but significantly negatively with coordination stress and disliking of inactive teammates. The tendency to imitate inactivity correlates significantly positively with faultiness of prompts but negatively with the objectiveness of prompts (see Table 10).

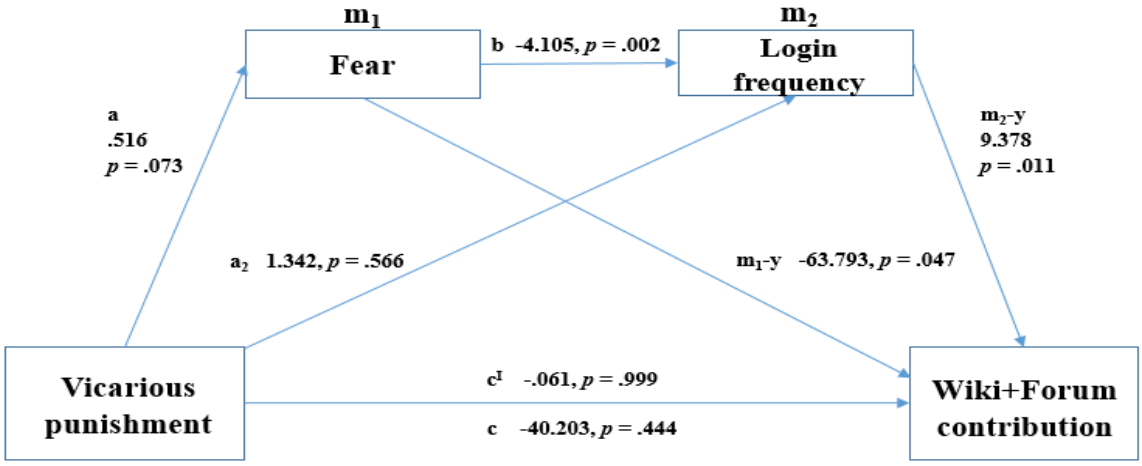
Thus, regarding subjective in-group experiences (RQ4.2), it can be concluded that the perception of prompts as faultier and less objective relates to the perception of more fear to get publicly criticized. Higher prompts' faultiness is also linked to higher conflict perception. In conclusion regarding perceived fear and satisfaction (RQ4.3), the higher tendency to imitate inactive teammates relates to prompts' higher faultiness and lower objectivity. The higher imitation tendency is also linked to lower satisfaction and more fear. Higher perceived fear relates additionally to less observability of others' contributions, less disliking of inactive teammates and the compensation of their inactivity.

Table 10
Bivariate Pearson's correlations among potentially relevant subjective data and objective behavior

	Faultiness	Satisfaction	In-group trust	Objective prompts	Fear	Login	Forum+Wiki contribution
Faultiness	1		-.038	-.856**	.264	-.133	-.106
Satisfaction	.029	1	.665**	.041	.139	-.048	-.179
Fact-based	-.569**	-.091	.019	.505**	-.151	.154	.187
Others' observability	-.500**	-.024	-.002	.484**	-.425**	.163	.120
Conflict	.384**	-.287*	-.294*	-.307*	.083	-.061	-.109
Disliked peers	.018	-.517**	-.356**	.032	-.280*	.251	.103
Disliked compensation	.032	-.521**	-.359**	.098	-.330*	.238	.066
Imitation tendency	.444**	-.394**	-.195	-.489**	.360**	.006	-.206
Others helpful	-.147	.603**	.577**	.113	.018	.068	.117
Coordination Stress	.026	-.526**	-.335*	-.023	-.132	.127	.271
Motivating prompts	-.276*	.163	.160	.523**	-.197	.175	.077
Hostile prompts	.446**	-.200	-.116	-.553**	.248	-.126	-.344*
Fear	.264	.139	.074	-.300*	1		
Login frequency	-.133	-.048	-.026	.125	-.363**	1	
Forum+Wiki contribut.	-.106	-.179	-.044	.259	-.430**	.563**	1

Note. * $p < .05$ (2-tailed); ** $p < .01$ (2-tailed)

Regarding *the prediction of contribution amount through vicarious punishment* (RQ5), fear and login frequency were explored as potential mediators. It was of additional interest whether fear predicts login frequency or vice versa, and whether their perception mediates the effect of vicarious punishment on the amount of contribution. To address this question a double mediation analysis using PROCESS macro for SPSS (see, for example, Hayes, 2018) was conducted, applying the mean values among both tasks (see Figure 16).



t(34) = 1.85, $p = .073$, $R^2 = .093$, $p = .073$
t(33) = .58, $p = .566$, $R^2 = .267$, $p = .003$; t(33) = -3.31, $p = .002$
t(32) = -.001, $p = .999$, $R^2 = .448$, $p < .001$; t(32) = -2.07, $p = .047$; t(32) = 2.72, $p = .011$
t(34) = -.77, $p = .444$, $R^2 = .018$, $p < .444$
Indirect effect X on Y:
Total: LLCI -120.03 ULCI = 28.70
Ind (1): x → m1 → y: LLCI = -100.78, ULCI = .411, Effect: -32.88
Ind (2): x → m1 → m2 → y: LLCI = -45.94, ULCI = 1.62, Effect: -19.85
Ind (3): x → m2 → y: LLCI = -29.47, ULCI = 55.52, Effect: 12.59

Figure 16. Double mediation model of vicarious punishment predicting contribution, fear and login frequency (RQ5).

The model, which included fear followed by login frequency, revealed that vicarious punishment was a marginal significant predictor of fear, $b = .52$, $SE = .28$, $p < .073$, but not of login frequency, $b = 1.34$, $SE = 2.31$, $p = .566$. Further, fear was a statistically significant predictor of contribution, $b = -63.79$, $SE = 30.88$, $p = .047$ and of login frequency, $b = -4.11$, $SE = 1.24$, $p = .002$. Additionally, login frequency was a predictor of contribution, $b = 9.38$, $SE = 3.45$, $p = .011$. Results showed that vicarious punishment was not a significant predictor of contribution with both mediators, $b = -.06$, $SE = 42.70$, $p = .999$ and without them, $b = -40.20$, $SE = 51.94$, $p = .442$, and the indirect effect was not significant (LLCI = -120.33, ULCI = 28.70, Effect: -40.14). The double mediation model and detailed values can be seen in Figure 16.

8.4 **Discussion**

In this study, the focus was on vicarious punishment and transparency of the system in online learning groups, improvement of users' behavior and perception of system, prompts and teamwork. The combined behavioral and survey data in a field experiment indicated equality of participation to predict teamwork satisfaction. Vicarious punishment increased constructiveness of the prompts, but decreased observability of others, i.e. how well students were able to estimate who participated how much. Participation equality was partly affected but no effect on the amount emerged, which is in contrast to earlier findings detecting higher productivity after offline vicarious punishment (Schnake, 1987). With system transparency, prompts were more comprehensive but noticed less frequently, while participants were more afraid to get criticized themselves, found action against inactive teammates less reassuring and others' contribution less observable. Over time (first vs. second teamwork) participation was getting rather more equal with vicarious punishment, but less equally distributed without it, and even more unequal with transparency. Over time stress increased only with vicarious punishment, while it decreased with a transparent system or without punishment. Transparency increased the fear to get criticized over time but also the tendency to imitate inactivity, while both decreased without transparency. These results are partly in line with the recommendations for balanced transparency of the system (Kizilcec, 2016).

Vicarious punishment showed some beneficial long term effects and will need to be investigated in large settings since the sample in this study had to combat high drop-out rates. Partly, the effects might be related to the transparency paradox (Bernstein, 2012), which was not a subject of interest in this study. According to the transparency paradox, observability counterintuitively reduced workers' performance, possibly because it motivated to hide activities (applying time and costs consuming means). Primary, this paradox seems to be related to the transparency condition and not to the one with vicarious punishment, however it has to be taken into account, that all three conditions were explicitly informed about the system and its' functions, i.e. even in the low-transparency condition students' focus was turned on the system and its existence. Even the basic information included a list of the basic sources for system calculations of participation and inactivity. This information might have been sufficient to activate students' feelings of being detectable and observable by the system and hide activities.

This, however, does not have to be detrimental or in contrast to the transparency manipulation, as participants still knew less or more about the functioning of the system, noticeable by the perception of prompts as more comprehensive.

Regarding potentially relevant factors which influence the objective behavior, several significant correlations emerged. The more frequent logins, the more contributions and the less fear were perceived by the students. The link between participation and contribution is in line with Chavez and Romero (2012), who indicated low level of participation as a main difficulty in CSCL, and participation as highly important and increasing group productivity, perception and results of learning, as well as the evaluation of results' quality and satisfaction. Additionally, the more contributions, the less hostile users' perception of prompts was. This is potentially linked to the own invested time and effort, i.e. the more students participated themselves, the worse and more unfair they might perceive others' inactivity, and therefore perceive prompts highlighting them indeed not as significantly "more legitimate", but as less hostile.

Regarding subjective user perception of prompts and in-group experiences, the less fear, the more objective and less faulty prompts were perceived. Students might feel secure and invulnerable regarding vicarious punishment, if they do contribute enough. However, in case they do not trust the system and the prompts, as well as the algorithms behind the vicarious punishment procedure, they might still be afraid of faulty and less objective choices of the system. Perceived faultiness of prompts was linked to less observability of others' contributions and trust in the fact-based character of the system. The existence of faulty prompts and a system, which students do not trust to be fact-based, could decrease the perceived possibility to estimate how much others have contributed. Further, with higher perception of faultiness, prompts were also perceived as more hostile, which indicates the importance of the system's accuracy. This relationship might be discussed as a potential hint to the existence of systems' idiosyncrasy credit (Hollander, 1958). As a kind of legitimacy or the right to act contrary to norms after following them sufficiently before, having earned enough idiosyncrasy credit allows to do so without negative consequences. In case of faultiness, system hints are perceived as more hostile since they are incorrectly delivered. Certain characteristics could replace the system's positive "proficiency", signal expertise and credibility, and finally enhance the system's legitimacy to highlight inactive team members. The opposite, kind of discredit, is expected if prompts are perceived faulty, as system's negative proficiency.

Furthermore, reported higher tendency to imitate other inactive teammates was perceived with higher perception of faultiness. This is a potential indicator of discrediting the system. If students do not trust the system's correct functions, they might also be less motivated to stop inactivity, perceiving the whole system as not functioning well and not threatening for them.

Further, regarding satisfaction, fear and the tendency to imitate inactivity, the more satisfaction, the more people trusted their teammates. Trust and satisfaction, however, increased with the perception of others' contributions as helpful for the group success, and with the perception of less conflict, less coordination stress, less inactivity dislike (of inactive peers and of the need to compensate them) as well as lower tendency to imitate inactivity. Furthermore, as stated above, it was also found that equality of participation predicts satisfaction. Nevertheless, not only the mere presence of inactivity in groups, as a common challenge for collaboration, but also the resulting prompts addressing teammates to take up work – both potentially foster conflict and disliking. Taken together, these findings underline even more the need for automated mediation and alternative prompting solutions. These measures can be promising in order to gain the benefits of prompts and group conflicts without the costs of conflicts and personal disliking. Negative consequences in the sense of vicarious punishment are just one of many options needing further investigations in this field.

Yet, it should be acknowledged that these relationships can be interpreted in both directions since correlations do not allow to interpret any directions. Thus, are conflict and disliking in e-learning groups contra-productive for satisfaction and trust or vice versa? Regarding the negative correlation of login frequency and fear, it stays unclear whether participants had more fear to also get criticized publicly the less frequently they logged in or the other way around. Mediation models' results showed non-significant total, direct and indirect effects, which indicate that it is indeed not easy to detect causal relationships in this area. However, fear significantly negatively predicted contribution as well as login frequency. Additionally, login frequency positively predicted the contribution amount. It can be concluded that participants' fear predicted their less frequent logins and less contributions, although more frequent logins predict more contributions. Future work should optimize and customize vicarious punishment to be sufficiently threatening but also sufficiently transparent, without inducing feelings of surveillance. Such balanced prompts could be more easily accepted, without leading to

login and contribution avoidance. Thus, studies could focus on the inclusion of mechanisms to improve vicarious punishment as severe and mild simultaneously, and to avoid the transparency paradox when informing about system's functioning. Similarly, the negative correlation of fear and contribution, as well as contribution and hints noticed remain to be clarified by future research.

