Conceptualizing and Supporting Awareness of Collaborative Argumentation

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Ithaka by C.P. Cavafis

As you set out for Ithaka

hope your road is a long one,

full of adventure, full of discovery.

Laistrygonians, Cyclops,

angry Poseidon—don't be afraid of them:

you'll never find things like that on your way

as long as you keep your thoughts raised high,

as long as a rare excitement

stirs your spirit and your body.

Laistrygonians, Cyclops,

wild Poseidon—you won't encounter them

unless you bring them along inside your soul,

unless your soul sets them up in front of you.

Hope your road is a long one.

May there be many summer mornings when,

with what pleasure, what joy,

you enter harbors you're seeing for the first time;

may you stop at Phoenician trading stations

to buy fine things,

mother of pearl and coral, amber and ebony,

sensual perfume of every kind—

as many sensual perfumes as you can;

and may you visit many Egyptian cities

to learn and go on learning from their scholars.

Keep Ithaka always in your mind.

Arriving there is what you're destined for.

But don't hurry the journey at all.

Better if it lasts for years,

so you're old by the time you reach the island,

wealthy with all you've gained on the way,

not expecting Ithaka to make you rich.

Ithaka gave you the marvelous journey.

Without her you wouldn't have set out.

She has nothing left to give you now.

And if you find her poor, Ithaka won't have fooled you.

Wise as you will have become, so full of experience,

you'll have understood by then what these Ithakas mean.

C. P. Cavafy, "The City" from C.P. Cavafy: Collected Poems. Translated by Edmund Keeley and Philip Sherrard. Translation Copyright © 1975, 1992 by Edmund Keeley and Philip Sherrard. Reproduced with permission of Princeton University Press.

Source: C.P. Cavafy: Collected Poems (Princeton University Press, 1975)

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Almost four years ago, I set out to on a journey to find my own research “Ithaka”. This dissertation signals the end of this journey. It was a journey full of adventure and discovery and along the way I had help from of a number of people that I would like to acknowledge here.

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I would like to dedicate this dissertation to my late grandfather, Manolis, who passed away last year. You were my number one supporter!

Maria Fysaraki

25.12. 2017

Statement of Collaboration

This thesis presents the results of the research I carried out between April 2014 and April 2017. However, this work would not have been possible without scientific cooperation with my supervisory team and with students of Media Informatics Department at LMU. I decided to acknowledge this cooperation by using the scientific plural throughout the thesis. All chapters present original content which was exclusively written for this thesis except for chapter three. In chapter three, parts of the text on related work, study methods and results are based on papers which I have published in the proceedings of two international peer-reviewed conferences (Fysaraki & Hussmann, 2016; Fysaraki, Fischer, Hußmann, & Stegmann, 2016). The co-authors of these papers offered valuable insights for the analyses of data and the interpretation of the results. Moreover, they have co-reviewed the related work parts of the papers.

In addition, some projects were supported by the practical work of students which was carried out under my constant supervision and guidance. The following two sections point out the concrete contributions of the students in the second and the third study. Detailed descriptions of these studies can be found in the chapters four and five respectively.

Chapter 4: In this chapter we describe the study design, the methods and the results of the study on "Awareness scaffolds for role-based collaborative argumentation". In terms of this study, I collaborated with Mrs. Carola Meier, a master student in Media Informatics at LMU. We co-created the material of the study i.e., problem cases, argument script cards and training material for the use of argument maps in Rationale. Mrs. Meier was responsible for the implementation of the role-based awareness visualization prototype and the role-based awareness reminders. She was also acting as an experiment facilitator together with me. The work was relevant to her in terms of her master thesis on conceptualizing a group awareness tool for social and behavioral group awareness (Meier, 2017). Thereby, she carried out a preliminary qualitative content analysis on the effects of the tools on the role-specific behaviors. Moreover, she analyzed the user experience with the tool based on the feedback data. In terms of this thesis, I utilized parts of the results of her analysis on user experience with the tools. The analysis of effects of the tools on role-specific behaviors was carried-out again by me. Thereby, her notes and coding-scheme for the qualitative content analysis formed the basis of the final coding-scheme.

Chapter 5: In this chapter we describe the study design, the methods and the results of the study on "Ubiquitous Media for a Role-based Awareness Notification System". In terms of

this study, I collaborated with Mrs. Tatjana Hinfner, a bachelor student in Media Informatics at LMU. Mrs. Hinfner contributed in the material of the study i.e., problem cases, argument script cards and training material for the use of argument maps in Rationale. She was also acting as an experiment facilitator together with me.

Together with Mrs. Hinfner, we created the prototypes for the awareness notification on the smartwatch and smartphone. She was responsible for the implementation awareness notification prototype on the smart-ring. She conceived, designed and implemented this prototype in terms of her bachelor thesis on the evaluation of mobile devices as awareness notification systems in CSCL Hinfner, (2017). In her thesis, Mrs. Tatjana has performed an analytical assessment of the awareness notification system from the second study with respect to the action models of IRC framework, which informed the design of the third study in this thesis (Hinfner, 2017). Moreover, we collected the questionnaire data on the use and the experience as well as qualitative data (i.e., video data) on the reactions to the tool together. However, the analysis by Mrs. Hinfner focused on the qualitative data (i.e., video data) for calculating the Interruption Reaction C values of the three prototypes. The results of this analysis were not included in this thesis. Finally, she performed her analysis of the user experience data which formed the basis of my analysis.

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Summary

In this thesis, we introduce "Argue(a)ware"[1]. This is a concept for an instructional group awareness tool which aims at supporting social interactions in co-located computer –supported collaborative argumentation settings. Argue(a)ware is designed to support the social interactions in the content (i.e., task-related) and in the relational (i.e., social and interpersonal) space of co-located collaborative argumentation (Barron, 2003). The support for social interactions in the content space of collaboration is facilitated with the use of collaborative scripts for argumentation (i.e., instructions and scaffolds of argument construction) as well with the use of an argument mapping tool (i.e., visualization of argumentation outcomes in a form of diagrams) (Stegmann, Weinberger, & Fischer, 2007; van Gelder, 2013). The support for social interactions in the relational space of collaboration is facilitated with the use of different awareness mechanisms from the CSCL and the CSCW research fields (i.e., monitoring, mirroring and awareness notification tools).

In this thesis, we examined how different awareness mechanisms facilitate the regulation of collaborative processes in the relational space of collaborative argumentation. Moreover, we studied how they affect the perceived team effectiveness (i.e., process outcome) and the group performance (i.e., learning outcome) in the content space of collaboration. Thereby, we studied also the effects of the design of the awareness mechanisms on the application of the mechanisms and the user experience with them. In line with the design-based research paradigm, we attempted to simultaneously improve and study the effect of Argue(a)ware on collaborative argumentation (Herrington, McKenney, Reeves & Oliver, 2007). Through a series of design-based research studies we tested and refined the prototypes of the instructional group awareness tool. Moreover, we studied the ecological validity of dominant awareness and instructional theories in the context of co-located computer-supported collaborative argumentation.

The underlying premise of the Argue(a)ware tool is that a combination of awareness and instructional support will result in increased awareness of collaboration, which will in turn mediate the regulation of collaborative processes. Moreover, we assume that successful

[1] The name "Argue(a)ware" comes from the combination of the verb "to argue" and the noun "awareness".

regulation of collaboration will result in high perceived team effectiveness and the group performance in turn.

In the first phase of development of the Argue(a)ware tool, we built support of the content space of collaborative argumentation with argument scaffold elements in a pedagogical face-to-face macro-script and an argument mapping tool. Furthermore, we extended the use of the script for supporting the relational space of collaboration by embedding awareness prompts for reflecting on collaboration during regular breaks in the script. Following, we designed two variations of the same pedagogical face-to-face macro-script which differ with respect to the type of group awareness prompts they used for supporting the relational space of collaboration i.e. behavioral and social.

Upon designing the two script variations, we conducted a longitudinal, multiple-case study with ten groups of Media Informatics master students (n = 28, in groups of three or two, group=case, 4 sessions x70 min, Behavioural Awareness Script group= 5, Social Awareness Script group =5.) where each group was conceptualized as a case. Students collaborated every time for arguing to solve one different ill-structured problem and for transferring their arguments in the argument mapping tool Rationale. Thereby, we intended to investigate the effects of different awareness prompts on (a) collaborative metacognitive processes i.e., regulation, reflection, and evaluation (b) the relation between collaborative metacognitive processes and the quality of collaborative argumentation as well as (c) the impact of the two script variations on perceived team effectiveness and (d) what was experience with the different parts of the script variations in the two groups and how this fits into the design framework by Buder (2011).

The quantitative analysis of argument outcomes from the groups, yield no significant difference between the groups that worked with the BAS and the SAS variations. No significant difference between the script variations with respect to the results from the team effectiveness questionnaires was found either. Prompts for regulating collaboration processes were found to be the most successfully and consistently applied ones, especially in the most successful cases from both script variations and have influenced the argumentation outcomes. The awareness prompts afforded an explicit feedback display format (e.g. assessment of participation levels of self- and others) through discussion (Buder, 2011). The prompted explicit feedback display format (i.e., ratings of one's self and of others) was criticized for running only on subjective awareness information on participation, contribution efforts and performance in the role. This resulted in evaluation apprehension phenomena (Cottrell, 1972) and evaluation bias (i.e., users

may have not assessed themselves or others frankly) (Ghadirian et al., 2016). The awareness prompts for reflection and evaluation did reveal frictions in the plan making process (i.e., dropping out of the plan for collaboration) in the least successful groups. Problems with group dynamics (i.e., free-loading and presence of dominance) but were not powerful enough to trigger the desired changes in the behaviors of the students. The prompts for evaluating the collaboration in both script variations had no apparent connection to argumentation outcomes. The results indicated that dominant presence phenomena inhibited substantive argumentation in the least successful groups. They also indicated that the role-assignment influenced the group dynamics by helping student's making clear the labour division in the group.

In the second phase of development of the Argue(a)ware tool, the focus is on structuring and regulating social interactions in the relational space of collaborative argumentation by means of scripted roles and role-based awareness scaffolds. We designed support for mirroring participation in the role (i.e., a role-based awareness visualization) and support for monitoring participation, coordination and collaboration efforts in the role (i.e., self-assessment questionnaire). Moreover, we designed additional support for guiding participation in the role i.e., role-based reminders as notifications on smartwatches.

In a between subjects study, ten groups of three university students each (n = 30, *Mage* =22y, mixed educational backgrounds, 1x90min) worked with two variants of the Argue(a)ware for arguing to solve one ill-structured problem and transferring their arguments in the argument mapping tool Rationale. Next, to that, students should monitor their progress in their role with the role-based awareness visualization and the self-assessment questionnaire with the basic awareness support (role-based awareness visualization with the intermediate self-assessment) and the enhanced awareness support (additional role-based awareness reminders). Half of the groups worked only with the role-based awareness visualization and the self-assessment questionnaire (Basic Awareness Condition-BAC) while the other half groups received additional text-based awareness notifications via smartwatches that were sent to students privately (Enhanced Awareness Condition- EAC).

Thereby, we tested the use of different degrees of awareness support in the two conditions with respect to their impact on a) self-perceived awareness of performance in role and of collaboration and coordination efforts (measured with the same questionnaire at two-time points), b) on perceive team effectiveness, c) group performance. We hypothesized that students in EAC will perform better thanks to the additional awareness reminders that increased the directivity and influenced their awareness in the role. The mixed methods analysis revealed

that the awareness reminders, when perceived on time, succeeded in guiding collaboration (i.e., resulted in more role-specific behaviors). Students in the EAC condition improved their awareness over time (between the two measurements). These results indicated that enhanced awareness support in the form of additional guidance through awareness reminders can boost the awareness of students' performance in the role as well as the awareness of their coordination and collaboration efforts over time by directing them back to the mirroring and monitoring tools. Moreover, students in EAC exhibited higher perceived team effectiveness than the students in BAC. However, no significant differences in building of shared mental models or performing in mutual performance monitoring were found between the groups. However, students in BAC and EAC did not differ significantly with respect to the formal correctness or evidence sufficiency of their group argumentation outcomes.