Limitations

This study has several limitations that should be acknowledged. First, a not-fully-crossed design was applied. The experimental group with vicarious punishment and low transparency was included in both comparisons. In case of specific characteristics or failures, these could be implied in all study results. An experimental group without transparency included should be applied in future research, as well as a control group without any prompts. Second, equality of participation was measured as a group value, further decreasing the sample size. Therefore, a higher number of participants in general, as well as a higher number of participating groups should be tested in future studies. Third, according to Collazos, Padilla-Zea, Pozzi, Guerrero, and Gutierrez (2014), collaboration does not happen automatically by building a team and letting it solve a task. Therefore, tasks were composed, supervised by pedagogical experts, as requiring collaboration but deliberately allowing success, also with fewer teammates if necessary in case of dropout. Thus, collaboration quality was not measured, but this is recommended for future work. However, in a manipulation check regarding noticed prompts, participants reported to have noticed them frequently. This measure should be considered cautiously since the phenomenon of banner blindness proposes that salient stimuli are often missed by users (Sun, Lim, & Peng, 2013). Future studies should take alternatives into account. Further, the questionnaire was filled in twice – after each team task. Future long-term tests should be applied, including a measurement of stress, fear, etc. also before the experimental manipulation. A better balance between short questionnaires in order to avoid dropout and longer standardized questionnaires is needed. Lastly, effect sizes of the results were small to medium.

Conclusion

In conclusion, participation equality predicts satisfaction. Vicarious punishment revealed more constructive prompts, but less observability of others, i.e. the ability to

estimate others' contribution, which was even lower when a detailed system function description was included for higher transparency. However, transparency revealed participants to be more afraid, and a negative correlation with number of contributions was shown. However, it remains unclear whether less fear is related to more contributions or less contribution to more fear. Regarding the carrots and sticks procedure, therefore further work is needed. Transparency might help have them appear as beneficial and credible as possible, especially in case carrots do not provide sufficient motivation, so that indeed sticks and other mediators are needed.

IV GENERAL DISCUSSION

This dissertation is motivated against the theoretical background of participation issues in CSCL and automated support as an alternative means to spare teammates the demanding but needed nudging role (Chapter II). Moreover, the media equation theory (Reeves & Nass, 1996) and its limitations allow assumptions of equal and unequal, i.e. more or less beneficial perception of automated support. Thus, the overarching aim of this dissertation is to explore the full potential of automated prompting, answering the question how it should be provided to improve collaboration in online learning groups in terms of students' satisfaction and participation. For this purpose, the empirical approach outlined in the previous Chapter III comprised three studies on the determining factors of automated prompting. To lay the foundations, an online study examined the relevance of the prompting source comparing automated and human prompting, their past proficiency and, additionally, the basic characteristic message publicness (Study 1). Furthermore, the characteristics of an automated prompting system are focused within field studies, combining behavioral and survey data. Applying this method, the personification of an automated system is investigated in the second study (Study 2), whereas the third study addresses the communication manner of the system. In terms of severity, negative consequences for inactive members were signaled as vicarious punishment and the role of transparency as a legitimacy means within the specific, more hostile communication.

In the following, the final chapter draws upon the entire thesis, tying up the various theoretical and empirical strands in order to retrieve briefly the research objective and key questions it seeks to answer, as well as the empirical approach which was applied. For this purpose, a synopsis is outlined (section 9) before the main findings are summarized (section 10), interpreted and reflected on (section 11). Moreover, this chapter

discusses and categorizes the findings and their implication against the background of theoretical (section 12) and practical (section 13) implications. Finally, the limitations of this thesis are taken into account, deriving future research directions from them (see section 14). At the end of this chapter, an overarching conclusion of this work is given (section 15).

9 Synopsis of the empirical approach and research findings

Group work, as a hailed solution of typical problems within online learning settings, has to function properly in order to unleash its potential and motivate rather than frustrate group members. However, online collaboration does not function automatically and faces several participation issues (Strauß et al., 2018), related to dissatisfaction and unequal participation. Against this background and against participation issues in online learning groups, teammates usually prompt inactive others to take up work, which might be demanding when done as personal remarks. Alternatively, prompting can be provided by an automated system and this way perceived equally, less or even more favorable according to the media equation theory (Reves & Nass, 1996) and its limitations.

Thus, in order to gain the benefits of nudging without the costs for group climate, this dissertation focuses on the employment of automated prompting and its improvement, aiming to adjust it in the most beneficial way. Hence, the studies in this dissertation addressed relevant determining factors of an automated system in order to improve the collaboration in online learning groups towards system persuasiveness, students' satisfaction and participation. Primarily the question was raised, whether automated and human nudging differ regarding user's perception. To this aim the source, i.e. the differences of both sources, as well as basic characteristics like past proficiency and prompts' publicness were explored (Study 1). Furthermore, focusing on the automated nudging system, the relevance of its personification (Study 2) was examined by providing the system with an appearance and a name, questioning if personification can improve automated nudging, respectively whether an abstract or a human-like system is perceived more beneficially. As a further potentially powerful option to adjust the automated nudging system, its communication manner was investigated (Study 3), seeking to answer how the severity of the system impacts participation and satisfaction. In this final study of the dissertation, severity of the system was signaled through the display of negative consequences for others, i.e. vicarious punishment. Additionally,

transparency was considered as a factor which might enhance system's legitimacy of hostile communication.

10 Summary of the main findings

Online learning, as rapidly developing field (Tamm, 2020) should be organized in the best beneficial way to unleash its full potential and promote learners with motivation instead of frustration. One potential solution of the typical challenges of MOOCs such as high dropout rates, low motivation and low satisfaction (Erdmann et al., 2017) can be group work. However, online group work itself commonly suffers participation issues like free riding and social loafing which have several detrimental consequences for both group-development and performance (Strauß et al., 2018). Additionally, group work does not function without additional means and effort, even if group work tools are given (Kreijns et al., 2003). This way online collaboration can easily turn frustrating rather than motivating, especially for active group members who experience the lack of feedback and unequal or missing participation.

Moreover, according to the intention-behavior gap (section 1.1), especially the positively intended are more likely to fail their intentions, i.e. to act accordingly and participate for instance, than negatively intended ones do (Sheeran & Webb, 2016). Thus, those who intend not to participate, more likely will not, independent of nudging. However, it might be worthwhile to facilitate and motivate positively intended course participants, inter alia, through clearly visible measures against inactivity. On the other hand, with regard to behavioral intentions – they can be influenced by attitudes and social norms. While satisfying group work experiences can impact positively the attitude, social norms include also comparisons to other group members (descriptive norms). However, nudging against inactivity simultaneously makes the problematic behavior more observable depending on the publicness of prompting, so it can potentially become a basic descriptive norm even though it is detrimental. Conflicting social norms in groups were shown to still impact but to weaken behavioral intentions. Thus, support is needed to prompt others to take up work and give the collaboration a boost, but it has to be cautiously adjusted and provided.

However, nudging provided among group members as personal criticizing remarks among group members can be demanding. As a form of criticism, they might be interpreted as unbalanced and consequently ineffective regulation of learning (Isohätälä

et al., 2017) or negative feedback, perceived as intentionally threatening (Gabelica et al., 2012). Moreover, as a conflict regarding the participation, it can be seen as a task conflict but its productive influence easily converts into a detrimental, personal conflict (Janssen et al., 1999) or interpersonal disliking (Ilgen et al., 1981). Hence, the group development, climate and decision-making may suffer (e.g. Walther, 1996). Moreover, from a group development point of view (Tuckman, 1965), the storming phase characteristically rich in similar conflicts was shown challenging, hindering groups to pass and move further to high performance stages because groups get frequently stuck in fights (Ayoko et al., 2012).

These challenges raised the question whether technology could alternatively undertake the nudging role and relieve group members of it, potentially protecting the group from additional conflicts. Indeed, automated support in terms of group awareness tools for instance have been shown as useful for this purpose, but the source of prompts and nudging was not focused with regard to members' satisfaction so far. Beyond its potential for group climate, automated support allows a cautious adjustment, impossible if undertaken autonomously by group members.

Thus, this dissertation sought to answer the question, how to improve collaboration in online learning groups via automated prompting, especially adjusting it to enhance system persuasiveness, students' satisfaction and participation. The communication with and perception of a prompting system depends on multiple factors. According to the media equation theory (Reeves & Nass, 1996) it can be equal to real-life human-human interactions. On the opposite, according to limitations of this theory (e.g. Bartneck et al., 2005; Lucas et al., 2014), automated sources can be perceived differently, even more beneficial, and additionally, according to the social cue/agency theory, the technology earns the more social responses, proportional to the more social cues it possess (Moreno & Mayer, 2000; Mayer 2005).

To systematically explore automated nudging, three empirical studies on easily adjustable key characteristics were conducted: source, personification and communication manner. The application of mixed methodological approaches as well as various duration and repeated measures within real groups allowed a more reliable, multifaceted investigation. This data combination promotes deeper insights of how the persuasiveness and perception of an automated system interact with other variables that are believed to be linked to – subjectively assessed variables (like human-likeness,

faultiness, emotional affect, satisfaction) as well as group or intention related ones (such as perceived conflict, fear and imitation tendency) and moreover additionally behavioral outcomes (like participation equality and contribution).

Exploring the nudging source (Study 1)

To provide the basis for this work, first, nudging by humans and by an automated system was compared in order to investigate potential differences with regard to users' perception (Study 1). Within an online experiment, an imaginary e-learning group setting was introduced with visual vignettes, which displayed prompt messages which addressed the participants and their own imaginary inactivity in a group. Source (abstract support system vs. other group members), past proficiency of the human source and message publicness were varied in order to investigate their influence on message persuasiveness as well as recipients' emotional affect, perception and attribution.

The findings revealed a different, more positive perception of prompts when they originated from an abstract automated system. Prompts sent by the system were perceived as more positive and persuasive, improved the general sender impression and internal causal attribution (i.e., participants more likely blamed themselves when confronted with negative feedback by the system than by other team members), but also increased the internal negative emotional affect. These effects and additionally increased message fairness were also obtained in a comparison of the system versus low proficient team members. However, the perception of highly proficient team members and of the system as nudging sources did not differ. Additionally, public prompts were perceived more persuasive but also more negative – as a message perception and in terms of a negative emotional affect. However, the publicness had no impact when only system prompts were considered for the comparison.

On the personification of an automated prompting system (Study 2)

These results were considered for the conduction of the second study. Having indicated that the source of nudging matters and the automated one rather than human peers even partially improved the positive user perception of nudging, further development of the automated system was aimed. In order to enhance the automated

system and configure it more advantageously, the second study focused on the influence of a system's personification (Study 2). The question was posited, whether an abstract or a human-like nudging entity is perceived more beneficially, i.e. whether personification can improve automated nudging. Therefore, in a long-term field experiment, the personification of the system was manipulated applying it with or without a name and a static appearance. Parallelly, during the collaboration of real groups within six weeks, objective behavioral data and subjective survey data were collected. Thus, various variables and their interplay could be obtained.

The findings indicated that the equality of participation increased participants' satisfaction with the group work, both measured in the final, third group task. Personification barely influenced users' perception, except for its negative effect on prompts' persuasiveness and students' overall satisfaction – these variables were in turn improved by an abstract automated system. Regarding the objective user behaviors, personification did not directly affect login frequency and contribution quantity, however it improved participation equality. Additionally, personification and perceived satisfaction were related through the behavioral mediator equality of participation – the personification of the system predicted a more equal distribution of participation within groups and consequently more satisfied were students with group work.

Over time, independently of the personification manipulation, students logged in less frequently, perceived prompts as less good willing, and assessed the prompting system less used for group optimizations and less useful to observe others' contributions. Personification had an effect on the equality of participation over time, indicating generally similar levels and a difference in the third, last task. Groups with a personified prompting system participated more equally, conversely to groups with an abstract system whose participation distribution became more unequal. Thus, the findings did not reveal a long-term facilitation of the abstract system, as hypothesized based on its lower potential for violated expectancies.

Summarized, an abstract system was identified to improve the perception of nudging to some extent and moreover increased overall satisfaction, whereas personification, on the other hand, increased the satisfaction with group work merely via participation equality in the last, third task.

On the communication manner of a nudging system (Study 3)

Keeping in mind the overarching aim of this dissertation to improve collaboration of online learning groups through prompting, the findings of the second study paved two basic directions to the third experiment – the mainly negative impact of personification and the importance of participation equality towards satisfaction. Considering that conventional human-like roles also serve as personification factors and social cues (Nass & Moon, 2000), the manner of communication as a further promising, entity-related characteristic was focused and reinforced with regard to its severity (Study 3). Modifying to some extent the behavior of the system, this study asked how severe the nudging system is allowed to communicate towards a stronger impact on participation and satisfaction. Additionally, the legitimating role of the transparency of the system was addressed. Therefore, severity and transparency were varied in a field experiment over the course of four weeks, where repeated questionnaires and behavioral data were collected. Inactive teammate confederates were addressed publicly by an automated system, i.e. visible for all other members of a group in a more or less severe manner. Therefore, vicarious punishment was conducted through criticizing concrete other inactive members or not (severity manipulation). Additionally, specifically participants in the experimental condition with vicarious punishment knew more or less about the functioning of this system in advance (transparency manipulation).

The findings indicated that equality of participation positively predicted teamwork satisfaction. Through the application of vicarious punishment within the prompting messages, they were perceived as more constructive, but less useful to observe others' contributions. Participation was partly affected – merely negatively with regard to its equality but not with regard to the amount of contribution, as opposed to earlier findings of higher productivity due to offline vicarious punishment (Schnake, 1987). The transparency of the system had an impact on the way prompts were perceived – as more comprehensive but less frequently noticed. However, transparency also made students more afraid to get criticized themselves, affirmingly they found action against inactive teammates less reassuring and others' contribution less observable.

Over time effects from the first to the second teamwork identified that stress was higher after severe prompts, and lower after transparent severe prompts or non-severe prompts. Participation equality increased only with vicarious punishment, but decreased when given by a transparent severe system or without severity, i.e. without any

punishment. This indicates that vicarious punishment stressed students more, but also boosted the equal distribution of participation. Interestingly, prompting without a punishment did not differ in time with regard to fear and imitation of inactivity, but vicarious punishment decreased both, while transparency increased both, i.e. students were more afraid and simultaneously tended more to imitate inactivity.

Overall, independent of vicarious punishment and transparency, correlational evidence for relevant objective and subjective factors was found, such as the relationship between frequent logins, more contribution and less fear. The assessment of prompts as faultier and less objective related to more fear to get publicly criticized, but also to a higher tendency to imitate inactivity, which, in turn, was related to lower satisfaction. Additionally, more fear related to less observability of others' contributions, less inactivity-based disliking – of the inactive teammates and of the need to compensate for them.

The identified relevance of fear and login frequency was applied in a double mediation between vicarious punishment and contribution amount, however, results yielded the complexity of these relationships and did not reveal vicarious punishment to predict the amount of contribution – neither with, nor without both mediators or as an indirect effect. Nevertheless, singularly, vicarious punishment increased marginally the perceived fear, which in turn significantly decreased both contribution amount and login frequency.

Overall

The overarching research question underlying all studies aimed to improve the collaboration of online groups by automated prompting. By raising this question, the nudging source was examined (Study 1) and revealed advantages of the automated system compared to other, low or average proficient group members. This indicated that the source of nudging matters and the interaction with an automated system was rather perceived *un*equally. Additionally, publicness resulted in a more persuasive and more negative perception of the prompts but did not make a difference among system prompts.

Based on these findings, the automated system and its personification were examined (Study 2), revealing that prompts by the personified system were perceived as less persuasive and overall students' satisfaction was lower. Behavioral factors were

barely influenced by the personification (neither over time, nor cross-sectional), except for a positive effect on participation equality. Moreover, a link between subjective and objective data was shown within the final group task. The personification led to more equal participation and thereby to higher group work satisfaction. Moreover, independent of personification, the equality of participation led to higher group task satisfaction.

Thus, findings generally indicated the importance of participation equality, but were conflicting with regard to personification. With a personified system, prompts were assessed as less persuasive and overall satisfaction was lower than with an abstract system, however, personification boosted behavior in the final task in terms of participation equality and, consequently, increased this way the assessed satisfaction. Due to some issues regarding the participation equality measurements and the reduced sample size, the abstract system was assumed as reliably beneficial and therefore it was rather applied in the final study, additionally avoiding mixed effects with this decision.

Therefore, an abstract system was applied to focus merely on the communication manner of the nudging entity as a behavioral factor of the automated system (Study 3). Through vicarious punishment on confederate group members within the groups, the severity of the system was varied. Additionally, transparency as the prior knowledge of the students regarding the system's functioning, was varied to examine its legitimating potential for more severe prompt messages. The findings replicated that the equality of participation predicts group work satisfaction. However, the severe communication through vicarious punishment was assessed as more constructive, but severity, as well as transparency, had a negative impact on the equality of participation and did not influence the contribution amount or other behavioral factors. With more knowledge about the functioning of the prompting system, students were more afraid and found the prompting means against inactivity less reassuring. Comparing the repeated measures after the first and the second group task, over time, stress was higher and participation more equal with severe system prompts, but in contrast, less stressful and more unequal distributed when transparency of the system was added or without severity. With non-severe prompts, students' fear and tendency to imitate inactivity did not differ after both tasks. However, students who had less fear, tended less to imitate inactivity, when the system prompted them in a severe manner. In turn, fear and tendency to imitate inactive teammates was higher with a transparent severe system. Generally, as overall factors independent of the communication manner of the system and its transparency, the tendency to inactivity

imitation and fear were positively related – the more imitation, the more fear was perceived, or vice versa. Considering the severity of the system to predict contribution indirectly through fear and login frequency did not turn out to be significant on any possible path of the considered model, however, fear negatively predicted login frequency and contribution.

With regard to the dependent variables, taken together, this dissertation provides findings referring to the impact of nudging and its characteristics on students' objective behavior and their subjective assessment of emotions, nudging and group related factors. Students' objective behavior was considered as amount of contribution, frequency and equality of participation, whereas their subjective assessment was collected generally in terms of emotional affect, perception of nudging – of the entity and of the messages as well as group climate and awareness. In the following, these factors will be discussed against the background of the single considerations of each experiment in which they were examined but in general, against the background and potential interplay of all three studies within this dissertation.

11 Interpretation and reflection on results

In order to classify the contributions of this dissertation in the academic framework, the presented findings are discussed and reflected against the background of prior research and the findings within this dissertation. First, the advantages of an automated system and additional basic factors are discussed, (section 11.1), the role of personification (section 11.2) and the severe manner of communication (section 11.3) are regarded, focusing along the discussion on key objective and subjective outcomes such as persuasiveness, satisfaction and participation as subsections.

11.1 Advantages of automated vs. human prompting

An automated prompting system interacting with group members through text (as a partner in a conversation), prompting them to hurry up and do their share of the work (in the role of a tutor or a peer) could have been perceived equally to human-human interactions, because it possesses basic social cues (Reeves & Nass, 1996). However, in the first study of this dissertation, contradicting to the theory, it was not the case. Prompts by an automated system were perceived differently from those sent by other group members. Prior to discussing these results considering the limitations of the media

equation theory in the next section, it is important to discuss whether other factors could explain this.

Indeed, the media equation theory postulated that a certain base of social cues is needed for technology entities to be perceived as humans while interacting. As mentioned above, the system in this case had a human role, as a peer who is nudging others, as a tutor, or as a conversation partner. However, it needs to be mentioned that the "conversation" was mainly in one direction, as a monologue on the part of the system instead of a mutual conversation. Even though this was the case in both conditions, i.e. equally when nudging messages were manipulated as if they have been sent by other group members, this might have been reducing the perception of a real conversation. However, one-sided and moreover two-sided interactions via text are nowadays ubiquitous (Walther, 2012). Furthermore, instructing was defined as an autonomous type among the ways users interact with a product or application, followed by the conversing type – a dialog, optionally done via text or speech output (Preece, Sharp, & Rogers, 2015). The upgrade which a conversation offers against an instruction is to encompass a two-way communication, with the system acting as a partner instead of a machine which obeys orders. However, even only machine instructions like warnings, questions, congratulations or update reminders, such as "…dialog boxes can lead people to infer that the computing product is animate in some way" (Fogg, 2003, p. 101). Moreover, even simple error messages via text have an impact on the recipients, who infer a personality to the device by simply reading them (Fogg, 2003). Thus, in this sense text can be seen as a replacement of voice or speech and has the potential of a conversation base.

Even though the users in all three studies did not have the possibility to initiate a conversation, in the visual vignettes within the first study prompts were displayed as inbox messages within the e-learning platform and included a visible reply button. Thus, participants have seen a system prompt, which theoretically could be answered, although the introduction they were given in the beginning did not explicitly inform them about this option or the interaction quality and ability of the system. On the contrary, in the field studies 2 and 3 of this dissertation, prompts were visualized within a group awareness tool on the default page of the platform and did not include a reply option. This could have biased the perceived level of interactivity of the system, signaling a reduced potential to communicate with it actively. Nevertheless, according to the classic concept of nudging in the field of health care, food or privacy, for instance (e.g. Acquisti et al.,

2017), nudges have also been sent as one-way warnings instead of conversational options. In real life, nudging by other group members also includes direct reply options. Thus, the participants' interpretation of the prompting messages implied within this dissertation might be similar associated with a received message by a human. In this sense, the role of a conversational partner delivering messages, i.e. a message sender, could also serve as a cue of interactivity, independent of the potential lack of interactivity of the particular system. Indeed, to undertaking a typical human role serves as a social cue as well (Nass & Moon, 2000). Thus, in sum, a prompting system seems to fulfill sufficiently the boundary condition of the CASA principle, to be an autonomous source of interaction and to possess social cues, as the automated prompting system includes basics in terms of a messaging function, signaling an interactive entity as well as the human-like role of a criticism source which is otherwise undertaken by peers or tutors. These characteristics of the system were given in all three studies of the dissertation and seem to successfully turn the system to a source instead of just a transmitter of communication, as postulated by Nass and Moon (2000).

Beyond these considerations, the first study does not support the media equation theory, as the findings confirm media *in*equalities regarding the perception of technology and interactions with it. These results are consistent with several studies refuting the equation as well (e.g. Bartneck et al., 2005; Lucas et al. 2014). Among the studies disproving the theory by showing differences rather than equalities, some researchers implied robots to directly interact with or to be observed during specific treatments. These comparisons of human-human and human-robot interactions can be assumed as more or less similar to an automated prompting system, although considerable as advanced merely through the included embodiment characteristics. However, robots as technological entities can be seen as advanced indicators. Furthermore, recently it was proposed that the media equation theory should be generally reconsidered and upgraded, since digital natives (but also others))) are used to interact with technologies in daily life, and might have developed specific scripts, others than those in human-human interactions, when interacting with machines (Gambino et al., 2020).

Compared to prompting by other group members, the messages of an automated system were assessed as both more positive and persuasive. Furthermore, they improved the general sender impression which was more positive when provided by a system (Study 1). This confirms results observed in earlier studies, identifying not only a

different but beyond that, even a more beneficial perception of technology, for instance increasing the willingness to self-disclose (e.g. Lucas et al., 2014). The positive effect on internal causal attribution leads to the conclusion that even if not perceived as more impartial, contradicting to the assumptions, a machine source of nudging indirectly led participants to focus on their potential responsibility for receiving criticism. These feelings of own guilt appeared especially in the first study, although it was an online experiment and not a field study. Thus, even the imaginary context of being late and not having contributed timely, seems to have been persuasive enough and improved by system prompts. The potentials and challenges of online and field studies on this topic are discussed in detail in section XY. Last but not least, the negative emotional affect was higher with regard to the internally (but not externally) indebted negative emotions, when prompts were sent by the system. Although this can be seen as a disadvantage of the system, the increased internal causal attribution can be proposed to explain partly this effect, as participants rather blamed themselves for the received negative feedback than suspected the automated source of criticism to be intentionally threatening.