Moreover, technical difficulties with the smartphones used as delivery devices for the awareness reminders (i.e., low vibration modus) hindered the timely perception of the reminders and thus their effect on participation. Finally, the questionnaire on the experience with the different parts of Argue(a)ware system indicated the need for exploring further media for supporting the awareness reminders to avoid the overwhelming effects of the multiple displays of the system and enhancing higher perceptiveness of the reminders with low interruption costs for other group members. The rather high satisfaction with the use of the role-based awareness visualization and the positive comments on the motivating aspects of monitoring how the personal success contributes to the group performance, indicate that the group mirror succeeded in making group norms visible to group members in a non-obtrusive way. The high interpersonal comparability of performances without moderating the group 's interaction directly in the basic awareness condition was proven to be the favored design approach compared to the combination of group mirror and awareness reminders in the enhance awareness condition.

In the third phase of development of Argue(a)ware, we focused on designing and testing different notification modes on different ubiquitous mobile devices for facilitating the next prototype of a notification system for role-based awareness reminders. Thereby, the aim of the system was again to guide students' active participation in collaborative argumentation. More specifically, we focused on raising students' attention to the reminders and triggering a prompter reaction to the contents of the reminders whilst avoiding a high interruption cost for the primary task (i.e., arguing for solving the problem at hand) in the group. These goals were translated into design challenges for the design of the role-based awareness notification system.

The system should afford low interruptions, high reaction and high comprehension of notifications. Notification systems with this particular configuration of IRC values are known as "secondary display" systems (McCrickard et al., 2003).

Next, we designed three low-fidelity prototypes for a role-based notification system for delivering awareness reminders: The first ran on a smartwatch and afforded text-based information with vibration and light notification modalities. The second ran on smartphone and afforded text-based information with vibrotactile and light-based notification modalities. Finally, the third prototype run on a smart-ring which afforded graphical- based (i.e. abstract light) information with and light and vibration notification modalities.

To test the suitability of these prototypes for acting as “secondary display” systems, we conducted a within-subjects user study where three university students (n= 3, Mage=28, mixed educational background) argued for solving three different problem cases and producing an argument map in each of the three consecutive meetings (max 90min) in the Argue(a)ware instructional system. Students were assigned the roles of writer, corrector and devil`s advocate and were instructed to maintain the same role across the three meetings. In each meeting students worked with a different role-based awareness notification prototype, where they received a notification indicating their balloon is not growing bigger after five minutes of not exhibiting any role-specific behaviors. The role-based awareness notification prototypes aimed at introducing timely interventions which would prompt students to check on their own progress in the role and the group progress as visualized by the role-based awareness visualization on the large display. Ultimately, this should prompt them to reflect on the awareness information from the visualization and adapt their behaviors to the desired behavior standards over time.

Results showed that students perceived the notifications from all media mostly based on vibration cues. Thereby, the vibration cues on the wrist (smartwatch) were considered the least disruptive to the main task compared to the vibration cues on finger (smartwatch) and the vibration cues on the desk (smartphone). Students also declared that vibration cues on wrist prompted the fastest reaction i.e., attending to notification by interacting with the smartwatch. These results indicate that vibration cues on the wrist can be a suitable notification mechanism for increasing the perceived urgency of the message and prompting the reaction on it without causing great distraction to the main task, as studies previous studies showed before (Pielot, Church, & deOliveira, 2013; Hernández-Leo, Balestrini, Nieves & Blat, 2012). Based on very limited qualitative data on light as notification modality and awareness representation type no

inferences could be made about its influence on the cost of interruption, reaction and comprehension parameters comprehensiveness.

The qualitative and quantitative data on the experience with different media as awareness notification systems indicate that smartwatches may be the most suitable medium for acting as awareness notification medium with a “secondary display” IRC configuration (low-high-high). However, this inference needs to be tested in terms of a follow up study. In the next study, the great limitations of study (limited data due to low power and mal-structured measurement instruments) need to be repaired. Finally, the focus should be on comparing notification modalities of one medium (e.g., smartphone) based on a larger set of participants and with the use of objective measurements for the IRC parameter values (Chewar, McCrickard & Sutcliffe, 2004).

Finally, we draw conclusions based on the findings from the three studies with respect to the role of awareness mechanisms for facilitating collaborative processes and outcomes and provide replicable and generalizable design principles. These principles are formed as heuristic statements and are subject to refinement by further research (Bell, Hoadley, & Linn, 2004; Van den Akker, 1999). We conclude with the limitations of the study and ideas for future work with Argue(a)ware.

Conceptualizing and Supporting Awareness of Collaborative Argumentation

1. Introduction

> "We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline."
>
> Karl Popper [2]

Over the past 25 years, group awareness has been identified as a core notion in the field of computer-supported cooperative work (CSCW) and more recently in the field of computer-supported collaborative learning (CSCL). Research on group awareness tools in CSCL environments focuses on the impact of the tools on learning processes and outcomes as well as on the psychological mechanisms that moderate the relationship between group awareness and learning (Bodemer & Dehler, 2011). On the other hand, research on group awareness tools in CSCW environments focuses on the influence of the design characteristics and the use context on raising awareness of cooperative activities and the impact of the tools on the performance in collaborative scenarios (e.g., Lopez & Guerrero, 2017). We argue that when studying awareness as problem in collaborative learning, one needs to look across the disciplines involved in the research on group awareness tools in the CSCL and CSCW communities. More specifically, we argue for combining CSCL and HCI/CSCW theories and research methods to address the conceptual and design issues of group awareness support for co-located collaborative argumentation.

In this thesis, we introduce "Argue(a)ware". This is a concept for an instructional group awareness tool which aims at supporting social interactions in co-located computer –supported collaborative argumentation settings. The conceptualization of the tool was informed by literature on group awareness tools for regulating group processes and guiding participation in

[2] Popper, K. R. *Conjectures and Refutations: The Growth of Scientific Knowledge*. New York: Routledge and Kegan Paul, 1963, p. 88.

CSCL to promote social and group performance (e.g., Janssen, Erkens, & Kirschner, 2011; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011; Miller & Hadwin, 2015; Kirschner, Kreijns, Phielix, & Fransen, 2015). The decisions for the design of the awareness mechanisms of the tool were influenced by guidelines for displaying and monitoring awareness in CSCL and user-centered approaches for supporting awareness in HCI (Buder, 2011; McCrickard, Chewar, & Sommervell, 2004). The implementation of the tool was facilitated with multiple ubiquitous media (i.e. large displays, personal computers, smartwatches, smartphones and smart-rings) in the form of low and medium fidelity prototypes (Tausch, Ta, & Hussmann,2016; Röcker, 2009). These prototypes were used as part of multi-device ecology in a co-located instructional setting for collaborative argumentation (Scott, Graham, Wallace, Hancock & Nacenta, 20152015). Finally, the design of the instructional support for the learning task at hand (i.e., learn to argue) was based on literature on epistemic and social scripts for guiding argumentative discourse, problem based- learning theories and argument mapping techniques (Stegmann, Weinberger, & Fischer, 2007; van Gelder, 2013).

Argue(a)ware is designed to support the social interactions in the content (i.e., task-related) and in the relational (i.e., social and interpersonal) space of co-located collaborative argumentation (Barron, 2003). The support for social interactions in the content space of collaboration is facilitated with the use of collaborative scripts for argumentation (i.e., instructions and scaffolds of argument construction) as well with the use of an argument mapping tool (i.e., visualization of argumentation outcomes in a form of diagrams) (Stegmann, Weinberger, & Fischer, 2007; van Gelder, 2013). The support for social interactions in the relational space of collaboration is facilitated with the use of different awareness mechanisms from the CSCL and the CSCW research fields (i.e., monitoring, mirroring and awareness notification tools)

In this thesis, we examined how different awareness mechanisms facilitate the regulation of collaborative processes in the relational space of collaborative argumentation. Moreover, we studied the effect of perceived team effectiveness (i.e., process outcome) and the group performance (i.e., learning outcome) in the content space of collaboration. Thereby, we studied also the effects of the design of the awareness mechanisms on the application of the mechanisms and the user experience with them. In line with the design design-based research paradigm, we attempted to simultaneously improve and study the effect of Argue(a)ware on collaborative argumentation (Herrington, McKenney, Reeves & Oliver, 2007). Through a series of design-based research studies we tested and refined the prototypes of the instructional

group awareness tool. Moreover, we studied the ecological validity of dominant awareness and instructional theories in the context of co-located computer-supported collaborative argumentation.

The underlying premise of the Argue(a)ware tool is that a combination of awareness and instructional support will result in increased awareness of collaboration, which will in turn mediate the regulation of collaborative processes. Moreover, we assume that successful regulation of collaboration will result in high perceived team effectiveness and the group performance in turn.

In the following sections, we first motivate the efforts taken to conceptualize and design Argue(a)ware as a holistic approach to supporting social interactions in both the content and the relational space of collaborative argumentation. Next, we describe the research approach. Finally, we present the structure of the thesis and give an overview of its content.

1.1. Problem Statement

Collaborative argumentation (CA) is regarded as a highly effective instructional strategy for higher education (Andriessen, Baker, & Suthers, 2003). Research about argumentation in CSCL environments has focused on students' ability "to participate in argumentative discourse; to make defensible claims (providing warrants, qualifications, etc.); to test the claims of others; to draw appropriate inferences, etc." (Goodyear, Jones, & Thomson, 2014, p.441). When designing instructional support for collaborative argumentation in educational practice, one could think of it as a dual-problem space (Barron, 2003). On the one hand, students need support for dealing with the argumentative task at hand in the content space of collaboration. Pedagogical scripts are defined as the most prominent instructional approach to supporting argumentation processes and outcomes in CSCL (Fischer, Kollar, Stegmann, & Wecker, 2013). Moreover, research in CSCL produces tools for visualizing collaborative argumentation i.e., argument mapping tools for formal and informal argumentation purposes (Karacapilidis & Papadias, 2001).

On the other hand, students in collaborative argumentation settings need additional information for monitoring their progress and coordinating their actions in the relational space of collaboration. Students in physical and online collaborative argumentation settings are dealing with interactional challenges. These challenges refer to negative collaboration phenomena i.e. dominating status in discussion or lack of joint attention, which can inhibit

substantive argumentation and influence the group performance in turn (Ryu & Sandoval, 2015). This inhibition is connected to problems with the social interactions i.e., the task and socio-emotional oriented exchanges in the group (Kreijns, Kischner, & Vermeulen, 2013).

Ensuring students' active engagement in these processes is considered a necessary prerequisite for effective social interactions (Kirschner, Kreijns, Phielix, & Fransen, 2014). Moreover, providing awareness information (i.e., participation levels in discussion) can enhance the regulation of the processes related to social interactions both in the cognitive (i.e. educational) and the social dimension of collaboration (Kirschner et al., 2014). Thereby, the focus is on regulating the group processes by stimulating metacognitive processes (i.e., coordination, planning, monitoring, reflection and evaluation) of both the cognitive (task-related) and social (non-task-related) processes. Finally, these metacognitive processes are mediating variables for perceived team effectiveness (i.e., process outcomes) and of group performances (i.e., learning outcome) in collaboration (Bodemer & Dehler, 2011; Fransen, Kirschner & Erkens, 2011).

Research in CSCL supports the provision of awareness information with a variety of monitoring and metacognitive tools which are known as group awareness tools (GATs) (Soller, Martinez, Jermann, & Muehlenbrock, 2005; Bodemer & Dehler, 2011). Typically, these tools afford visualizations of raw or processed information on prior and current knowledge of students, as well as on students' interactions in the group and participation rates (Baker, 2003; Buder & Bodemer, 2008; Chavez & Romero, 2012). Group awareness tools hold potential for influencing students' individual behaviors and regulating their participation by allowing them to verify and negotiate their activities in the group (Belkadi, Bonjour, Camargo, Troussier, & Eynard, 2013). However, these tools support the metacognitive processes of cognitive (task-related) aspects of collaboration and neglect the support for the social (non-task-related) aspects of collaboration (i.e. group dynamics) (Kreijns, Kischner, & Vermeulen, 2013).