Additionally, further basic factors can reduce or intensify the perceived threatening effect of nudging – for instance the message itself and its publicness as well as specifics of the object, a technology is compared to like prior engagement in the group. Both were scrutinized and derived basic recommendations from the first study for the next two as discussed in the following.

11.1.1 **Human past proficiency and insights for a prompting system**

Solely the past proficiency of a human nudging source was explicitly manipulated, i.e. the prior engagement of other group members, however beyond its main effects, it might provide insights into system adjustments and will be discussed to this purpose. Displayed in terms of a timely manner and an appropriate amount of contribution. Teammates' past proficiency had an effect on the comparison of human- and technology-based prompting, confirming the beneficial investment in an idiosyncrasy credit (Hollander, 1958). Group members, who were introduced as high engaged in the past, were assessed similar to the system, meaning that prompting by them, rather than by medium and low engaged group members, was also perceived as more positive and persuasive, improving sender impressions and internal responsibility for having caused the negative feedback.

Moreover, prompts were perceived as less fair only when sent by group members with low past proficiency, confirming once again the relevance of the idiosyncrasy credit and that feedback is more likely perceived as accurate from credible, powerful, knowledgeable sources (London & Sessa, 2006). Thus, the endangering potential and relevance of participation issues as well as the broad spectrum of disadvantages, which unequal or missing participation can cause were confirmed to impede personal impressions as well as the perception of criticism.

Knowledge and assessment of past proficiency

Keeping in mind that group work is more dynamic and complex than the sum of all individual perceptions and experiences of its members, these findings need to be considered with regard to their consequences for real groups. As it turned to be a significant factor, group members' past proficiency is not well known in groups and needs to be signaled or shown explicitly. Within online collaboration, single contributions cannot always be displayed and visualized as needed for group members to be aware of everybody's participation for two reasons – due to the hardly detectable and visualizable missing contribution and due to the failures in self- and others-assessment.

First, beyond the complete lack of knowledge about others' work within group work, even if monitoring tools are applied and attempt to highlight members' contribution, it is frequently measured as the number of detectable signs, e.g. written words. However, the participation includes much more invisible, barely detectable aspects. A more holistic operationalization should be found for the dimensions of participation which are not easily measured automatically (Hratinski, 2008, 2009). Moreover, the alternative measurement of invisible participation data requires self-reports which may also vary and be less reliable.

Second, and most problematic for self-reports and non-visualized participation amounts – they are easily misinterpreted. Regarding self-assessment, participants may generally assess inaccurately their own contribution, for instance by overestimating various aspects. Students indeed overestimate their own expertise (Dunning, 2011), the own contributions (underestimated by engaged users and vice versa) (Zepke & Leach, 2010) as well as compared to those of others (Alicke & Govorun, 2005) and simultaneously the accuracy of these assessments (Moore & Healy, 2008). Moreover, inaccurate self-evaluation can be the foundation of others-assessment or even serve for

the (mis)interpretation of clearly visualized contribution amounts due to varying outcomes of the social comparisons with others (e.g. Michinow & Primois, 2005) or dimensional comparisons of the own contributions against each other (Dickhäuser, Seidler, & Kölzer, 2005). Thus, the self- and others-evaluation in online-courses easily goes wrong, even if a group awareness tool is applied and attempts to highlight contribution amounts. The overestimated perception of the own contribution and engagement means that even high-engaged other members can be underestimated, which consequently, as the first study showed, disimproves their messages and their impression on others while nudging, confirming the assumed transformation of task conflicts into personal conflicts and reciprocal disliking, which can occur despite criticism is justified (Ilgen et al., 1981; Janssen et al., 1999).

However, in real groups it cannot be defined who will undertake the role of the nudging source, whether it would be a high- or low-proficient group member. Keeping in mind the potential failures in self- and others-assessment, even high-proficient members can be perceived as low proficient and therefore illegitimated to prompt others. Therefore, these findings highlight the importance of awareness tools in order to visualize the contribution of single members within e-learning groups independently of group members' subjective perception of who did what. As an alternative solution, certain scripts can be applied to divide teammates' responsibilities or even nudging tasks among the group members. To this aim it needs to be defined in advance, who will be engaged or not. However, further participation-related issues appear to be problematic for this purpose as contribution amount (if visible number of words or self-reported as described in the prior section), but not its quality can be measured and displayed appropriately. This gap can additionally provide uncertainty regarding the actual past proficiency of the teammates and potential failures assigning low-engaged members to ineffectively nudge others. In this sense, the quantity of participation should be supplemented by additional indicators for the quality of contribution, for instance applying concept coverage of written text. Moreover, scripts for certain, even definitively high-engaged members assigned to nudge others, can be additionally unfavorable in terms of the "Keener" within groups, which was identified as over-involved among the top unpleasant and frustrating, yet common roles in group work (Phirangee, 2016).

Hence, it can be proposed that scripting especially high proficient members might be effective when messages should be received in a fair manner but not with regard to

satisfaction and emotions of the group members (e.g. Alavi & Dufner, 2005). Considering these issues, an automated system to nudge others in groups remains among the best solutions, as it was perceived as positive as a high-proficient group member and even better than average- and low-proficient members.

11.1.2 Publicness and persuasiveness

As a further significant aspect beyond the source of nudging, the publicness level of the prompts was scrutinized as crucial for the perception. The negative feedback within prompting messages can be perceived as more threatening if targeted on a group level, i.e. highly visible for others (e.g. Leary et al., 2009 and section 2.2.2). In contrast, privately provided, it can be perceived more moderate. With regard to publicness it was shown that it only differs in terms of nudging among group members. In this case, public nudges were perceived as more negative but also more persuasive. Since there was no difference with regard to the public and private messages sent by an automated system, but there also was no difference between the system and high-engaged group members with regard to their perception and impression on others, the effects could be assumed to be valid for a system, in case more than one kind of a system is presented and its characteristics serve as past proficiency indicators. Thus, public nudging messages were preserved for the studies with focus on the automated prompting system. Nevertheless, this might be beneficially reassuring for active group members who are potentially frustrated by the participation issues of inactive members and observing the lack of solutions or warnings against them. The application of public messages has another advantage with regard to the communication manner of the system, as it is relevant for its actions to be visible and allows a minimum of interaction, respectively also the development of attitudes and expectancies towards the system.

11.2 The role of personification

Having shown that an automated system is beneficial for the perception of the nudging process in terms of messages and source, the further focus in this dissertation was on an automated system and its characteristics. The adjustment of social cues of the system was undertaken in order to improve the system with the aid of personification, by adding an appearance and a name. However, the personification showed conflicting effects on the assessment of the nudging messages and most of all on behavior of the group members

within the 6-weeks of the study. On the one hand the abstract system appeared to be more beneficial and improved the message persuasiveness and students' overall satisfaction with the course. On the other hand, taking a closer look at the interplay of personification, students' objective behavior and subjective assessment of satisfaction, personification emerged to be beneficial in this combination – the personified system increased equality of participation, which increased in turn the satisfaction with group task. In order to discuss this discrepancy in general, the conversed findings are taken into account in the next sections.

The advantages of the abstract system in Study 2 regarding persuasiveness and overall satisfaction confirm broadly the first study in this dissertation, where the system was also an abstract one and showed beneficial effects. However, the non-personified system there demonstrated advantages when compared to other group members and not to other systems. Beyond this major difference, the abstract system was perceived as more positive and more persuasive even if not experienced in real group work but imaginary online. However, the constellation, similar to real participation issues in group work, was displayed in a figure within the visual mockup-vignettes, as a "simulation" of the mirroring tool applied later in both field studies (Study 2 and 3), therefore both studies can be interpreted as a confirmation of the benefits of an abstract system in similar circumstances.

In contrast, the disadvantages of the personified system confirmed that personification can also have detrimental effects beyond the benefits, like reviewed by Heidig and Clarebout (2011) – in the realm of learning it was also found either without effects or detrimental for users in terms of distraction, increased effort, lowered performance and heightened expectations. With regard to the static appearance and a name tag applied to personify the system (Study 2), this approach is similar to the one on appearance and animation (Baylor & Ryu, 2003), asking to what extent personification is enhanced with the extension of social cues, and also in line with the findings which emerged. Baylor and Ryu demonstrated first that the presence versus absence of an image did not make a difference for the characteristics engagement, person-likeness and instructor-likeness. Second, the addition of an image (both static and animated) facilitated agent's credibility, but not its person-like perception. The latter findings were confirmed in Study 2 within this dissertation - with regard to persuasiveness and the human-likeness of the system. Additionally, confirming the generally positive effects of the abstract

system, in the absence of an image participants mentioned less things they disliked in Baylor and Ryu's study (2003), which can be compared within a very broad interpretation, with the improved overall satisfaction with an abstract system. However, a major difference between both settings (and findings) should be considered in terms of a name for the system. Baylor and Ryu gave the system a name even in the no-image-condition, i.e. they personified it with this concrete social cue, so their manipulation was not, either with or without social cues, but instead with a name and with or without an image, extended from static up to animated. As opposed, in this dissertation, persuasiveness and overall satisfaction with the course were improved even by an abstract system without a name but rather with the basic social cues of a human-like role and a messaging function.

Additionally, similar, beneficial effects were found with regard to avatars – quite different in their aim but yet technological entities displaying humans (Nowak & Biocca, 2003). The application of abstract rather than lifelike avatars stimulated the greatest presence, copresence and social presences responses. Moreover, according to Walther (2011), although social presence was repeatedly disregarded in computer-mediated communication, it remains as an inherent consequence of multiple cues.

In line with Walther's discourse, the findings of the second study also concur well with the CASA principle (Nass & Moon, 2000) that specifies that basic social cues are enough for technology to be perceived as human-like. Both the personified and the abstract system were perceived slightly more than medium human-like and did not impact the amount of participation and contribution. However, not only the persuasiveness but also the overall satisfaction was improved through the abstract system. This is partly in contrast to the social cue/agency theory and the idea that the more social a system is perceived, the more social responses it elicits, motivates and promotes the learners (Moreno & Mayer, 2000). These findings are additionally opposed to the beneficial effects of graduating human-likeness (Burgoon et al., 2016), mostly including animation and barely comparable with the static appearance, but potentially crucial for the effects over time. Except for the effect on participation equality, which is discussed in the next paragraph, personification lacked over-time effects, i.e. additional social cues did not improve the assessment of the abstract system in the long term as assumed potentially based on less expectancy violations, which was theoretically considered but not measured in this dissertation and will be recommended for future work (section 13). However, in

the second study both automated prompting systems were perceived as decreasingly good willing over time, independent of the personification. This can be interpreted as an identification of a violation but needs a measurement of the prior expectancies to allow this conclusion.

Thus, it was shown that the extended personification is not needed for better persuasiveness of an automated prompting system, as the same abstract system was previously (Study 1) perceived even more beneficial to this purpose than average and low proficient team members – *un*equally, i.e. disproving the media equation theory proposed (Reeves & Nass, 1996). Indeed, the results of the second study confirm and extend the findings regarding persuasive advantages of an abstract system in comparison first to other group members (Stoyanova & Krämer, 2019) and second – to a personified system which revealed to be less persuasive.

To explain improved persuasiveness also the principles of similarity and physical attractiveness can be considered as top persuasive ones (Fogg, 2003). Since personification did not improve any other characteristics of the system unlike prior findings, neither persuasiveness nor other variables seemed to benefit from the halo effect of attractiveness, at least not by the one arbitrarily given through the appearance in the second Study. It has to be mentioned, that the applied appearance was assessed as rather likeable in the pre-test and this might not have been attractive enough. However, the similarity principle can be based on various possible concepts, i.e. even attitudes perceived as similar can also motivate and persuade better (Fogg, 2003). Hence, a system perceived as more similar to one (or interpreted imaginary this way, without an apparently highly differing appearance), might have been involved even in terms of behavior of the system, nudging. Thus, although similarity was not measured in the present study, it can be considered, that the abstract system was perceived by the students as more similar to them due to the mere absence of a *dis*similar appearance; or even due to the imaginary more attractive appearance in the case of the abstract system. Following the idea of Silvervarg et al. (2013), undefined agent cues seemed to be beneficial to allow imaginary personalization, the abstract system was more persuasive than the personified one with an appearance.

Last but not least, the high persuasiveness of a system with minimum social cues supports the idea to design persuasive technology in a “boring” way, i.e. as familiar and

mundane as possible (Wai & Mortensen, 2007), which is barely considerable for all recipients of a certain appearance due to their various perceptions. However, the pretest of Study 2 did not explicitly focus on a less-exciting appearance (which will be discussed in detail among the future research recommendations in section 14), but rather on generally balanced instead of extreme character attributes, potentially also relatively boring – androgynous, less authoritarian, medium likeable, trustworthy, intelligent and helpful. Nevertheless, the content of the prompting messages was intentionally kept monotonous and included no changes except for synonymous paraphrases.

The benefits of personification over time and with equal participation

However, as relatively opposed to these general advantages of a system with minimum social cues regarding persuasiveness and overall satisfaction (with group work and assessed successful group work after all three tasks), the personified system increased the satisfaction with group work in the current task (here also explicitly the last) task by causing a more equal participation. Two additional aspects should be taken into account. First, the over-time analysis showed in detail a change and the solely occurrence of more equal participation in the last task. Furthermore, the different type of satisfaction should be considered. The abstract system improved the satisfaction across all three tasks, whereas the personified one improved equality of personification and satisfaction explicitly in the third, last task.

One possible interpretation of this constellation is the one-time occurrence of the later effect, which did not lever the overall higher satisfaction with group work with the abstract system. Another consideration can be that the contradicting findings may be an expression of a discrepancy between what participants answered when being asked explicitly about how they find the system and their actual behavior related to the perception of the system. On the one hand students seem to dislike personified entity to criticize them. On the other hand, especially this one seems to motivate them to contribute more when other group members already started, so that an equal participation is reached but not a higher amount of contributions with the one or the other system, keeping in mind that only the equal distribution of participation but not its amount changed with personification.

With regard to the expectancy violation theory (Burgoon & Hale, 1988), the abstract system as potentially less violating students' expectations, was assumed to have

an improving effect overtime. However, this was not the case. One possible argument for this finding is that expectancy violation theory which was postulated initially with regard to behavior and confirmed also regarding embodied agents and their appearance. Thus, expectations and violations can also be caused by less visual social cues of technology, for instance by its behavior or communication. Even though the expectancy violation theory assumed richer media to offer more potential for violations, the CASA principle in turn suggested, as mentioned above, that people infer social cues and personality to computer entities even if they are only computers (Nass & Moon, 2000). Students could have expected more interactivity or changing content of the prompting messages, which however was not the case in all three studies and may have violated their expectations, despite of the recommendations for "boring" persuasive technologies that are attempted to be followed within this dissertation (Wai & Mortensen, 2007).

11.3 The severe manner of communication

So far, the advantages of an abstract automated system as a prompt provider compared to other group members (Study 1) and compared to a personified system (Study 2) were discussed. However, students' behavior was barely affected, except for the distribution of participation, which revealed the importance of this variable as an outcome and simultaneously as a mediator. Thus, the promising abstract system was upgraded in order to combat participation issues in a more effective manner and improve the online collaboration. As inactive participants were not addressed explicitly so far in the first and second study, the communication manner of the system and especially interventions' severity was varied. To this end, along the prompts regarding unequal participation, the system employed vicarious punishment, i.e. demonstrated negative consequences for inactive group members (confederates) by criticizing them namely in public.

Participation equality

As mentioned, in the second study beyond conditions, the equal distribution of participation within the groups increased the satisfaction with group work and served moreover as a mediator between personification and satisfaction in the second study, highlighting its importance. The overall effect of participation equality was confirmed in the third study, as the search for more effective behavioral solutions was reinforced. This finding repeatedly revealed in study 2 and 3 of this dissertation and are in line with prior research suggesting this link (Zmud et al., 2001). It supports to certain extent the

correlational evidence in classic group work for dissatisfaction related to limited individual participation in larger groups (Patterson & Schaeffer, 1977). Beyond its crucial role, generally, the equality of participation can be seen also as a confirmation of the overall detrimental participation issues, as studies rarely distinguish between these dimensions of participation.

In contrast, the contribution amount did not differ in both field studies – neither depending on personification, nor on the severe communication manner of the system. Keeping in mind prior findings already indicated, that online instructions did not improve the quantity of contributions, but instead improved interaction quantity and the equality of participation (Miyazoe & Anderson, 2010). This indicates the contribution quantity as a more stable outcome, which might be hard to bias, as the real act of producing content and performing in online groups for example. The participation equality in turn is more dynamic and depends additionally on others' contribution, which can also be even more motivating to be a part of the performance – be it self-intended by willingness to compete or socially interact, or even involuntary after being nudged, partly confirmed in this dissertation. Last but not least, Miyazoe and Anderson (2010), which revealed in a comparison of online to face-to-face instructions and showed effects on equality of participation instead of contribution amount. Although vicarious punishment was not the topic in their study, the offline effects of vicarious punishment, which did not occur within online collaborating groups in this dissertation (Study 3), can be broadly considered to differ in an online setting. Nevertheless, as the interaction quantity was also improved with online instructions (Miyazoe & Anderson, 2010), and interaction is beneficial and needed for group development and generally for group work (section 1.2), this side effect would be welcome too and highlights once again the advantages of online collaboration and online instructions, to which automated prompting also broadly belongs.

However, the participation equality increased satisfaction with group work significantly merely in the second, i.e. last group work task within the experiment. As already outlined, this might be due to its occurrence as a one-time effect or also, as opposed, due to a certain minimum of time needed to start collaborating and especially, to get used to the prompting system. This time limit can more broadly be linked to the different evaluation and acceptance of nudging depending on users' experience, as it was shown that experienced users evaluate digital nudging more positively and accept prompting messages more compared to new users (Lidynia et al., 2019).

With regard to the severity of the prompting system, a negative effect on the equal distribution of participation was found when conditions with and without vicarious punishment were compared. The equality of students' participation shortly before the deadline was higher without vicarious punishment. The addition of transparency to the severely prompting system was also detrimental for the equality of participation, signaling that the more fear in the transparent condition yet impacted negatively the behavior i.e. the participation.

Taken together, participation equality increased the satisfaction with group work in both field studies within this dissertation (Study 2 and 3) and highlighted repeatedly the importance of this behavioral variable on a group level. Moreover, the equality of participation also mediated the effect of personification on satisfaction, demonstrating its potential as a tool for the interplay of other variables. In this case it even enhanced a positive path of personification to satisfaction via equally distributed participation, although alternatively the personification was a negative and non-significant predictor of satisfaction. However, both the severe communication and the knowledge about the system's functioning, i.e. transparency, had a negative impact on the equality of participation.

Nevertheless, the repeated measures indicated that severity with low transparency resulted in an improvement of participation equality after the second group task. In contrast, both transparent severity and no severity of the system resulted in more inequality after the second group task. Seemingly, the vicarious punishment developed within the repeated measures relatively as a motivator for more equal participation, while it did not when students knew more about its functioning or when the system did not communicate the potential negative consequences at all. This could be broadly interpreted as a link to the transparency paradox (Bernstein, 2012), according to which, observability reduces performance and will be discussed in detail in section 11.3.2.

However, with regard to stress, the opposite interaction over time emerged – severity, conflicting to transparent severity and no severity, increased the perceived stress within the group work. This finding indicates once again the differences between objective and subjective data and their potential interplay. These findings can be interpreted as somewhat confirmation of the experimental manipulation of severity over

time, as stress within groups increased when vicarious punishment was applied, although groups did not differ with regard to it.

Beyond the complexity of the participation equality as a variable on a group level and some limitations (see section 14), the additional results regarding severity and transparency have to be taken into account for better understanding and interpretation and are discussed in detail next

11.3.1 **Severity through vicarious punishment**

Further, with respect to the severe communication manner of the system, the vicarious punishment was employed to serve as an effective warning with rewarding effects among the remaining active members. It should increase the opposite of the punished inactive behavior, i.e. activity, as it was shown in offline settings in the realm of working psychology (Schnake, 1987). In contrast, although severe prompts were perceived as more constructive, the participation was less equal with vicarious punishment, and more equal without it.

The negative effect of vicarious punishment on participation equality and the missing effects on further behavioral outcomes are both contradicting to prior research, which demonstrated mainly the reduction of the criticized behavior due to vicarious punishment (Malouff et al., 2009). Therefore, the amount of contribution as a similar opposite of the criticized unequal participation and inactivity within the prompts, was further applied in a mediation model including the further relevant factors fear and login frequency. However, the assumed increasing effects did not emerge, which highlighted once again the complex links of objective and subjective variables within real groups as well as the need for an extension of the sample size, which is discussed as a limitation in section XY.

Nevertheless, an exploratory research question about further correlational relationships within the third study, revealed several additional relevant factors, but did not allow conclusions about the causality of the relationships between them, i.e. fear, logins and contribution. Beyond them, the mediation model yielded several significant links between the single variables, which are only to interpret with utmost caution as tendencies rather than as mediation results due to the various other impacts within the model. Thus, it is still worth to be mentioned that seemingly, students with more fear

contributed and logged in less, whereas, more logins increased the contribution. Moreover, within this model, the severity of the system only marginally significantly induced fear. As recommended, the punishment needs to be severe enough, for the mechanisms of vicarious punishment to function (Schnake, 1987), however the minimum has not been defined and could not be proven. This topic is discussed as a challenge for future work (section XY). Further characteristics of the automated prompted system like transparency indeed revealed to serve as a tool to induce more fear as discussed next.

11.3.2 **Transparency of the severe automated system**

Transparency revealed beneficial effects and generally contradicting results in prior research (e.g., Kizilcec, 2016 and section 7.1). Study 1 has shown that the past proficiency of nudging humans is crucial for the differences and equalities to technological nudging sources, and that the perceived fairness of prompts characteristics which count as past proficiency of the system are of interest. Thus, it was considered as a factor to enhance system's legitimacy to communicate in a more hostile, severe manner. This additional, legitimizing characteristic was applied additionally to the system's severity and revealed several effects. Students indeed perceived prompts in this case as more comprehensive, confirming the manipulation in Study 3. However, those who were better informed about the system, were also more afraid to get criticized themselves and perceived accordingly measures against inactive group members as less reassuring. Several explanations for students' increased feelings of fear based on more knowledge about the system could be considered: First, regarding students' actual or planned participation, second regarding systems' characteristics in terms of faultiness or even transparency itself.

Having interpreted vicarious punishment and generally the effects on participation against the background of transparency and increased fear, participation can also play another role in this constellation – as independent, interpersonally different variable. Indeed, over all conditions, a negative correlation was found in terms of decreased fear of students, when contribution and login frequency increased or vice versa (as correlational evidence can be interpreted in both directions). In this sense, it is possible that students generally planed less participation and contribution in this online course from the beginning and were more afraid, however the actual contribution did not differ depending on the transparency condition. Thus, the more fear of participants who knew

more about the system, can be related to their own participation only in terms of a plan or general intention.

With regard to the intention to imitate the inactivity of other group members, it did not influence the contribution and intention directly, but changed over time depending on the transparency. The severe communication manner of the system when transparency was added, contrary to low transparency, induces higher levels of fear and imitation of inactivity tendencies after the second group task. This confirms the changes over time stated by Pfeifer and Bockmore (2011) with regard to social responses to computers. Moreover, the changes might be related to the different perception of the system and its communication manner over time, probably related to a more or less violated expectancy. As outlined earlier (section expectancy violation), expectancies and their violation can, but do not have to be based on the appearance of the system and originates from behavior patterns during distancing (Burgoon & Hale, 1988). Thus, synonymous severe prompts by a system, without knowing its functions, could have reduced students' fear. On the contrary, knowledge about functionality could also have increased fear because they had more knowledge about the sources of to the prompts.