In terms of online collaborative argumentation settings, awareness of socio-cognitive and metacognitive aspects of collaboration is raised with augmented group awareness tools for regulating group processes (Buder & Bodemer, 2008). These tools provide feedback about what a group thinks in the form of aggregated visualizations of students' ratings of the contributions of members and their novelty to the discussion. Group awareness tools have been mainly used for displaying differences in knowledge on arguments or for visualizing the construction of arguments (Tsovaltzi, Puhl, Judele, & Weinberger, 2014). Combining argumentation scripts and group awareness tools (i.e., information on group members' prior

and current knowledge) has positive synergetic effects on argumentation quality (Tsovaltzi, et al., 2014; Gijlers, Weinberger, van Dijk, Bollen, & van Joolingen, 2013; Stegmann, Weinberger, & Fischer, 2007). The effects of combining argumentation scripts with awareness support for social aspects of collaboration on the quality of collaborative processes and argumentation outcomes are still to be researched. Lastly, to our knowledge, there is no research on dedicated awareness support for metacognitive processes in the relational level of in co-located collaborative argumentation settings.

Further awareness systems from the CSCL and CSCW research fields include light - based ambient awareness tools and notification systems for orchestrating classrooms activities (Alavi & Dillenbourg, 2012; Martinez-Maldonado, Clayphan, Yacef, & Kay, 2014; Carroll, Neale, Isenhour; Rosson, & McCrickard, 2003). These systems afford processed information on learning interactions and advice about the next steps in collaboration, thereby acting as coaching systems for tutors (Jermann et al., 2005). To the best of our knowledge, combinations of group awareness tools and notification systems have not been studied with respect to how they support social interactions in the relation level of collaboration respectively.

In addition to technical approaches for supporting metacognitive processes in collaboration, instructional design mechanisms such as reflection breaks, and process prompts have been used (Verpoorten & Vestera, 2014; Bachhel & Thaman, 2014). The combination of reflection breaks, process prompts, and process displays as part of reflection and metacognitive awareness tools is suggested by literature on reflective thinking (Lin, Hmelo, Kinzer, et al., 1999; Kim, Grabowski, & Sharma, 2004). However, little is known about the potential of this combination for raising awareness of and metacognitive processes in the relational space of collaboration.

The problems stated above indicate the need for further research on how different awareness supporting mechanisms influence the collaborative processes and the outcomes of collaborative argumentation. However, literature on awareness in the CSCL and the CSCW differs with respect to the awareness types and the awareness mechanisms it employs for raising awareness of collaboration. Moreover, research on awareness types and tools produces results depending on the research foci of the different communities within the research fields of learning sciences, educational practice, and human-computer interaction. In that sense, awareness is an interdisciplinary problem which lays in the intersection of the Learning Sciences (LS) and Human Computer Interaction (HCI) research fields.

Based on the problems stated above and with the interdisciplinary nature of awareness in mind, we see the need to explore different awareness supporting mechanisms from the CSCL and CSCW field with respect to their design, and their influence on the collaboration processes in in the relational space of collaboration. Finally, we see the need to explore the mechanisms that connect awareness of collaborative processes in the relational space to the outcomes of collaboration in the content space of collaboration.

In our attempt to conceptualize and support awareness of collaborative argumentation we invest on the advocated synergetic effects from combining the different research foci in LS and HCI fields (Rick & Horn, 2013). These effects occur when the focus of HCI on designing effective technologies and the focus of LS on achieving deeper understanding of the learning processes inform one another with respect to methodologies and research practices. Furthermore, we acknowledge the common ground between the two communities. Researchers on both communities, agree that there is a need to focus on solving real problems in authentically complex contexts with the use of advanced technologies to support the learning goals (Rick & Horn, 2013). In doing so, we focus on simultaneously improving the design of the awareness support and studying its impact on collaborative processes and outcomes in terms of an authentic learning environment for collaborative argumentation i.e. class-room based instructional environments for collaborative argumentation. This approach is represented here with the Argue(a)ware concept for an instructional group awareness tool for co-located collaborative argumentation.

The design and the implementation of Argue(a)ware is based on the rigorous and reflective inquiry approaches of design-based research for testing and refining the problems, solutions, methods and for producing design principles. Following, we explain our research approach with respect to the design-based research approaches in educational technology research.

1.2. Research Approach

Predictive research is the main model for inquiry in educational research (Herrington, et al., 2007). However, this research model has been criticized for focusing overly on the gains of technology-based teaching over conventional teaching methods while ignoring the psychological mechanisms behind these gains (Herrington, et al., 2007). Moreover, predictive research has been called "socially irresponsible" because it examines the development and use

of educational technologies in a decontextualized way (Herrington, et al., 2007). As a response to this critique, an alternative inquiry model in educational research has been suggested. This model has been labeled in many ways including “design -based research”, “design research”, “design experiments”, and many more. Regardless of what it is called, design -based research (DBR) stands for enhancing both the theoretical contributions and the practical value of educational technology research (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). It has been argued that design-based research can contribute to the acquisition of different kinds of knowledge such as “better theoretical understanding of the learning phenomena addressed by an intervention and knowledge of useful and generalizable design practices” (Sandoval & Bell, 2004, p.200)

Design-based research addresses the conception of educational technology as an ongoing, iterative process with a simultaneous focus on the design utility and theory aspects. Most importantly, the design-based research approach looks for solutions to practical problems of learning environments with the aim of producing reusable design principles. The close collaboration between practitioners and researchers for defining the problem area as well as for designing and carrying out the interventions is considered cornerstone of the model (Herrington et al., 2007). Reeves (2006) defined the four stages of conducting design-based research. These stages include: a) the analysis of practical problems (in collaboration with practitioners), b) the development of solutions informed by existing design principles and technological innovations, c) a series of iterative testing and refinement of solutions in practice, d) and the final reflection phase for producing design principles.

This dissertation implements these stages, to the extent possible, based on the guidelines for conducting design-based research in doctoral study programs by Herrington et al. (2007). The research problems were defined by means of literature review on awareness tools in CSCL with an emphasis on computer-supported collaborative argumentation settings. The consultation with researchers was assisted thorough the interdisciplinary supervisory team with input from computer science and educational psychology. The teaching experience of the supervisory team and myself was used for grounding the research problems within the co-located computer-supported collaborative environment for teaching argumentation skills to students in higher education. Moreover, the supervisory team and I were actively involved in designing educational materials and teaching within the environment for collaborative argumentation. The preliminary literature review was not only used to identify the conceptual underpinnings of the problem, but it also helped draft design guidelines to inform the design

and development of the first intervention. Findings from the iterations often required us to conduct further literature review to understand aspect of the theories better and to predict the elements of a potential solution in the next phase of the development.

Design-based research is not a methodology, but rather an exploratory research approach (Herrington et al., 2007). As such it bears a lot of similarities with the mixed methods research approach. Mixed methods research is defined as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purpose of breadth and depth of understanding and corroboration" (Johnson, Onwuegbuzie & Turner, 2007, p.123). In line with the exploratory aim of DBR we employed the mixed methods research approach on the level of the study design and the data analysis of our iterative studies. Any hypothesis testing performed in this dissertation was carried out with respect to the standards of predictive research. However, the hypothesis testing aimed at defining the success of our intervention with respect to the learning goal and causality was handled with realist, process-oriented view on causality (Bakker & van Eerde, 2015).

Finally, the reflections on the procedural and declarative knowledge acquired from the interventions are summarized in the form of replicable and generalizable design principles These principles are formed as heuristic statements and are subject to refinement by further research (Bell, Hoadley, & Linn, 2004; Van den Akker 1999).

1.4. Thesis Structure

Figure 1.1 illustrates the structure of the thesis which is organized in six chapters. Chapter 1 introduces the research problem and the research approach of this study.

Chapter 2 provides an overview of the psychological theories that formed the conceptual background of Argue(a)ware. Next, we present the design choices for the support in the content and the relational space of collaborative argumentation throughout the development phases of Argue(a)ware. Thereby, we define parameters of interest in the design of the awareness support based on design theories for awareness mechanisms in CSCL and CSCW systems.

Chapters 3, 4 and 5, represent the three stages of development of Argue(a)ware and they form the main body of this work. Each of these chapters starts with a description of the proposed design guidelines for the tool in the current phase. The design guidelines are formed

with respect to the literature insights and the discussion on the findings from the previous studies. Next, in each chapter we present the studies that were performed to assess the impact of the design of the tool on the collaborative processes and outcomes of collaborative argumentation and we conclude with a discussion on the findings. Figure 1.2. gives an overview of the development of the support for the content and the relational space of collaborative argumentation across the three phases of development of Argue(a)ware.

In chapter 3, we present the first prototype for the Argue(a)ware tool. The first prototype comprises a pedagogical script for collaborative argumentation with embedded scaffolds for argumentation and awareness prompts for triggering metacognitive processes (i.e., regulation, reflection, evaluation) during scripted breaks from collaboration (i.e., awareness breaks). Thereby, we describe a study on two variations of this script which differ with respect to the type of awareness information they are prompting (i.e., behavioral vs. social). The impact on Metacognitive collaboration processes and group outcomes are measured here with a mixed methods analysis.

Chapter 4 presents the second prototype of Argue(a)ware in the second phase of development of the tool. The second prototype comprises now a combination of mirroring (i.e., Group Mirror), monitoring (i.e., self-assessment questionnaire) and guidance tools (i.e., awareness notification system). The basic script for collaborative argumentation is now built based on the role-assignment scaffold. Thereby, two variants of Argue(a)ware are compared with respect to how they influence a) awareness of role based-active participation, b) argumentation processes c) and perceived team effectiveness. Additionally, we explore the experience with the different media (large display, laptops and smartwatches) for facilitating awareness scaffolds with the two prototypes of the technology-enhanced instructional settings for Argue(a)ware. The main aim of this study is to evaluate the impact of awareness scaffolds for mirroring and monitoring for raising awareness of participation in the role and to study the surplus value of introducing awareness reminders.

Chapter 5 presents the third phase of development of the Argue(a)ware. The focus in this phase is on the design and implementation of an awareness notification tool to act as a secondary display system in the Argue(a)ware system. To investigate the notification affordances of different ubiquitous media for becoming a secondary display for notifications in our system, we have designed three low-fidelity prototypes. In a study, we compared three role-based notification system prototypes for delivering awareness reminders on a) a smartwatch, b) a smartphone and c) a smart-ring of the collaborators in the “Argue(a)ware”

with respect to their suitability for facilitating notifications with low interruption cost, high reaction, and high comprehension values.

In chapter 6, we summarize the findings from all the studies and use them for answering the underlying research questions of the thesis and for producing design principles. Moreover, we present the limitations of this work and suggest directions for future work on the project.

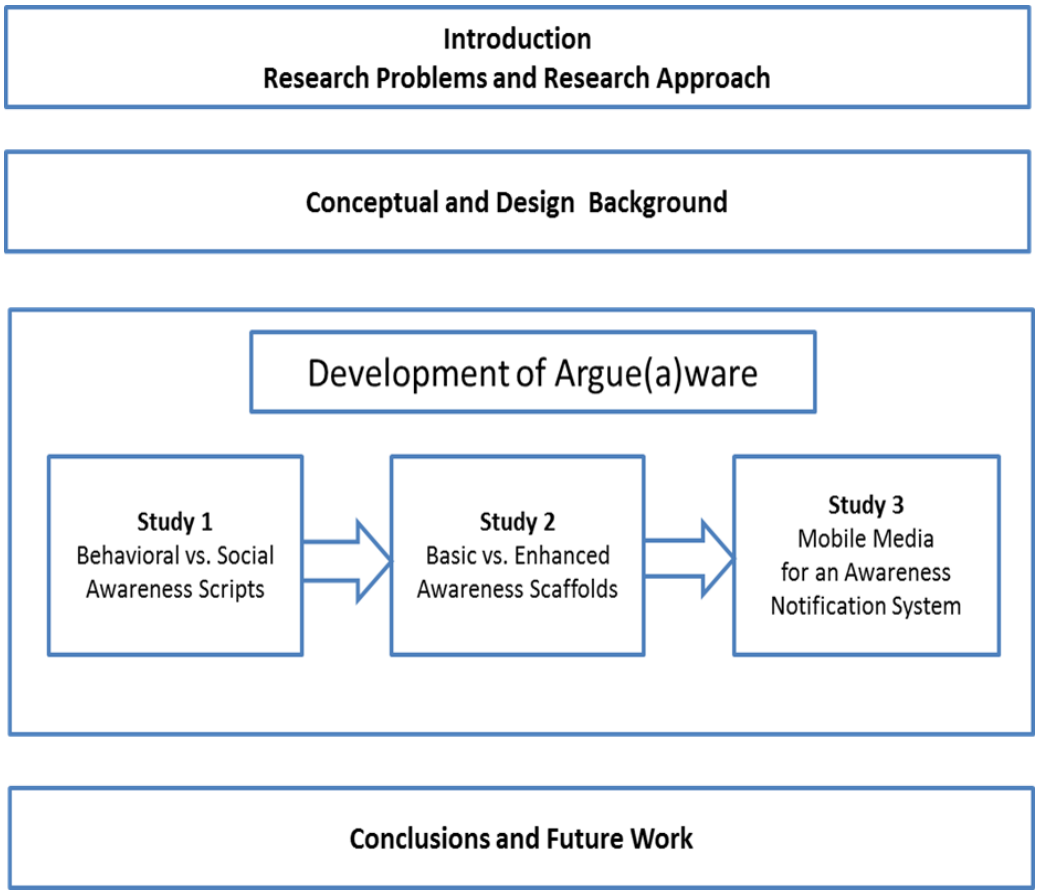


Figure 1.1. Thesis structure.

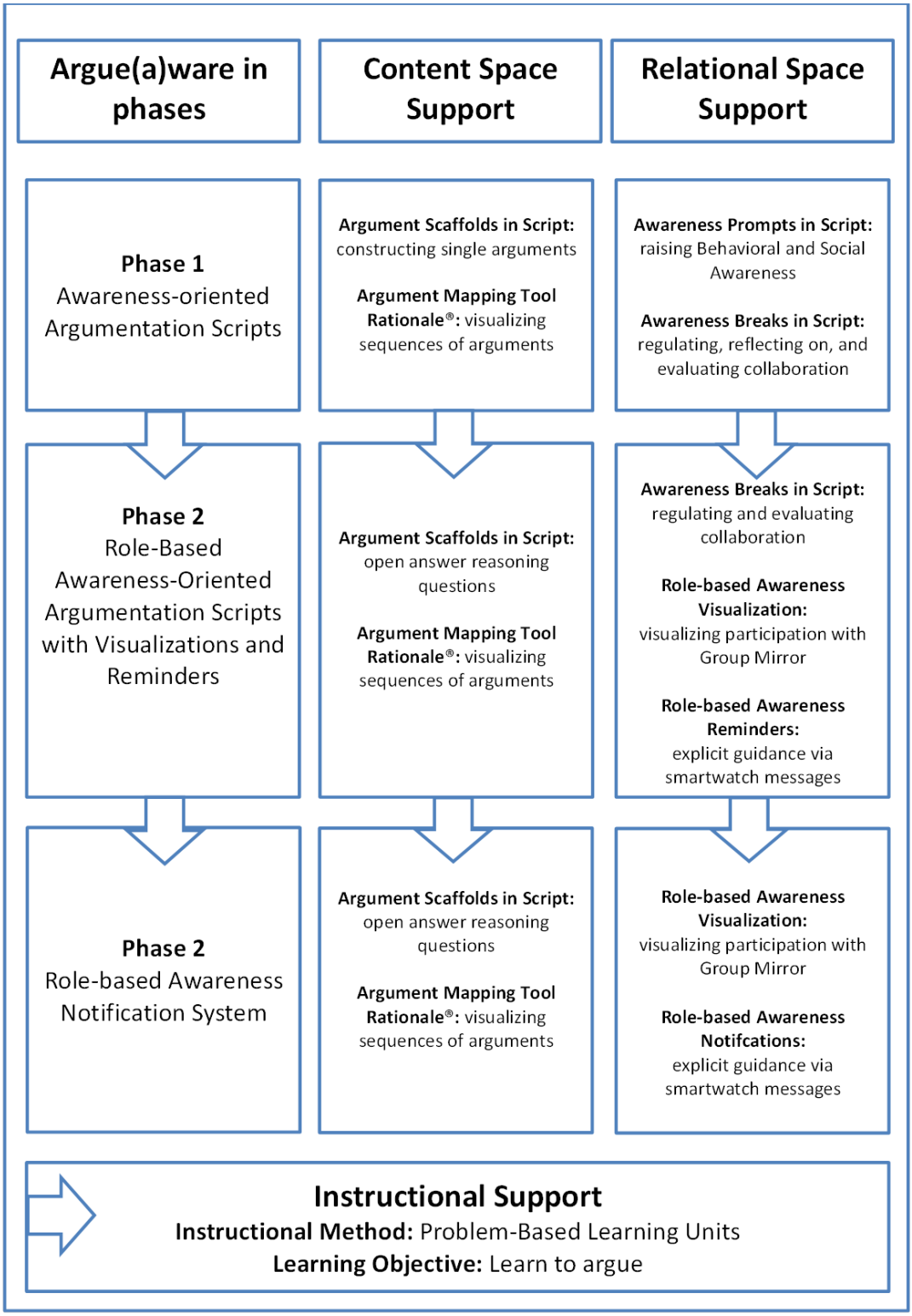


Figure 1.2. Development of Support for the Content and the Relational Space of Collaborative Argumentation across Phases.

2. Background

In this chapter, we present the psychological theories that formed the conceptual background of Argue(a)ware. Next, we present theories on the design choices that have shaped the development of instructional and technical support for Argue(a)ware.

2.1. Conceptual Background of Argue(a)ware

Collaborative argumentation has been acknowledged as a highly effective instructional strategy for higher education. Argue(a)ware builds on the dual space model of collaboration for defining the requirements of collaborative argumentation (Barron, 2003). Moreover, it draws upon the framework on the dual function of social interaction in CSCL to define the role of collaborative processes for effective collaboration (Kreijns et al., 2013). Finally, Argue(a)ware is shaped by literature on group awareness for regulating participation and social interactions and for mediating team effectiveness of learning groups (Fransen, Kirschner & Erkens, 2011).

2.1.1. Collaborative argumentation.

Collaborative argumentation (CA) is defined as a "social process in which individuals work together to construct and critique arguments" (Nussbaum, 2008, p.348.). It is a form of productive critical thinking which involves the evaluation of claims and supporting evidence, the consideration of alternatives and the exploration of implications (Nesbit & Leacock, 2009). As such, it goes beyond the mere conflict or persuasion-oriented argumentation techniques associated with other types of argumentation i.e. debate and rhetoric. A distinction is made with respect to the type of content learning in CA. "Learning to argue" is concerned with learning about components and effective practices of argumentation and "argue to learn" is concerned with mastering the content of the argumentative task (Andriessen, 2005). Collaborative argumentation builds on scientific data from (competing) theories to facilitate the learning of domain knowledge, and on argumentation models (e.g., Toulmin's model) for modeling argumentation in reasoning and decision-making processes (von Aufschnaiter et al., 2007; Nussbaum, 2008; Toulmin, 2003).

Collaborative argumentation in educational practice is associated with deep-level understanding of content and more permanent domain learning gains (Clark & Sampson, 2008;

Kuhn & Udel, 2008). These gains are attributed to socio-cognitive conflict phenomena (i.e., resolving conflicts related to different viewpoints on arguments through discussion) and cognitive elaboration phenomena (i.e., associating concepts and with prior knowledge, offering explanations and repairing flaws in existing mental models) (Nussbaum, 2008; Schwarz, 2009). Tasks for learning to argue are linked to improved general argumentation skills (i.e., constructing arguments effectively), while tasks for arguing to learn are linked to improved scientific argumentation skills (i.e., evaluating domain specific knowledge effectively) (Chinn & Clark, 2013). Finally, collaborative argumentation is linked to increased interest and motivation levels of students, and improvements in performance on problem solving tasks (Chinn, 2006). Enhancements in motivation could be explained by the high autonomy and increased interaction affordances of collaborative argumentation environments (Chinn & Clark, 2013). Research on problem solving settings attributes improvements in problem solving performances to the generation of alternative reasons (Arkes; 1991; Cho & Johansen, 2002). For all these reasons, CA has been acknowledged as a highly effective instructional strategy for higher education (Andriessen, 2006; Chinn, 2006).

The success of collaborative argumentation as an instructional strategy is also measured by the quality and quantity of the learning outcomes (e.g., argumentative essays). The quantitative standards analyze the functions of arguments in the discussion (i.e. claims, counter-arguments) and their connections to each other (structural interrelations) (Weinberger & Fischer, 2006; Chinn & Clark, 2013). The quality standards focus on the quality of arguments contributions with respect to their argumentative force or the proper use of scientific facts (Clark & Sampson, 2008; Kuhn & Udel, 2008). Complex argument structures, with higher level of interlinking of ideas from all group members and high levels of counter argumentation are associated to learning gains (Chinn & Clark, 2013). Moreover, research on CA suggests that learning gains occur from activities which aim at the integration of multiple (opposite) perspectives as students defend themselves less and explore new ideas more (Asterhan & Scwarz, 2007; Clark, D'Angelo, & Manekse,2009).

Students in CA environments need instructional guidance for engaging in more productive argumentative exchanges. Pedagogical scripts (i.e., set of instructions) with scaffolds for structuring collaboration and for modeling argument structures have been found to enhance argumentation in collaborative settings (e.g., Fischer, Kollar, Stegmann, & Wecker, 2013). This instructional support is often paired with joint representations of arguments (i.e., argumentation diagrams or text) for scaffolding the understanding of basic components of

argumentation (e.g., Nussbaum & Schraw, 2007). A review by Noroozi and colleagues (2012) has highlighted a variety of scaffolding approaches for supporting the co-construction of arguments in terms of computer-supported collaborative argumentation settings such as shared workspaces, game-based learning, awareness features, knowledge representations and collaboration scripts. Furthermore, choosing relevant and complex problems for argumentation tasks, building the content knowledge needed for working on these problems and assigning students with multiple-ability levels in groups are some of the aspects of orchestrating collaborative learning in classroom (Chinn & Clark, 2013).

Finally, several factors can inhibit the implementation of pedagogically effective collaborative argumentation in classroom. In order to examine the difficulties associated to the tasks and processes of collaborative argumentation, we view this form collaboration under the prism of the dual-space of collaborative learning by Barron (2003).

2.1.2. Dual-space model of collaborative argumentation.

Barron (2003) suggested viewing collaborative learning as involving a dual-problem space. The dual-space model defines the two spaces of collaboration as following: the content space, where students are dealing with the problem at hand and the relational space, where students' interpersonal relations are at stake. The content space and the relational space are interfearing constantly and they competing for students' limited attention. Furthermore, research on the topic suggests that activities in the relational space enable students to interact meaningfully in the content space of collaboration (Janssen & Bodemer, 2013). Coordination and regulation of activities in the content space and the relation space can be an overwhelming endeavor (Slof, Erkens, Kirschner, Jaspers, & Janssen, 2010; Janssen, Erkens, Kirschner, 2011). In the case of collaborative argumentation, students often need to take care of the collaboration dynamics in the group while struggling with learning how to argue and arguing for learning at the same time (von Aufschnaiter, Erduran, Osborne, and Simon, 2008).

2.1.2.1. Content space of collaborative argumentation.

In the content space of collaborative argumentation students interact with each other for co-constructing arguments in terms of complex problem-solving scenarios. The goal of interaction depends on the type of collaborative task at hand i.e., learning to argue or learning by arguing. In both tasks, students engage in cognitive activities such as critical information

checking, argument elaboration and exploration of multiple perspectives (Kirschner, Buckingham-Shum, & Carr, 2012). Well known strategies for assisting these cognitive activities include combinations of structured and unrestricted interaction with instructional and computer-support for collaborative argumentation tasks. These tasks should afford multiple acceptable solutions, detailed instructions on the task requirements and processes, embedded role-playing or predefined conflicting stances, equal distribution of important information, individual preparation phase and a focus on joint product of collaboration (Veerman, 2001).In addition, students need to maintain a joint focus on the discussion topic and the argumentation processes to achieve effective argumentation and collaborative problem solving (Kanselaar, et al, 2002). Employing metacognitive activities such as discussing the best strategy to solve the argumentative task can help students maintain a joint focus (Ryu and Sandoval, 2015).