Nevertheless, further two over time interactions were found, which can be discussed with the focus on transparency. Participation got rather more equal with vicarious punishment, but less equally distributed without it and with transparency of the system. In contrast, over time, stress increased only with severity, while it decreased with a transparent system or without severity. This might indicate the smoother but still severe kind of prompting due to transparency, which as discussed above increased fear, imitation of inactivity and participation inequality after the second task, but decreased group-work stress. In contrast, the severe but low transparent prompting system increased stress within the group work, but decreased fear, imitation tendency and the inequality of participation at the end of the second task. These findings might be interpreted as transparency to be a smoother, but also scarier tool to reduce stress but not inequality of participation, as opposed to low transparent severe prompts, which were seemingly more stressful but still reduced fear, imitation and unequal participation. This interpretation can be in line with the recommendation for balanced interface transparency from Kizilcec (2016). Moreover, violated expectations were demonstrated to lead to less trust in system's outputs, unless the system was more transparent. In this study, the expectations and their violations were not measured, but potentially could be violated by the repeated

display of similar prompts and therefore indicate effects, which did not emerge as a difference between the experimental groups, for instance regarding stress and tendency to imitate inactive members. However, the latter might be less visible and yet relevant for students' behavior.

Additionally, correlations of the tendency to imitation of inactive members over all conditions need to be mentioned, even though they emerged not as a main effect of transparency but across all three experimental groups in Study 3. For instance, the positive link between fear and imitation of inactivity can be interpreted in both directions – from inactivity imitation to more fear but also vice versa. Indeed, this could be interpreted as a confirmation of the idea, proposed earlier (section 2.1), that the descriptive norms regarding others' ubiquitous behavior, could be detrimental due to the nudging acts, which remain of inactivity even more and make it more observable. In this case, over all conditions, i.e. all with prompts for the unequal participation and some even including more severe, namely emphasizing, might have been perceived as an obvious demonstration of others' inactivity, taken for "standard". Although general rules, i.e. injunctive norms, would be to participate and contribute within a group task, the conflicting descriptive, reminding inactivity, norms and the injunctive, pro activity norms, could weaken behavioral intentions (Smith et al., 2012). The intention related to the conflicting norms which occurs through nudging might be both positive and negative. Students could continue behaving according to the injunctive norms and contribute further, whereas weakening this intention would be detrimental. However, students can also develop the intention to "misbehave", be inactive, according to the more observable inactivity of others. Weakening this intention, on the other hand, would be helpful to keep students active and away from ideas of increasing inactivity as a norm or common behavior within group work. Possible solutions in this direction are discussed in the future research section (XY).

Intentions, however, can be hardly measured with regard to the topic and social desirability, since students would refer to their own, less fair and, to a certain extent, antisocial behavior within a group. However, beyond the measurement difficulties, intentions are of interest in this study and within the dissertation only as an explanation for potential behavior, but not explicitly considered as possible mediators. Therefore, also considering the situative, instable character of intentions, further system characteristics

might be more reasonable as an explanation for the increased fear with detailed knowledge about the system.

Transparency itself, by potentially fostering the understanding of the system and its perception as fair and accurate on a certain level, is able to induce positive and negative attitudes toward a technological entity (Kizilcec, 2016), and finally to assure users that they will not be exploited. However, it did not always have advantageous effects. For instance, Kizilcec (2016) demonstrated that when expectancies were violated, they led to decreased trust against the system, which could be fixed by transparency, unless in the highest transparency level. Too much transparency had negative consequences. Hence, it was recommended to avoid too much of it or to offer it in a balanced way. Students' fear in the transparent condition in the third study of this dissertation appear to be linked to these findings. Since transparency levels were not pre-tested and the sample size did not allow the application of a medium level between the high and low one. However, comprehension plays a significant role to proof the effect of transparency, and whether it opens the "black box" instead of reducing understanding, as it is supposed to (Kizilcec, 2016). In this dissertation, the high transparent prompts were perceived as more comprehensive than the low transparent ones. In contrast, in the referenced study, more comprehension was indicated in the medium transparent level than in the high transparent, which seemed to be confusing. Thus, the high transparency level in this dissertation was apparently moderate enough and successfully increased system comprehension. As the better understanding of the system may increase trust in it (DeVito, Gergle, & Birnholtz, 2017), but the system communicated in a hostile, more severe manner, trust could have turned to fear. Moreover, having persuasively outlined how the system functions and how it measures inactivity might have scared students generally. Indeed, according to the transparency paradox (Bernstein, 2012), the feeling of being "detectable", i.e. the observability counterintuitively reduced workers' performance. They were rather motivated to hide activities, even applying to this purpose means related to a loss of time and costs. Moreover, all participants were provided with a basic text briefing regarding the system functions and its calculation sources. It additionally differed more or less with regard to transparency information as planned for high and low transparency levels. The basic information might have been scary enough to let the students hide their contributions or even directly participate less. Neither transparency nor vicarious punishment revealed effects on "performance", here the

contribution, but both had a negative effect on the equality of participation and students were most afraid in the high-transparency condition, fitting well the privacy paradox (Bernstein, 2012).

Nevertheless, another system characteristic may be interpreted as responsible for students' fear – the faultiness of the system. Keeping in mind the findings of the first study and the importance of students' past proficiency regarding the perception of the nudging sender and its messages, faultiness can be interpreted as a past proficiency characteristic on a system level, signaling its credibility and accurate actions for instance. According to Fogg (2003), psychological cues as a subtype of social cues can be included in a simple message line to signal empathy or convey a personality in a more complex way, which appears after a minimum duration of interaction with the technology. As an example, "a computer that keeps crashing may convey a personality of being uncooperative or vengeful" (Fogg, 2003, p. 94) and erratic technologies were shown problematic with respect to several outcomes, as discussed in the next paragraph among the overall relevant factors. Additionally, the imitation tendency to inactivity was linked to other prompts' characteristics – positively with faultiness of prompts but negatively with their objectiveness. This confirms the outlined complexity of the reasoned action approach (Fishbein & Ajzen, 2010), which can be used to explain group work dynamics also involving and interpreting nudging in the right frame. Thus, there is big potential of perceived norms to impact the intentions, and hopefully overall also the behavior.

11.3.3 **Fear, hostility and other factors relevant independent from conditions**

Additionally, in the third study, several relevant factors independent of the conditions were explored and correlational evidences were found. For instance, links between more fear to get publicly criticized and the perception of prompts as less objective and faultier confirm the explanation of fear to be related to faultiness of the system outlined in the last section. Especially the more knowledge about the system and its "advanced" methods might have turned participants to try to test and play the system, to challenge its real functions, as they got to know them in detail. Participants might have noticed that being inactive themselves did not lead to negative consequences, compared to others (confederates), who were criticized by name in each group. This might have served as an evidence that the system has indeed less abilities than they were informed about, reduce their trust and let them believe the choice to "punish" one is either random or mistaken.

Whether it was users' believe or actual errors of the system – human-computer interaction can be influenced by errors of the technology and were broadly shown detrimental especially for trust in the system, which could be crucial especially in the case of nudging, as the system even dares to criticize one. Indeed, humans' perception of the machine is affected in a more severe and long-term way by an accumulation of small errors rather than one single big error (Muir & Moray, 1996), which would rather be the case with the nudging system and eventually "wrong" choices who to emphasize. Moreover, it was shown that errors' frequency and significance have an influence on humans' trust even in an imperfect online system, i.e. users did not want to follow an imperfect robot if there were serious consequences for the users in real life (Wang, Pynadath, Unnikrishnan, Shankar, & Merchant, 2015). Controversially, research on human perception of trust in robots showed that even when they were showing faulty behaviors, no matter how erratic they actually were, participants still followed robots' instructions (Salem, Lakatos, Amirabdollahian, & Dautenhahn, 2015).

Indeed, besides the influence on trust in the technological entity, the faultier prompts were perceived, the more hostile too, indicating the importance of the accurate functionality of the system or at least users believe to be so. This correlation might be discussed as idiosyncrasy credit (Hollander, 1958) of the system instead of the classic concept with regard to humans, giving them the right to deviate from the norms after following sufficiently before. The more one has earned regarding idiosyncrasy credit, the more he or she is allowed to act contrary to the rules without negative consequences. With regard to faultiness, prompts were perceived more hostile too, however, certain characteristics could replace the positive "proficiency" of the system, signal expertise and credibility, legitimating the system to criticize at all and even emphasize inactive team members by name. Contrary, a discredit, as a kind of a system's negative proficiency can be expected if prompts are erratic or perceived this way.

Furthermore, students reported to be more likely to imitate other inactive teammates with the higher perception of faultiness. This may be interpreted as an act of discrediting the automated prompting system. Moreover, the system should persuade group members not to quit participating and should demonstrate active means against inactivity for students to trust it and its accurate functions. Thus, it might be less promising if the whole system is perceived as erratic, not functioning well and related to that also as (too) hostile.

Group dynamics

Further relevant factors for group dynamics which can help to better understand group work as an overview should be mentioned. As was noted in the theoretical framework of this dissertation (section 1), participation issues endanger group work, development processes and performance. Indeed, the exploration of overall relevant factors within the group work confirmed many of the elaborated problems and potentials so far. For instance, prompt's faultiness, which was discussed in the previous section as potential past proficiency of the system correlated also with in-group conflict, which on the other hand was negatively linked to satisfaction with teamwork. Thus, nudging, which can be interpreted as a task conflict, develops into a personal one and endures detrimentally (Janssen et al., 1999; Tuckman, 1965), can be seen similarly as negatively linked to satisfaction. The satisfaction in turn was positively related with others' helpful contribution and negatively with conflict, coordination stress and the perception of inactive members (as disliked peers, disliked compensation of their inactivity and the tendency to imitate them). In terms of coordination stress, linked negatively to satisfaction, its longer duration or barriers due to missing participation can also endanger early coordination, which beyond this was demonstrated as a crucial negative indicator of productivity and participation distribution (Doberstein et al., 2019).

Especially the tendency to imitate other inactive group members as a behavioral intention, seems to be overall related to the satisfaction. This finding highlights repeatedly the importance of satisfaction and its links with more behavioral outcomes, as stated earlier and confirmed here – individuals' attitudes towards behaviors can be related to satisfaction (e.g. Ku et al., 2013). Taken together, the intentions beyond the attitudes, as discussed earlier in this section (e.g. general discussion of transparency section), seem to be promising for the actual behavior and partly related to the communication manner of the system.

According to the link between participation and contribution, as elaborated already in the beginning of this dissertation, group work requires participation not only as a minimum base for performance at all but also depends on group development processes and vice versa – group development processes depend on the participation (Walther & Bunz, 2005). Accordingly, the overall relevant factors which emerged in the third study showed several significant relations with the objective behavior. The more

frequent logins, the more contributions and the less fear were perceived by the students. The link between participation and contribution confirmed prior research indicating the low level of participation as a main difficulty in CSCL, and moreover, participation as highly important and increasing productivity, but also the perception and results of learning, as well as the evaluation of results' quality and of course satisfaction (Chavez & Romero, 2012).

Last but not least, the more in-group trust, the more satisfied were the students with group work and vice versa, which also highlights the importance of group-development processes. Furthermore, the more students contributed, the less hostile their perception of prompts was and vice versa – the more hostile they perceived the prompts, the less satisfied were the students. This can be interpreted as potentially linked to the time and effort students have invested each personally. The more students participated themselves, the worse and more unfair they might have perceived others' inactivity, and therefore perceive prompts highlighting these inactive teammates (even though, they partly included the possible negative consequences for them), indeed not as significantly "more legitimate", but instead as less hostile.

Nevertheless, an issue has to be mentioned when discussing any results related to the equality of participation (Study 2, 3). Participation equality showed an interaction with personification over time, which revealed the difference to be especially in the last task, as participants in groups with a personified system participated more equally, while those with an abstract system did not. Even though, all analyses referred to the last task, as students were expected to need a sufficient amount of time and interactions with the system, the long-term analysis identified this turn. Beyond the assumption that effects emerged later, towards the last task, it should be mentioned that there is a probability and an extraordinary event cannot be completely excluded. Moreover, keeping in mind the explicitly small sample sizes which could be applied for the repeated measures and the Gini coefficient, which is calculated on a group level.