Students often struggle with cognitive activities during argumentative knowledge construction. The latter is described as "the joint construction and the individual acquisition of knowledge through collaborative argumentation" (Stegmann et al., 2011, p. 299). They have problems engaging in argumentative discussion in classroom, unless they receive some scaffold by the learning environment (Evagorou, & Osborne, 2013). Moreover, when presented with a topic for argumentation, students find it difficult to collect the evidence or provide adequate evidence to support their claim (Bell, 2004; Sandoval & Milwood, 2005). Problems related to the structure of arguments include difficulty to rebut an argument or claim provided by other students (Cavagnetto, Hand, & Norton-Meier, 2010). In addition to the challenges related to argument knowledge construction, students struggle with coordinating differences in experience, values and goals amongst them. Furthermore, students have also problems maintaining an overview of the steps required for building a complex argument (i.e., task identification, data interpretation). These problems relate to lack of metacognitive skills such as the ability to think about one's own arguments, think about the quality of group argumentation, and evaluate the arguments in the group (Miller & Hadwin, 2015; Ryu & Sandoval, 2015).

2.1.2.2. Relational space of collaborative argumentation.

In the relational space of collaborative argumentation students face social and interpersonal challenges. Typical communicative activities in the relational space of collaboration include exchanging opinions and asking clarifying questions. These activities

aim at establishing and maintaining a shared understanding of the concepts discussed in the content space. A common strategy for achieving shared understanding is by discussing all conflicting views on the topic (i.e., creating common frame of reference), and checking if the opinions and the material which inform the arguments fit in the common frame of reference (Janssen & Bodemer, 2013). Moreover, students perform social activities (i.e., exchanging compliments, giving positive feedback) to take care of the well-being of group members and the group cohesion (Slof et al., 2010). These efforts are influenced by problems related to social and interpersonal relationships among group members. More specifically, students' performance is influenced by their struggle with social problems e.g., regulating interaction dynamics within the group (Barron, 2003). With regard to the influence of group dynamics on collaborative argumentation, we know that negative collaboration phenomena i.e., dominating status in discussion and lack of joint attention can inhibit substantive argumentation, while social conflict can promote it (Ryu & Sandoval, 2015).

Ignoring other members' contributions or rejecting them without discussion in the group can be detrimental for the quality of group outcomes. On the contrary, respect and acceptance of other members' contributions in the discussion can lead to higher quality group outcomes. Especially when arguing for solving ill-structured problems, power dynamics issues can arise and can affect the interaction between group members (Ryu and Sandoval, 2015). For example, group mates who are friends with each other often show higher agreement rates and proceed faster with building their arguments. Less frequent but still apparent in small groups' collaboration is the "free-rider effect" (aka. "free-loading effect") where one member is not contributing enough in the group discussion, as well as the "social loafing effect" where one member is lacking motivation to add to the group effort (Dillenbourg & Kanselaar, 2002).

2.1.3. Collaborative processes in collaborative argumentation.

Collaborative argumentation is a pedagogical approach for collaborative learning. As such it should take care of the five essential conditions to reach the full potential of the group and achieve the learning goals in collaborative learning (Johnson & Johnson, 1999; Kirschner Kreijns, Phielix, & Fransen, 2014). These conditions include positive interdependence, individual and group accountability, promotive interaction, appropriate use of social skills, and group processing (Johnson & Johnson, 2004). The effective elicitation of these conditions in collaborative learning requires that certain cognitive processes (i.e., planning task-related

activities) and metacognitive processes (i.e., monitoring and evaluating collaboration processes) as well as socio-cognitive (i.e., group forming) and socio-emotional processes (i.e., exhibition of trusting and helping behavior) take place. For example, monitoring team members' activities can strengthen the link among their actions (i.e., positive interdependence) while evaluating collaboration processes can promote individual accountability. Furthermore, exhibiting helping behavior can provide a sense of cohesion and resolve potential of group conflicts (i.e., promotive interaction).

When these five conditions are realized, social interaction is stimulated on the content space of collaboration resulting thus in better cognitive performance (e.g., equality of participation of all peers, product quality) which is made tangible through cognitive performance outcomes (i.e. high-quality argumentative essays). Moreover, when social interaction is stimulated in the relational space of collaboration it can lead to better social performance outcomes which are manifested as a sound social space (i.e. group cohesiveness, satisfaction) (Kirschner et al., 2014). Ensuring students' active engagement in these processes is considered a prerequisite for effective social interactions (Kirschner et al., 2014). Ongoing active participation is also considered a crucial factor for success in collaborative learning (Chavez and Romero, 2012). When both cognitive performance and social performance are at a good level, they reinforce each other, and students feel content, and motivated to continue their participation (Kirschner et al., 2014).

In order to ensure high cognitive and social performance in collaboration, support for overcoming the problems the relational and cognitive space of collaboration (subchapter 2.1.2.) and enhancing the processes involved in them (subchapter 2.1.3.) is needed. Research in CSCL has attributed these problems to lack of group awareness and has focused its veins in enhancing group awareness in computer-supported learning environments (e.g., Buder & Bodemer, 2008; Jermann & Dillenbourg, 2008).

2.1.4. Defining group awareness.

Researchers in the CSCL field refer to awareness of collaboration aspects as group awareness. They associate it with "the understanding of who is working with you, what they are doing, and how your own actions interact with theirs" (Gutwin, Penner, & Schneider, 2004, p. 73). Researchers in the CSCW field define group awareness as "an understanding of the activities of others, which provides a context to your own activity." (Dourish & Bellotti, 1992,

p. 1) Awareness concepts in the CSCW research field include informal or social awareness (i.e. information on presence and current or intended actions of collaborators), group-structural awareness (i.e., information about roles and responsibilities within the group) and workspace or task-oriented awareness (i.e. information about other participants' interactions with the shared space and the artifacts it contains) (Gross, Starry, & Totter, 2005). For conceptualizing awareness in Argue(a)ware, we focus on group awareness concepts from the CSCL literature corpus and we point out the common ground with the awareness concepts in CSCW.

Bodemer and Dehler (2011) defined three key group awareness types for effective collaborative learning in CSCL environments, namely social, cognitive and behavioral awareness. Cognitive awareness refers to the awareness of the knowledge levels of group members (Sangin, M., Molinari, G., Nüssli, M.-A., & Dillenbourg, 2011). It comprises information about self and partners' knowledge of current task (Ghadirian et al., 2016). Partly overlapping awareness concepts from the CSCW field include task-awareness (i.e. information on how the learners accomplish the knowledge task) and concept awareness (i.e. information on how activities or knowledge fit into the learner's existing knowledge framework or completes the task) (Ogata, Matsuura, &Yano,1996).

Behavioral awareness refers to awareness of learner's activities in the group (Pifarré, Cobos, & Argelagós, 2013). It comprises information about the frequency of interactions of self and others and history of learner's actions (Ghadirian et al., 2016; Liccardi, Davis, & White, 2009). Behavioral awareness is also known as awareness of participation in CSCL and it focuses on information about the participation levels in the discussion (Janssen, Erkens, & Kirschner, 2011). Other related awareness types from the CSCW field include situation awareness (i.e. awareness of collaborator's behaviors with respect to shared goals and working processes) and activity awareness (i.e. information on how collaborators share and coordinate their efforts to work together effectively) (Chewar, McCrickard & Sutcliffe, 2004; Carroll, Rosson, Convertino, & Ganoe, 2006).

Social awareness was initially defined as "user's consciousness of the presence and availability of others" in CSCW field (Carroll et al., 2003 in Ghadirian et al., 2016, p. 124). It was later extended with information on perceived social behavior (i.e., friendliness, cooperativeness and reliability), on perceived strength of social relations between self and others as well as information from researchers in CSCL field (Pifarré, Cobos, & Argelagós, 2013), In that sense, social group awareness refers not only to awareness of group member's activities, communication patterns contributions towards the joint goal, and presence in their

roles but to also to feelings associated with these aspects of collaboration (Janssen & Bodemer, 2013, Kirschner et al., 2014; Ghadirian et al., 2016). An even broader definition of social awareness includes information on group members' collaborative behaviors i.e., equality of participation, number of contributions to discussion (Janssen & Bodemer, 2013; Ghadirian et al., 2016). However, the latter is creating an intersection between the behavioral and social awareness concepts. Therefore, in terms of this thesis we will proceed with the definition of social awareness as "the awareness of students' functioning in the group as perceived by their collaborators" (Pifarré, Cobos, & Argelagós, 2014, p.301).

2.1.5. Group awareness in CSCL.

Research on group awareness in CSCL has focused on how different awareness concepts support collaborative processes and outcomes (Bodemer & Dehler, 2011). Cognitive awareness information can affect the coordination of collaborative activities in the content space of collaboration (Janssen & Bodemer, 2013). Providing cognitive awareness information can minimize the effort needed for answering questions relevant to the coordination of activities in both spaces e.g., "Do my partners have the same knowledge as I have?" Particularly, cognitive awareness information can reduce extraneous cognitive load by allowing students to share the burden of information processing and promote germane learning processes by structuring their learning interactions (Sweller, 2010; Bromme, Hesse, & Spada, 2005). These processes include sharing of unshared information, comparing ideas on the topic and they are linked to higher cognitive performance (Dehler, Bodemer, Buder, & Hesse, 2011; Janssen & Bodemer; 2013).

Behavioral awareness information on participation levels can influence the coordination and regulation of activities in the relational space by promoting the discussion around the collaboration processes (Janssen & Bodemer, 2013). However, the increase in awareness of participation level does not guarantee better cognitive performance at the content space of collaboration (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Janssen, Erkens, & Kirschner, 2011). Students use behavioral awareness information (i.e. participation rates) to plan, monitor, and evaluate the group's collaborative processing for achieving better coordination at the content space of collaboration (Belkadi, Bonjour, Camargo, Troussier, & Eynard, 2013; Janssen et al., 2007). Finally, raising students' awareness of group dynamics (i.e. social functioning) can lead to better cognitive and social performance and prevent

negative collaboration phenomena such as the "social loafing" and the "free-rider" effect (Kirschner, Jochems, Dillenbourg, & Kanselaar, 2002; Kirschner et al., 2014).

Finally, awareness of team and task-related issues of collaboration supports students in performing metacognitive processes. These processes address the cognitive and social demands of collaboration i.e., establishing a joint understanding of the task, taking responsibility for their own learning and engaging in active support for each other (Fransen, Kirschner, & Erkens, 2011). Thereby, performing metacognitive activities i.e., making plans, monitoring task progress, and evaluating plans or ideas can support students' social and cognitive performance in the relational and the cognitive space of collaboration respectively (De Jong, Kol- löffel, Van der Meijden, Kleine Staarman, & Janssen, 2005). Moreover, awareness of team and task-related issues of collaboration can stimulate key factors of collaboration which, in turn, mediate the effectiveness of the team as explained in the next section.

2.1.6. Group awareness for team effectiveness.

Fransen and his colleagues (2011) conceptualized the role of awareness of team and task-related aspects of collaboration (i.e., a mix of social, cognitive and behavioral awareness) for mediating team effectiveness. They defined team effectiveness of learning groups as a combination of high quality learning outcomes and high-quality team performances, as well as the satisfaction of needs of group members. This definition was in line with social-constructivist paradigm, that asks for more active engagement in the processes of knowledge construction i.e., discussion, argumentation etc. for achieving deep learning and conceptual change. They formed a conceptual framework for team effectiveness based on the framework of "The Big Five in teamwork" by Salas, Sims, and Burke (2005). Thereby, they examined the application of the five key factors (i.e., team leadership, team orientation, mutual performance monitoring, back-up behavior and adaptability) in learning groups. Their conceptual framework for team effectiveness defined how these factors relate to each other and to the effectiveness of the learning team. In particular, they focused on how awareness of team and task related issues can facilitate mutual trust, shared mental models and mutual performance monitoring as intermediate variables for team effectiveness.

Mutual performance monitoring (MPM) refers to "being aware of and keeping track of one's fellow team members' work while carrying out one's own work to ensure that everything

is running as expected and procedures are followed correctly" (Fransen, Kirschner, & Erkens, 2011, p. 1103). According to this definition, students need information on task and team aspects to establish a shared understanding of both task and team responsibilities. Also, they need to update their understanding of the current status of group processes with information from the environment, in order keep up with the effective monitoring of team performance This is type of awareness information draws on the situation awareness concept (Leinonen, Järvelä, & Häkkinen, 2005) and functions both as a prerequisite for mutual performance monitoring, and as an assurance mechanism for its effectiveness. Mutual performance monitoring depends also on awareness of participation, as students need to exchange information about team members' activities within the team (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Kreijns, Kirschner, & Jochems, 2003). When awareness information of these types is provided, effective mutual performance monitoring should occur and result in effective task execution in relatively. Based on this, Fransen et al, (2011) hypothesized that mutual performance monitoring can predict the learning-team effectiveness.

Mutual performance monitoring processes may create frictions among group members as feedback and/or critique on the actions of other members are part of it. Moreover, students are often protecting information, checking, and inspecting each other and each other's' behaviors, leaves little room for constructive collaboration. When mutual trust is established, team members feel more comfortable to share information freely and fear less for the critique of fellow team members (Nelson & Cooprider, 1996). Mutual trust (MT) can be achieved by raising awareness of the interests of all members and by highlighting the interdependence of their actions (i.e. social dimension). Moreover, it can be achieved by encouraging the sharing of information among group members (i.e. cognitive dimension). Fransen et al, (2011) hypothesized that mutual trust (both social and cognitive) is a critical condition for team effectiveness in all stages of teamwork, and especially in the initial stages of collaboration

Another important supporting mechanism for effective mutual performance monitoring is the building of shared mental models. Shared mental models (SMM) can be distinguished to team and task-related mental models i.e., for allocating subtasks among members in the group. Team-related mental models refer to shared understanding of team processes. They require information on the team functioning and the expected behaviors of the team members individually and as group (i.e. team awareness). Task-related mental models refer to shared understanding of task processes such as planning the collaboration steps in advance. They require information regarding the materials and strategies needed to successfully carry out the

task (i.e. task-awareness). “Shared team-related and task-related mental models, or team and task awareness, facilitate task execution by creating a framework that promotes common understanding and action” (Fransen et al., 2011, p.1106). Based on this statement, Fransen et al., (2011) hypothesized that team and task-related mental models are conditional for effective mutual performance monitoring in learning teams.

Fransen and his colleagues (2011) tested their conceptual framework in study with teacher students of a Dutch university (N=116), who collaborated in groups for design the pedagogical and organizational policies of a primary school as part of hypothetical scenario. The tasks afforded a blended model of communication (face-to-face, online and virtual) and required them to develop both team skills and task skills. The degree of development of mutual trust, shared mental models, and mutual performance monitoring, as well as their impact on team effectiveness were measured with the help of questionnaire. The hypothesized connections among the three intermediate variables (SMM, MT, MPM) and team effectiveness were tested by means of regression analyses. The results indicated that developing shared mental models in collaboration, as well as to some extent performing mutual performance monitoring is important for effective collaboration in groups. Also, interpersonal trust was shown to be conditional for building adequate shared mental models but was not associated to completing the task successfully. Furthermore, students focused on task- mental models and awareness taking thus a pragmatic stance on collaboration. The lack of adequate mutual performance monitoring techniques was explained by the absence of any plenary discussion for agreeing on how to perform monitoring and give feedback in the virtual reality environments, and how to deal with the feedback accordingly. Finally, the study indicated the need for further research on how to enhance the team-related models and awareness in collaboration and how these affect the procedures of mutual performance monitoring.

2.2. Design Background

In this thesis, we argue for a holistic approach to supporting social interactions of collaborative argumentation in a co-located CSCL setting. In this section we outline the design choices for the support in the content and the relational space of collaborative argumentation throughout the development phases of Argue(a)ware. Moreover, we define parameters of interest in the design of the awareness support based on guidelines for designing group awareness tools in CSCL as well as for designing awareness notification systems in CSCW.

The support for the content space of collaboration in Argue(a)ware is formed with respect to CSCL literature on instructional supporting mechanisms and methods, as well as computer-based support for argumentation processes and outcomes. The support for the relational space of collaboration builds on design choices for design awareness tools in the CSCL and the CSCW research field. Thereby, we examine the awareness tools from the two fields with respect to their affordances, common use cases and prominent frameworks for designing awareness tools.

2.2.1. Computer support for collaborative argumentation.

Research on computer-supported collaborative learning produces tools for supporting collaborative argumentation in diverse settings ranging from simple discussion forums to sophisticated and formal argumentation and decision support systems (Tsovaltzi, Puhl, Judele, and Weinberger, 2014; Karousos et al., 2010). In terms of this thesis, we focus on tools for supporting the visualization and the structuring of collaborative argumentation processes and outcomes in classroom i.e. argument mapping tools (Van Amelsvoort, Andriessen, &. Kanselaar, 2007). These tools are based on the concepts of argument maps and their potential for supporting different collaborative argumentation tasks i.e., learning to argue or learning by arguing.

Argument maps (also known as argument diagrams) refer to external knowledge representations that help students structure their arguments visually (Scheuer, McLaren, Weinberger, Niebuhr, 2013). They are an advocated method for teaching argument analysis skills (Harrell & Wetzel, 2015) and have been proven to be effective for enhancing critical thinking skills (Twardy, 2014, van Gelder, 2013). In creating argument maps, students learn higher-order thinking skills, like how to organize complex information and present the information clearly (Davies, 2011). Next to that, argument maps allow for more effective reflection and evaluation of the strength of one's argument by identifying the key components of an essay or a report, thereby resulting in better structured and more convincing arguments in the context of essay writing courses at the college level.

Argument mapping is often applied in problem-based learning situations where it transforms the process of finding a solution to an unfamiliar task using the knowledge they have into an argument based on informal reasoning. It helps users collect and represent all the required information to reach conclusions and even identify the weakness of the reasoning

process or several possible answers that can vary in effectiveness. In the case of problem- based collaborative learning environments, where multiple actors need to construct appropriate mental representations for modeling problems and their solutions, argument maps can help collaborators explicate and share their representations, resolve disagreements rationally and maintain the focus on the topic at hand on the key issues. Additionally, in the case of ill-structured problems, it can assist learners to go through the problem-solving states but also move back and forth between states for work on partial solutions and refining their solution (van Bruggen, Boshuizen, Kirschner, 2003).

There are many argument mapping tools supporting computer supported argument visualization (CSAV) currently available in the market. Buckingham-Shum (2003), has categorized argument mapping tools based on their stakeholders they appeal to (education, science, business etc.), the different argumentation models for the representation of arguments (i.e., Toulmin's model, Wigmore or Bayesian) they embody and the trade-off they make between expressiveness and usability. Research comparing argument mapping tools to systems that support threaded discussions show knowledge maps can better facilitate collaboration (Suthers et al., 2008). Finally, research presents us with different use cases for argument mapping tools i.e., as a means for debate or as representation of the debate (Lund, et al., 2007). In the study by Lund and colleagues the instructions on the proper use of the argumentation diagram were found to assist the argumentation processes and outcomes.

2.2.2. Instructional support for computer-supported collaborative argumentation.

Design choices for building the instructional support of collaborative argumentation processes and outcomes in CSCL include the use of pedagogical scripts (i.e., set of instructions for collaboration and argument knowledge construction). Thereby, the distinct roles and argument scaffolds are briefly presented.

2.2.2.1. Scripting.

Research on Computer-Supported Collaborative Learning acknowledges computer-supported collaboration scripts as a promising approach for facilitating specific collaborative processes of learners in CSCL environments (Goodyear, Jones, &Thompson, 2013). Scripting

is defined as an instructional method for instructing students about how they need to collaborate i.e., distributing tasks or roles, setting turn taking rules, defining their work phases and the quality standards of their deliverables (Dillenbourg & Jermann, 2007). The main objective of scripts is to foster knowledge productive interactions i.e., argument-building and explanation sharing, by intervening at the right point of collaboration for regulating these interactions (Dillenbourg & Hong, 2012). In terms of computer-supported collaborative argumentation systems, scripts are categorized as epistemic, argumentative and social scripts (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012).

Argumentative scripts take care of the macro and/or the micro-level of argument co-construction (i.e., argument sequences and/or single arguments) by means of process prompts and sentence openers for enhancing the quality arguments with warrants and qualifiers for claims. Stegmann, Weinberger, and Fischer (2007), tested a combination of message constraints and labels (e.g., claims and qualifiers) and pre-set argumentation sequences for their effects on facilitating argumentative knowledge construction in CSCL environments with positive outcomes. Epistemic scripts guide students through their discourse with instructions for engaging in task-oriented activities such as for understanding of the problem and relating the theoretical concepts with case information and prior knowledge. Lastly, social scripts are used for specifying and sequencing learners' interactions, so they can, in turn, internalize these strategies with time and use to foster the elaboration of their arguments (Noroozi et al., 2012).

2.2.2.2. Roles.

Roles are known to facilitate collaboration and task completion by giving students a sense of security and therefor enabling them to concentrate on the task. Roles can be defined as "prescribed functions that guide individual behavior and group collaboration" (Morris et al.,2010 p.816). Roles can be viewed as a scaffold in collaborative learning processes where the goal is to gain new knowledge, as well as cognitive and collaborative skills. Assigning roles may foster interdependence while at the same time it promotes individual accountability Roles can be classified as functional roles and cognitive roles.

Functional roles define the steps necessary for carrying out a task by classifying and assigning tasks to people. Typical examples of functional roles are the role writer and data analyst. Cognitive roles focus on supporting engagement in academic work by classifying and assigning relevant types of thinking, processing, and cognitive engagement into designated

roles in a collaborative context. While scripted functional roles, such as the writer or corrector, help reduce the process losses (i.e. coordination problems) (Strijbos et al., 2004; Weinberger, Stegmann, Fischer, 2010), cognitive roles could help enhance cognitive engagement with the task by defining and assigning learners with relevant types of thinking and action-taking in the collaborative argumentation context (Morris et al., 2010; Gu, Shao, Guo, and Lim, 2015). Typical examples of cognitive roles include the roles of "feedback provider", "summarizer", "questioner", "clarifier", "challenger/asker" or "tutor" and "tutee" (De Wever et al., 2010; Morris et al., 2010; Gu, et al., 2015; Chou et al., 2002).

Assigning roles as part of a social script for collaboration in collaborative argumentation settings has been found to have beneficial effects on argumentative knowledge construction (i.e. discourse activities on for learning to argue within a domain) (Weinberger and Fischer, 2006). In a study by Weinberger et al., (2007) on comparing the use of different scripts (epistemic, argumentative and social) for promoting argumentative knowledge construction in computer-supported learning environments, we see that the roles of "analyst" (for composing analyses of the case and responding to critiques) and the "constructive critic" (for criticizing the case analyses) as part of the social script were linked to higher levels of engagement in the "social modes of co-construction", a construct for describing to what extent learners refer to contributions of their learning partners during the argumentative discussion (Fischer, Bruhn, Gräsel, & Mandl, 2002). This engagement led, in turn, to higher transactivity i.e., critical reciprocation to the reasoning of peers (Teasley, 1997) which resulted in more frequent epistemic activities i.e. applying theoretical concepts adequately to the case problem and higher individual knowledge acquisition (Weinberger and Fischer, 2006).

2.2.2.3. Argumentation scaffolds.

Argument scaffolds take many forms. One form of scaffold for argumentation is question asking. This method provokes students to exchange information and check their knowledge on the topic, create claims for answering the problem at hand and provide explanations and justifications for their claims (Veerman, Andriesse, & Kanselaar, 2002). Another type of argumentation scaffolds are sentence openers. They are typically used for encouraging students to engage in certain types of interaction and thereby regulating their collaboration or structuring the interaction to facilitate computational analysis of collaboration processes and outcomes. The use of sentence openers in CSCL environments has been studied

for effects on fostering online peer-to-peer interaction or structuring argumentation (Lazonder, Wilhelm, Ootes, 2003; Yiong-Hwee & Churchill, 2007) with mostly positive results. In the case of collaborative argumentation environments, sentence openers are known to support students in starting with the writing process, communicate their arguments more explicitly and to reflect upon them (Yiong-Hwee & Churchill, 2007). However, sentence openers are often only focusing on how to start a sentence and not on how to make proper sequences of sentences or with logical connection between the claim and the ground (Lee & Kim, 2003).

Lee and Kim (2003), suggested a design for extending sentence openers to sentence templates, based on Toulmin's model for argumentation and a writing template in an asynchronous communicative environment for fostering learners' argumentative knowledge and enhancing the quality of argument, therefore reaching a fruitful shared understanding. They propose a template design that pays attention to several important aspects for collaborative argumentation: First, they adopted an abstract version of Toulmin's argumentation model called the Micro Argument. This model included a claim and the ground rather than all the components of a typical argument according to Toulmin model i.e., claim, data, warrant, backing, and qualifier. Then this abstract version was employed for addressing the argumentation of inexperienced learners. Second, they adjusted the freedom of the use of sentence templates in their environment as flexible, as users were not forced to work with all the sentence openers during collaboration. Furthermore, they created their sentence templates based on domain-general pattern, claiming that their use of the sentence template is independent of the specific domain.