In order to recapitulate the generally discussed results, Figure 17 shows the modified overview model of the empirical approach, which was already displayed in section 5. Having laid the motivational and the theoretical foundations of this dissertation as well as the empirical approach and results of the three studies in detail, the updated version of the model includes the complete operationalization, the main findings and their

interactions. Keeping this overview in mind, in the following the theoretical, methodological and practical implications of this dissertation are discussed, followed by some limitations and considerations of the application of this knowledge in future research and real life are discussed.

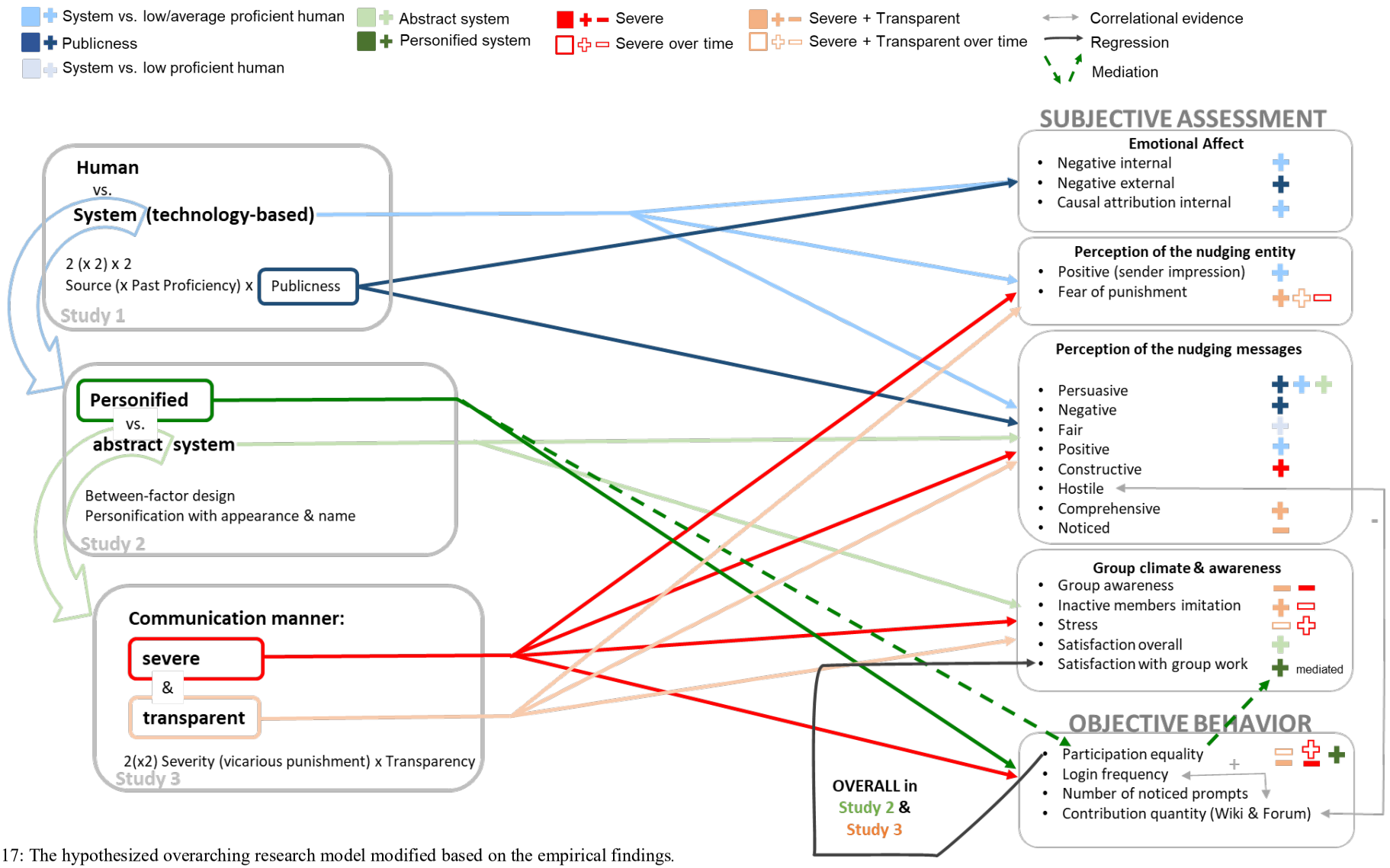


Figure 17: The hypothesized overarching research model modified based on the empirical findings.

12 Theoretical implications

The main theoretical implication of this work is that it identifies the nudging phenomenon, which is barely defined within group work, especially regarding the source of prompting and the differences compared to an automated nudging system. Consequently, current knowledge regarding group work phenomena is collated and broadened. In this specific case with the focus on the improvement of automated prompting, the media equation theory of Reeves and Nass (1996) is re-examined, as well as the impact of certain social cues such as appearance and communication manner.

Originally, the media equation postulated that the interaction of humans with technology are equally perceived as human-human interactions. In this dissertation, however, nudging by humans compared to an automated system revealed to be equal only in case of high proficient team members. Low and average proficient team members were less beneficial than an automated prompting system. Consequently, mixed results occurred with regard to the media equation theory.

On the one hand, the media equation theory was supported, as messages from the system were perceived equally to those from a high-proficient team member. Furthermore, the personification of the system was not more beneficial. This indicates that the minimum of social cues could be sufficient in terms of persuasiveness and overall satisfaction, respectively the abstract system was even more beneficial in contrast to the social cues/agency theory (Mayer, 2005; Moreno & Mayer, 2000). In particular, the more social cues of a system, like an appearance and a name, did not impact its perception as more social.

On the other hand, contradicting the media equation theory and CASA principle, a system was perceived differently, i.e. even more beneficial than average and low proficient team members regarding persuasiveness, positive messages, positive sender impression, causal internal attribution. But the system was also partly perceived negatively with regard to the emotional internal affect, probably due to guilty feelings, i.e. the higher internal causal attribution effect. Furthermore, additional social cues in terms of the communication manner as a part of the behavior of the system matter, even though other social cues, such as appearance and name of the system, did not. The transparency of a more severe prompting system as well as its faultiness seem to be crucial

additional factors. Taken together, distinct categories of social cues operate in different ways, and induce different outcomes for users' perception and group processes. Therefore, it is highly relevant to distinguish between various types of social cues on a theoretical level in order to understand computer supported collaboration holistically. This theoretical differentiation is a precondition to derive practical implications for improving online learning group work.

Furthermore, another main theoretical implication of this dissertation is the consideration of mixed realms instead of solely learning outcomes or social factors. For instance, the mere focus on performance reduces the insights on the potential reasonings for dissatisfaction, intentional and motivational gaps. This is given through addressing the social-psychological view on online learning groups and nudging, combined with pedagogical ideas as well as the media-psychological view regarding the communication with and perception of an automated support system (media equation theory). Thereby, diverse relevant factors and characteristics are summarized – those, involved in students' intention and behavior within groups as well as factors crucial for the perceived persuasiveness of support and consequently the willingness to follow system prompting messages. Within the three studies past proficiency and publicness determined the equality of human-human and human-computer interaction and improved persuasiveness, whereas personification did not reveal to be additionally beneficial for an automated system. The amount of contribution was barely biased by other factors than the hostility of prompt messages within a negative correlation. Nevertheless, the equal distribution of participation within groups revealed as a mediator towards higher satisfaction and impacted by the severe communication manner of an automated system and its' transparency.

From a methodological point of view this dissertation contributes to prior academic research on collaboration as it expands the methods of investigations in this realm by collecting mixed data types, connecting and analysing them. This solution improves previous methods which mainly employed subjective, survey generated or merely qualitative data, which is frequently even interpreted for conclusions regarding group processes. However, group dynamics could be clearly misinterpreted and insufficiently verified without behavioral data due to the gap between qualitative data, intentions and, on the other side, real experiences (e.g. Ayoko et al., 2012). In contrast, directly stored data from the interactions can be promising to detect hidden schematics.

Moreover, behavioral data of online learning groups are scarcely utilized, even though they are promising for a process-related examination of group dynamics and for deeper understanding of their basic causes and consequences. Moreover, repeated measures in a longer period of time rather than the ubiquitous solo, stand-alone experiments valorize the method allowing to observe the development of groups over time or at least more generalizable results.

13 Practical implications

The main practical implication of this dissertation is the identification of specific automated support for online learning groups to assist students by relieving them of the demanding role of a nudging source. Due to participation issues, teammates need to be prompted, however this can be challenging among group members in terms of task and personal conflict, reciprocal disliking, potentially impeding interpersonal relationships and group development processes, as already elaborated in section 2.2. Especially being usually the one in charge of nudging, as a one-sided shared regulation attempt, is ineffective and moreover a struggle at a student and lecturer level. This role should be undertaken externally by an automated entity instead of teammates. In the specific case, an automated entity signals visually the variable of interest, e.g. participation, and relieves group members of the nagging task as well as of its consequences by prompting.

According to the findings of three empirical studies in this dissertation, the prompts from an abstract prompting system are indeed more beneficial compared to those sent by group members. Moreover, with this knowledge, further questions arise with regard to the beneficial adjustment of the automated support. This dissertation provides answers to this question in two directions – with regard to the prompting system as well as to the prompting messages separately.

Particularly, public rather than private messages are perceived more persuasive. Therefore, the system should criticize on a group level, visible for others to unfold its full potential. Although personification revealed partly positive impact on satisfaction with group work within single tasks, an abstract automated system was more persuasive and overall satisfying. Hence, the implied system does not need a concrete appearance to persuade the users. Against the assumptions of this dissertation the severe communication (vicarious punishment) neither low nor high transparent improved contribution. However, transparency revealed to be a crucial characteristic. An automated system should provide

transparent feedback because it was shown that it increases the fear to get criticized. This indicates the potential of a severe but transparent communication manner to improve participation over time. Additionally, a negative relation overall between prompts' hostility and contribution was shown, indicating the importance of a non-hostile system. Similar solutions could be implied for any group work and alternative outcome variables depending on the desired improvement within e-learning groups, for instance time management et al.

14 Limitations and future directions

Some limitations of this dissertation have to be acknowledged regarding the generalizability of the results. The small sample size should be considered as an unavoidable limitation of field settings, which underpowered the statistical tests. With a small sample size, caution must be applied, as the findings might not be transferable, however field experiments in the realm of education are typically facing such challenges. But they are still the sole option to deliver authentic behavioral data, which makes them worthwhile even against the background of small and varying sample sizes. Consequently, these challenges did not allow a multilevel analysis or a "zero-treatment" control group – both recommendable to be considered next. In both field studies twice as much participants were planed per condition in order to solve the issues related to the small sample size and low retention rates in an online course. However, this calculation turned insufficient. Future studies should be conducted within real MOOCs with a minimum of three to five times more than the recommended number of participants per condition, as a prevention of high dropout rates. Experimental within-designs rather than between-designs could be applied to additionally reduce the required sample size. Nevertheless, methodical alternatives also bare different other risks and demand characteristics, like within-designs with respect to learn effects and habitualization. Thus, a universal methodical solution of these challenges is yet unknown.

Except for the first study, which was conducted online and aimed to collect data from various target groups for the initial comparison of interactions between human and technological nudging, the topic of this dissertation generally refers to online learning. Hence it was appropriately tested on participants who were merely students and of the same age in Study 2 and 3. However, due to the particular course and topics in both field studies, results are not broadly generalizable as results from courses in various realms and

organizations could be. Therefore, future research should focus on more variety in this realm. Furthermore, the repeated measurements in the last two studies were within three, respectively even two group tasks instead of a whole course. A longer period could be beneficial to earn more important insights into the development of system perception, its disadvantages and potentials especially to prevent dropout in the long term. Nevertheless, also due to the repeated measures within field settings, many one-item variables had to be adapted in this context in order to make the repetition of surveys more acceptable for the students. However, more balanced solutions should be considered in the future.