2.2.2.4. Instructional method.

Problem-Based Learning (PBL) is a pedagogical approach often used in the curriculum design for higher education courses for helping students improve their argumentation skills and enhance their abstract and critical thinking skills, since students are called to interpret, connect and criticize theories for creating effective arguments to solve the problem (Barrows,1996). In doing so, students need to follow rules of logic and at the same time consider the perspectives of other group members and seek evidence to support their arguments. Studies indicate that computer-based argumentation scaffolds can help middle school students build evidence-based arguments (Belland, Glazewski, and Richardson, 2011), as well as support higher education students in co-constructing knowledge while elaborating on the material and interacting for

solving complex and ill-defined problems as part of small group problem-solving activities (Liu and Tsai, 2008; Monteserin, Schiaffino, & Amandi, 2010; Weinberger, Ertl, et al., 2005).

2.2.2.5. Learning to argue based on a simplified Toulmin model for argumentation.

From a theoretical point of view, both instructional techniques for teaching argumentation as well as computer support for visualizing argumentation processes and outcomes are relying on Toulmin's model for argumentation (figure 2.1.) (Toulmin, 1958; 2003). The emphasis of this model is placed on the identification of structural elements of single arguments (e.g. claims, rebuttals and backing, etc.) as method for analysing and evaluating actual human reasoning or as it is better known today "informal logic" (Toulmin,2003). Ever since it was introduced, Toulmin's model has been widely adopted by educational institutions as it was found to provide a useful framework for students to construct and deconstruct an argument to its basic elements (Harrell and Wetzel, 2015). The model is also used for measuring the quality of argumentation the nature of argumentation and its assessment and the content of an argument itself (Osborne et al., 2004).

The elements of this model are defined as following (Rahwan & Sakeer, 2006 p. 7):

Claim: This is the assertion that the argument backs.

Data: The evidence (e.g. fact, an example, statistics) that supports the claim.

Warrant: This is what holds the argument together, linking the evidence to the claim.

Backing: The backing supports the warrant; it acts as an evidence for the warrant.

Rebuttal: A rebuttal is an argument that might be made against the claim and is explicitly acknowledged in the argument.

Qualifier: This element qualifies the conditions under which the argument holds.

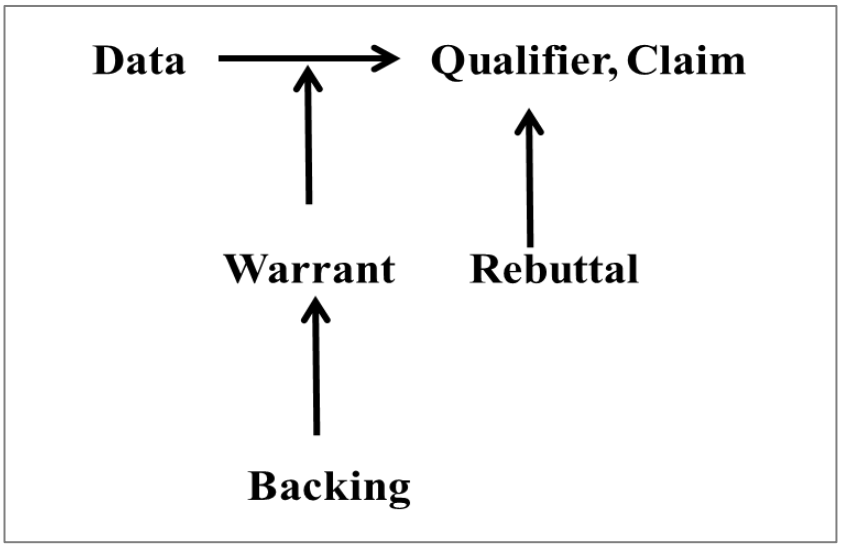


Figure 2.1. Toulmin's example of his model of argument diagramming (1958, p. 97).

2.3. Group Awareness Tools

Group awareness tools are employed for establishing and interpreting group awareness as a natural by-product of interaction, an otherwise not so easy task in CSCL environments (Bodemer & Dehler, 2011). Group awareness tools can be differentiated with respect to the types of conceptions of group awareness i.e. behavioral, social, cognitive awareness, and the methods used for conceptualizing and displaying awareness in the system e.g., implicit or explicit feedback methods (Ghadirian, Ayub, Silong, & Hosseinzadehakar, 2016). Moreover, group awareness tools have been investigated with respect to their ability to support social performance in the group (interactions in the group), and their impact on collaborative learning process and outcomes in CSCL environments (Bodemer & Dehler, 2011).

Group awareness tools assist learners in processing awareness information before acting on it by means of information visualization tools, thus providing tacit guidance to students for adopting their learning activities (Bodemer & Dehler,, 2011). Group awareness i.e., knowledge of cognitive, behavioral and social aspects of collaboration is often supported with the help of group awareness tools in CSCL environments (Ghadirian, et al., 2016). Typically, these tools afford visualizations of collected, disseminated and integrated information on prior and current knowledge of students, as well as on students' interactions in

the group (Schmidt, 2002). Research on educational and social affordances of group awareness tools in CSCL has indicated their potential for influencing students' individual behaviors and regulate their participation and to verify and negotiate the activities in the group for achieving better coordination (Belkadi, Bonjour, Camargo, Troussier, & Eynard, 2013; Janssen, Erkens, & Kanselaar, 2007; Sangin, Molinari, Nüssli, & Dillenbourg, 2010).

2.3.1. Multiple displays for awareness visualization.

With respect to the use of different display types for facilitating awareness visualizations in collaborative learning systems, we see that shared large displays i.e. wall displays, or tabletops are predominately used. This is explained by their potential to augment shared visual representations, which mediate and facilitate shared cognition and consequently promoting shared mental models for effective learning (Yusoff & Salim, 2015). In that sense, shared visual representations on large shared displays can facilitate collaboration by promoting a shared understanding of the collaboration processes and increase shared situation awareness by acting as a shared visual reference point for monitoring cognitive, social or behavioral aspects of collaboration (Yusoff & Salim, 2015; Kao and Liu, 2005).

More specifically, wall displays, or shared tables have been used in co-located collaborative learning scenarios for hosting shared visualizations of collaborative work and individual work, thereby making use of different visualization strategies (e.g. shared visualization, shared coordination, or shared mirroring) and different techniques of shared visualization applications (e.g. collaborative concept mapping, collaborative discussion board). In a study by Wallace et al., (2011) with variations of a large display as part in a multi-display co-located collaborative, positive effects of the large display as "status display" (shared visualization of team performance) for facilitating monitoring of group progress and of the large display as "replicator" of the contents of the personal computers on grounding conversation in the group were observed.

2.3.2. Awareness tools for regulating participation.

Regulation of participation can be achieved with the help of systems for distributing metacognitive information (Jermann & Dillenbourg, 2008). Literature distinguishes these tools in three categories; mirroring tools, monitoring tools and guiding tools based on how they utilize the awareness representation they support collaborative processes and how they promote

desired interaction modes in the group (Jermann, Soller, & Muehlenbrock, 2001). Mirroring tools offer feedback via a dynamic graphical representation of the group's actions while metacognitive tools allow for monitoring interaction by diagnosing the interaction through visualizations or self-assessment questionnaires and comparing it in the group against an (often implicit) standard. Evaluating ones' own contributions to the collaboration processes and comparing it to the ones of their group mates can enhance students' sense of responsibility for the group progress by training their reflective and critical thinking skills (De Wever, Van Keer, Schellens, and Valcke, 2009; McLoughlin and Luca, 2002). Self-assessment techniques in collaborative contexts aim at increasing students' critical and perceptive thinking towards their personal contributions and the input of others (Larres et al. 2003; Robinson & Udall 2006), which results in gains in their content-related learning, quality of problem solving and self-reflection (Sluijsmans et al. 1999; McDonald and Boud 2003).

Both mirroring and monitoring (i.e., metacognitive) group awareness tools are often combined with scripting mechanisms (Järvelä & Hadwin, 2013; Miller & Hadwin, 2015) for prompting students' self-reflection and assisting them in adapting their activities to the group awareness information at hand by pointing out the "degree of asymmetry in action or the rate of acknowledgement in interaction" (Dillenbourg,1999, p.6). Finally, both tools support students in creating a shared mental model of collaboration by allowing the comparison of the current state of the interaction to an optimal mental model of productive interaction (Mohammed & Dumville, 2001; Fransen et al., 2011). Shared mental models are in turn considered to be a prerequisite for adequate mutual performance monitoring, which is connected to the positive interdependence of group members and more frequent communication on the team and task aspects of collaboration (Fransen et al., 2011).

Guiding tools (aka advising or coaching systems) build upon the awareness information for comparing current mental shared mental models to ideal ones from mirroring or monitoring systems and extend it by offering direct advice to increase effectiveness of the collaboration process in the same way a teacher would act in a collaborative learning classroom (Jermann, Soller, & Muehlenbrock, 2001). While mirroring tools and monitoring tools support learners in the basic awareness support for regulation by collecting interaction-related data and diagnosing interaction problems respectively, coaching systems offer enhanced support for collaboration by proposing remedial actions based on a computational assessment of the situation, there triggering behavioral adaptation (Jermann, Soller, & Muehlenbrock, 2001; Jermann & Dillenbourgh, 2008). Most group awareness tools (mirroring, monitoring and

guiding) aim at behavioral adaptation, which is considered to be pivotal for effective learning, but it can be argued that tools support different degrees of matching monitored information with immediate action (Buder, 2011).

2.3.3. Awareness support for Metacognition.

Lin (2001), defines metacognition as "the ability to understand and monitor one's own thoughts and the assumptions and implications of one's activities" (p.14). She asserts that monitoring and evaluating the process of solving a problem can guide the learner to make informed choices about the selection of solutions by assessing alternative solutions, and justifying the chosen solutions. However, students' engagement in the monitoring and evaluation of their problem-solving depends on the degree of metacognitive skill students already have.

2.3.3.1. Process Prompts

Lin (2001), proposes strategies for teaching metacognitive skills and amongst them also the prompting method. She suggests using question asking prompts for guiding students' attention to specific aspects of their learning process and thereby triggering their monitoring and evaluation skills. Question prompts can guide students to evaluate and reflect on relevant aspect of collaboration (a) planning (e.g., do we all understand the text? Or the goals and the plan for the task?) (b) how they completed the task (e.g., what were our strategies for solving the problem?), (c) challenges or difficulties with coordination of the processes, and (d) socio-emotional challenge(i.e. group dynamics) (Miller & Hadwin, 2015).Research on the use of question prompts shows that students use such prompts as a check-list for structuring their collaborative processes and reflecting on the meaning of the problem (Ge & Land ,2003). Thereby, Ge and Land (2003) used question asking prompts for triggering reflection i.e., "What is the best solution to this problem?" and elicit self-explanation to justify decision in the group and elaboration prompts for prompting students to articulate their thoughts better and elicit explanations (Ge & Land, 2004).Finally process prompts are used for monitoring how and why certain decisions were made and for evaluating their effectiveness . These process prompts are used either of helping students pin-down their misunderstandings or for becoming more self-aware of their own learning and assess themselves against a set of criteria. (Lin, 2001).

2.3.3.2. Reflection Breaks.

Pausing a lecture briefly for reflecting together with peers on collaboration processes is well documented active learning technique (Rowe, 1980; Parker, 1994) with positive effects on the engagement of the students with the task (Verpoorten & Vestera, 2014; Bachhel & Thaman, 2014). Research studies on the 'pause procedure'– also known as "pausing principle" or as "reflection breaks" examines the breaks from performing the main collaborative task with respect to their length and order of appearance of the pauses within the lecture as well with respect to the different tasks assigned to the pauses. These pauses are typically kept short (i.e., 2 to 5 minutes), appear either during the class at regular intervals and the students are asked to complete tasks such as discussing their notes and revise them (Ruhl, Hughes and Schloss,1987; Bachhel and Thaman, 2014) or perform either puzzle, an individual review of the notes, or a group discussion (Di Vesta and Smith, 1979) Verpoorten and Vestera (2014), investigated the potential of practicing short reflection breaks for stimulating metacognitive awareness of reflective processes, as inspired by the "split screen teaching" practice (Claxton, 2006). They tested the impact of reflection break on maintaining the focus on the content of the lesson and the learning processes with secondary school children (n=40) in a computer-based learning environment. While the study showed that the learning performance of students was not affected by the embedded reflection breaks, the breaks had significant effect on perceived learning and helped modify. Students also declared that they would be inclined to apply similar reflective approaches to other learning situations.