The combination of both data types, survey based and behavioral, is a clear methodological advantage of this work. However, an upgrade of further qualitative data could offer even deeper insights into the group dynamics and already started. Moreover, semantic real-time analyses of contributions as well as forum content could be applied in order to adjust the prompting even more precisely and effectively, depending on the topics and events within single groups. Furthermore, the application of physiological measures via users' own smart devices to collect such data could be an additional way to collect additional, highly reliable data and to reduce the length of the surveys when it comes to emotional affects for instance.

Regarding the dependent variables, it needs to be taken into account that the equality of participation is a variable on the group-level, calculated equally for each member of the same group. Additionally, as it refers to the cumulated proportions of contribution within a task until a concrete day before the deadline, at least it offers a more general calculation over the duration of group work so far instead of the contribution in a single moment. Although the assumed effects on contribution did not occur through vicarious punishment, the mediation model(s), and especially the one in the third study, including vicarious punishment, fear and login frequency showed several, nearly significant indirect effects. The complexity of the links between objective and subjective variables, and moreover the need for an extension of the sample size were highlighted this way. Additionally, further dependent variables could be helpful to better explain the variance in the model. Persuasiveness, for instance, was identified to vary in the first and second study, depending on the automated prompting system and its characteristics. This variable was disregarded in the third study of this dissertation, as the focus was mainly on behavior and participation through severe communication of the system. However, as transparency and severity of the prompting system barely influenced the contribution, but

instead showed contradicting results with regard to the equality of participation, persuasiveness may be considered as related to the effects. Therefore, future research should additionally focus on such factors which can potentially explain the differences.

The intentions of the students were barely measured in this dissertation, despite of their tendency to imitate inactivity in the third study. However, as a crucial factor for the actual behavior in online learning, they should be included in future research. Moreover, the conflicting descriptive and injunctive norms within groups should be investigated in detail, since they were considered as an option to weaken intentions. The interaction of prompts on participation issues, i.e. signaling to warn but potentially also turning the focus on inactivity, its impact on group norms and the resulting, instable intention of single group members, should be focused in the future. This might be done by concrete, iterative real time measures of all the variables. Personalized adjustment of the support system and its severity, depending on the intentions of the students, could be beneficial, especially as it can be done automatically. This way, positive intentions could be promoted, whereas students intending to participate less, could be prompted in a more severe way, potentially taking into account the perceived group norms.

Furthermore, the expectancy violations of the users could explain the assessment of the system as decreasingly good willing over time. This effect, although it emerged independent of the experimental conditions, as well as the partly contradicting personification effects could have emerged due to expectation violations of the students – not only with regard to its appearance but also with regard to its behavior or interactivity level as well as development or habitualization over time. However, expectations were not considered due to the restrictions of the amount of survey questions to be replied by the students after each group work task. However, the expectations, measured in advance and regularly after group work, especially in the long term, can be helpful to explain the perception of additional social cues such as appearance and name or a different communication manner within the second and third study of this dissertation. Future work should take them into account.

Within this dissertation, the dropout rates were not considered specifically as an outcome. The major difficulty for the analyses of dropout rates are differences in the courses and most of all in the participants, whose personal context and preferences should be taken into account. Keeping the sources of these variables on a comparable level is

among the main challenges for dropout investigations. However, as outlined earlier (section 1), the advantages of improved interpersonal relationships and group dynamics should be considered as an overarching aim of prompting systems. Future work is needed to explore their impact in the long term.

With regard to the social cues/agency theory and the function of a prompting system as a simple information sender – when less socially perceived – as well as the recommendation for "boring" persuasive technology, both should be considered at least in pretests in future research. This method could enhance the balanced adjustment of social characteristics. Especially long-term investigations within real courses could help prepare recommendations for the design of a system, as courses regularly have longer duration and cross-sectional effects can be considered or even better extended this way. Nevertheless, prompting systems and their prompts should be upgraded in order to be likeable instead of hostile, however, too monotonous contents might be better for usability and less attractive. Therefore, experiments on this balance are needed. Moreover, as the result revealed differences between the categories of social cues and their effects, further investigation is needed to compare systematically various kinds of social cues and their effects in the context of automated prompting systems.

Overarching, the combination of educational and research activities raises some questions from methodological and ethical perspective. Participants could have assessed the participation at the experiment as obligatory, even though they were informed in advance about the independence of the course and the accompanying research setting. Additionally, students could doubt the anonymous participation at the experiment along the course. They could therefore feel obligated and consider an influence on their course grades. This combined with the presence of the researchers as teaching staff could result in socially desirable answers and even behavior, since participants were also informed, that the behavioral data is being logged on the learning platform. The survey questions were also focused on group work and related problems and asked regularly in real time. Questions about these issues might draw students' attention in a certain direction, potentially influencing group work behavior or assessment on an unconscious level.

Additionally, from the ethical perspective, participants could doubt that participation is absolutely voluntary and anonymous. This was highlighted in various messages per e-mail and prompts on the learning platform in the field experiments in this

dissertation. The addition of an explicitly written consent to be signed by the students can also be applied in the future. The teaching research teams need to be handling ethically too while operating with the software. Tasks should be divided between several responsible parties in order to guarantee in advance the secure, anonymous processing of the data. Such divided instead of centralized responsibilities, adopted also during the field studies of this dissertation, eliminate every possible access to the data and enhance mutual control among the responsible parties.

In contrast to the outlined potential disadvantages, the combination of research and teaching also bears several advantages. It enhances long-term participation of the students and their availability for reminders per email for instance integrated in other course related newsletters and deadline reminders. This way the students were repeatedly reminded that both the course and the accompanying research are absolutely independent, anonymous and voluntary, and the course can be attended and completed without research participation. This was also preferred by some course participants indicating that this option was clearly available but needs to be highlighted explicitly. Additionally, the presence of the researchers as a teaching team can also be seen as an advantage of this method. Moreover, participants' actual responsibility to support a scientific project with their participation is more visible and concrete with a nearby existing research team, compared to online studies of unknown, less realistic and less present researchers. Additionally, the significance of students' participation as help for scientific solutions to be found for similar group work settings in the future was repeatedly highlighted in parts of the learning videos regarding the course schedule and other organizational topics. Knowing the real humans behind research could have been more motivating for participants to do all the surveys. Taken together, beyond the discussed concerns, the benefits of the integration of research into teaching courses far outweigh the disadvantages, especially due to the enhancement of real learning and group work circumstances, i.e. realistic rather than laboratory conditions as a main advantage of this method.

The effectiveness of severity via vicarious punishment, as well as some ethical questions should also be considered in detail. First, the severity of the system only marginally significantly induced fear. Moreover, the negative effects of fear on the login behavior and the less fear through the severe but low transparent system could be interpreted as a limitation in terms of less threatening vicarious punishment than needed

to enfold its potential. Indeed, students with more fear contributed and logged in less, while more frequent logins were related to more contribution. However, as the required minimum of severity was not defined in the classic concept of vicarious punishment, its investigation within both offline and online settings could be helpful. A recommendation how much severity promotes contribution without frightening the students too much should be given.

Second, the ethical point of view on explicit (des)information of the students should be considered. Severe communication of the system employed as vicarious punishment contradicting to the assumptions and findings of prior research within offline settings, did not increase the amount of contribution as expected. However, there were mixed results with regard to the inequality of participation. Cross sectional data revealed more unequal participation with vicarious punishment (vs. without) and with high transparency of the system (vs. low transparency). However, high transparency revealed students to be more afraid of getting criticized too. Moreover, additional tendencies emerged over time, partly in contrast when comparing the sever communicating system with high and low transparency. After the second group work, the fear but also imitation of inactivity and inequality of participation were higher, while stress was lower with high transparency, whereas the opposite was true for the low transparent system – stress was higher, while fear, imitation and inequality were lower.

Thus, the initial effects changed within two group tasks and a severe system with low transparency might be recommendable for more equal participation, however, it also induced more stress and revealed less equal participation in the first task than a system without vicarious punishment at all. Future work should investigate these effects within a longer period of time in order to recommend the best solution for participation and stress or differ between them. This way, teaching employees could chose the automated system and adjust it beneficially for their own purposes. However, from an ethical point of view it should be considered whether the costs of students' increased fear should be taken into account for the benefits of less stress. Otherwise, a severe but less transparent system, which indeed revealed more equal participation over time could be rather recommended. Furthermore, ethically it is questionable whether the functions of the system in terms of which data is collected, what is analyzed etc., which seemed to induce more fear, could and should be hidden from the students. Nevertheless, the negative correlation of hostile perceived prompts and contribution should also be taken into account. Apparently,

generally more hostile prompting messages are detrimental for the contribution amount, hence the impact of transparency on messages' hostile perception should be focused additionally. Leaving teaching employees to decide about these ethical questions might be difficult and potentially dangerous for students' basic rights of fair information access. A mixed solution could be best and should be investigated within a larger sample and a longer period of time as well as various course structures, e.g. blended learning courses. Moreover, various target groups beyond the context of the university are of interest since online learning is increasingly applied for self-improvement aims and for professionals' upskilling in companies.

15 Conclusion

Nudging within e-learning groups is needed, but potentially challenging among group members and can be therefore undertaken by an automated system to avoid interpersonal disadvantages and still prompt students to participate. Thus, the overarching aim of this dissertation was to investigate this role reversal as well as the system characteristics personification and communication manner in order to extend the knowledge about their effective, persuasive adjustments for higher satisfaction and participation. Therefore, in an online experiment and two field studies, subjective measures like the perception of the nudging source, messages, emotional affect, as well as objective behavioral data were collected and analyzed.

Results suggested that the abstract system and its prompts were perceived equally to high-engaged teammates but as more persuasive and positive, compared to average and low-engaged teammates. Overall, public prompts were perceived as more persuasive but also as more negative. As these results suggested, an abstract system with public prompts is promising and should be applied in following studies. The personification with an appearance and a name barely improved nudging, however, solely mediated by the equal participation it was satisfying within a group task. In contrast, the abstract system was more persuasive and overall satisfying. Thus, as more beneficial, the abstract system was further manipulated in terms of a severe communication manner and system transparency as potentially legitimizing it. However, the severity of the system applied as vicarious punishment did not improve the amount of contribution as expected, but rather negatively influenced the equality of participation – inequality was higher with a severe prompting system, but got more equal over time, opposed to the increased inequality

over-time with a transparent prompting system. Transparency seems to be a crucial characteristic of the system, as it induced more fear but also increased students' tendency to imitate inactivity. Nevertheless, in both field studies with an automated prompting system the equality of participation increased the satisfaction with group work, confirming the importance of behavioral outcomes for the subjective assessment of group work. Moreover, this finding demonstrates explicitly the significant role of equal participation for satisfying group work and respectively the need for prompting towards its improvement.

The main implication of this work is the identification of the influencing factors of the nudging phenomenon in online learning groups and the potentials of automated support to release group members of the consequences. In this context, the media equation theory and the social agency/cue theory are re-examined, both partly supported, since the equal perception of interactions with technology and humans as well as the role of additional social cues revealed mixed results depending on humans' past proficiency, respectively on the category of social cues and further factors. Nevertheless, the main methodical advantage of this work is the combination of objective behavioral data and subjective survey-based assessments within real online-courses which were collected repeatedly across two, respectively three group tasks. However, related to this advantage, unavoidable field setting difficulties occurred regarding a rather small and varying sample size in two of three empirical studies. Therefore, future research should consider MOOCs with even more course participants in order to extend the knowledge on automated prompting systems and the role of further social cues categories.

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Declaration of independent authorship

Erklärung über die eigenständige Verfassung der vorgelegten Dissertation

Hiermit versichere ich, dass die vorgelegte Dissertation, gemäß §9 der Promotionsordnung der Fakultät für Ingenieurwissenschaften der Universität Duisburg-Essen vom 06. August 2015, eine selbstständig durchgeführte und eigenständig verfasste Forschungsleistung darstellt und ich keine anderen als die angegebenen Hilfsmittel und Quellen benutzt habe. Alle Stellen, die wörtlich oder sinngemäß aus anderen Schriften entnommen sind, habe ich als solche kenntlich gemacht. Die Arbeit lag weder in gleicher noch in ähnlicher Form einem anderen Prüfungsausschuss vor.

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DOI: 10.17185/duepublico/74927
URN: urn:nbn:de:hbz:464-20211110-155401-0