2.3.4. A framework for displaying and monitoring awareness information in group awareness tools.

Buder, (2001) summarized current trends in the design of group awareness tools in CSCL and categorized with visualization-based group awareness tool from literature with respect to how the approach the displaying and monitoring of awareness information. Displaying refers to "the process of by which the things to be made aware of are generated" (Buder, 2011, p.1115). Thereby, he differentiates the methods for designing and supporting displaying activities with respect to four empirical issues that are associated with distinctive design options of group awareness tools. The first issue refers to difference between as explicit feedback and implicit feedback in the literature on information retrieval systems. Explicit feedback is a deliberate, intentional and conscious displaying activity of awareness information

by learners (i.e., assignment of badges to reward others or self-assessment). On the other hand, implicit feedback tools generate awareness information without requiring the learners to perform a deliberate, action. Implicit feedback systems are preferred over explicit ones because they are associated to more objective feedback and because they afford collecting feedback automatically and in an unobtrusive way. However, Buder suggests that explicit feedback displaying activities may be beneficial for collaborative learning as they cater quite well to the constructivist nature the learning tasks. Next, he describes the issue of

using dynamic vs. static displays of awareness information. This issue refers to the frequency of updating awareness information during collaboration, Dynamic tools employ mechanisms for updating the awareness information about the collaborative processes regularly while static ones gather the information at the beginning and the end of the collaborative session. Dynamic display of awareness information can assist the fine-tuning of activities in the group but when combined with explicit feedback methods (i.e., rating) it can increase the workload though the repeated ratings. Thirdly, he addresses the issue of encouraging or even forcing learners to display awareness information. He states that script the processes of display may be particularly helpful for establishing a common ground in CSCL. The fourth issue addressed in this paper concerns the display format. Closed format displays refer to graphical interphases for rating on a pre-defined scale whereas open-format utilizes displays which allow for more variability in expression of awareness information (i.e., open text fields).

The second group of empirical issues relates to monitoring i.e., "the process of becoming aware of information that was displayed by other group members" (p.1116). Thereby, the first issue relates to how obtrusive can monitoring can be. Regulating awareness is typically a secondary task to the main task of collaboration and when displaying and monitoring become extra activities, the question of how much monitoring comes at the cost of attention to the main task arises. The second issue with respect to monitoring of awareness' information, refers to the comparability affordances of the tool i.e., how and if it allows for comparing pieces of information that were displayed. Comparability can have both positive and negative effects: in the best case, it triggers help-giving behavior and positive interdependence among group members, while in the worst case, it can be associated with demotivation and abstinence from collaborative processes. The third issue of monitoring is related to the effects of comparing openly available information in the group; it can create some normative pressure which is positive for the collaboration or lead to negative collaboration phenomena such as evaluation apprehension phenomena (Cottrell, 1972). Finally, the fourth

issue of monitoring refers to the directivity or guidance affordances of the visualization too. The effectiveness of tools depends on the degree of behavioral adaptation they trigger. Almost all group awareness tool aim at triggering behavioral adaptation but differ to the extent they couple monitored information with immediate action. Lastly, he suggests that combinations of pedagogical scripts and group awareness tools could be a way for enhancing the guidance and directivity of a tool.

2.4. Awareness Notification Systems.

Notification systems attempt to deliver "current, important information through a variety of platforms and modes in an efficient and effective manner" (McCrickard, Catrambone, Chewar & Stask, 2003, p. 548). Notification systems have been employed in in CSCW and CSCL research for supporting student's self-regulation by raising awareness of presence, tasks and actions of collaborators, as well as for supporting teachers' feedback provision by raising awareness of students' achievements and weaknesses (Carroll, et al, 2002; Martinez-Maldonado et al, 2014).

2.4.1. Media for facilitating awareness notifications.

A review study on technologies used for providing awareness in research revealed that awareness notification systems run mostly on traditional graphical user interfaces a (46% of research papers), while mobile devices (especially smartphones) account for 35% percent of the delivery systems for awareness notifications studies (López & Guerrero, 2017). Media used as notification systems in CSCL research studies include email-digests, interactive webpages and homepage widgets (Laffey, Young,Hong, Galyen, & Goggins, 2008), mobile applications (Sirisaengtaksin & Olfman, 2014) and wearable signaling devices such as necklaces, fabric belts or arm bracelets (Hernández-Leo, Balestrini, Nieves & Blat, 2012). These media represent the wide range of physical and screen-based ubiquitous computing systems for assisting ambient notification systems (Pousman & Stanko 2006; McCrickard et al, 2003). Typically, ambient information systems are not placed at the center of user's main attention priority and they are used to maintain awareness of low-priority information in conjunction with large displays (Tang & Lee, 2016).

The main use case of smartwatches in day to day life is the visualization of notifications from smartphones (Schirra & Bentley, 2015). The use of smartwatches for delivering

notifications is associated with high awareness of incoming notification but also to higher distraction from another task (Shirazi & Henze, 2015; Lee, Kwon & Kim, 2016). Research on smartwatches as notification devices in CSCL environments capitalizes on vibrotactile stimuli for supporting collaborative learning orchestration in pervasive classroom environments with vibration signals for group formation and change of activity (Manathunga et al., 2015), and for supporting lecturer-student communication in big lecture halls with a vibration-based notification interface on lecture's smartwatch and as part of a communication response system (CRS) in less obtrusive way (Wang, Millet & Smith, 2016; Caps, Delf & Vetterick, 2015).

Notifications on smartphones alert users about new text-messages, missed phone-calls emails, social network updates, and other events in day to day life. Even though the use of widely spread smartphones is still restricted in most modern-day schools, research on the appropriation of the powerful multimedia applications of smartphones for employing them in face-to face and distance CSCL settings in conjunction with mobile learning (Seralidou & Douligeris, 2016; 2017) and ubiquitous learning concepts (Jung, 2014) has been flourishing. In the CSCL context, text-based notification systems on smartphones with light and vibration modalities have been researched (Manathunga et al., 2015) for their potential to function as middleware to establish connection to shared displays in a pervasive classroom environment and for improving user's awareness in collaborative writing environments (CWEs) in conjunction with other ubiquitous monitoring devices (Brenes, Lopez & Guerrero, 2017).

On the contrary to well-known ubiquitous mobile and wearable devices (i.e., smartphones and smartwatches), smart-rings are fairly new wearable interaction devices with an expanding variety of use cases. For example, commercially available smart-rings are used as an alternative to smartphones for making payments with the use of near-field communication technology (i.e., Kerv Ring) or in connection to smartphones for notifying users of incoming calls, text, emails, (i.e., Ringly) and finally as activity trackers (i.e., Motiv Ring). Typically, smart-rings don't afford displaying any text-based or graphical information per se but they notify users by means of light signals and vibration cues to check on this information in the connected devices via smartphone applications and webpages, while gesture control technologies are used for controlling smart home gadgets or unlocking phones and doors. Interaction with the system is mainly facilitated through smartphone applications and only some smart-rings afford physical or capacitive buttons for activating or deactivating certain functions.

Research on smart-rings as notification systems focuses on their affordances for providing real-time auditory and vibrotactile feedback (Shilkrot et al. 2014; Roumen et al. 2015). Vibrotactile cues on the fingers can be effective in alerting users for incoming notifications thanks to the particular sensitivity and the high level of organic sensing in the hands and phalanges (Butz and Krüger 2014). In a study by Roumen et al. (2015), we see that users prefer vibration-based notifications on smart-rings for urgent situations i.e., incoming phone calls, while they dim light-based notifications to be a better fit for less urgent notifications (i.e., social media notifications). However, studies on perceived urgency of light-based notifications indicate that red color LED lights with a high frequency of blink are effective in conveying urgency information (Kim et al., 2014; 2015). Abstract light-based visualizations of information with combination of color and blinking on LEDs can be used also for conveying information (Tarasewich et al., 2013). To our knowledge, there is no research on their use as notification systems in the CSCL context yet.

2.4.2. A Framework for Designing Notification Systems.

The key to designing a successful notification system is supporting the allocation of attention between tasks, while simultaneously enabling utility through access to additional information for achieving user's goals with the system. The effort to balance between these desirable but often conflicting design goals is known as the "Attention-Utility Tradeoff" (McCrickard & Chewar, 2003;2006). Users of notification systems are often willing to sacrifice some primary task attention to gain benefits such as important information about task processes. However, untimely interruptions or overactive alarms insensitive to user priorities may result unwanted distractions, the loss of critical content, and ultimately in low satisfaction with the system (Arroyo & Selker 2003).

McCrickard and Chewar (2003) developed a user-oriented framework that accounts for the user notification goals with respect to the three critical parameters of interruption, reaction, and comprehension (IRC). The framework defines the three critical parameters as user objectives for the design and the evaluation of notification systems that evolve around sources of utility such as interruptions to primary tasks, reactions to specific notifications, and comprehension of information over time (McCrickard & Chewar 2003). Designers use these objectives to assess attention and interruption cost factors and to determine target parameter levels of existing notification systems in order to improve these or to inform the development

of new systems (McCrickard & Chewar, 2006). The "Interruption" parameter in notification systems is concerned with events that prompt the transition of attention focus from the primary task to the notification. Responding to a notification stimulus, with or without shifting the attention between tasks for making decisions about it or acknowledging its status is the objective of the "Reaction" key parameter. Finally, the "Comprehension" parameter defines how users identify state changes, as well as how they monitor, remember and assimilate complex awareness information over time.

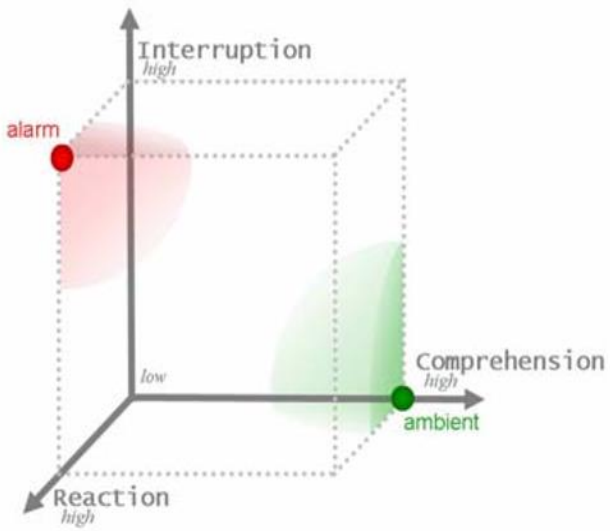


Figure 2.2. "Framework reflecting the user goals for interruption, reaction, and comprehension- critical parameters for system success. Two types of systems, ambient and alarm are depicted according to the goals they support." (in McCrickard & Chewar, 2003 p.69).

The creators of the framework suggest assessment techniques for evaluating notification interfaces with the use of the IRC critical parameters with the use of equations that account for various aspects of these parameters (Chewar, McCrickard & Sutcliffe, 2004). “Interruption” is measured by calculating the cost of interruption to the main task i.e., disruptiveness to main task and the primary task sustainment i.e., how much was the primary task affected by the notification. “Reaction” is measured by hit rate i.e., how often user notice the notifications and the response time i.e., reaction time to the suggested action by the notification. Finally, “Comprehension” is measured by calculating the perception rate i.e., the ratio of interactions with the notification system in response to the notification, base

comprehension i.e., amount of notification content remembered by the user shortly after the delivery and the projection i.e., successful projections or predictions about future status in the task. This approach to measuring the IRC critical parameters is made operational with a variety of usability evaluation instruments for analytical and empirical testing.

The three critical user objectives are illustrated with the help of a three axes system, similar to a 3D coordinate system. Each dimension is assigned a rating of high (1) or low (0) and depending on the estimation of the values these critical parameters (Chewar, McCrickard & Sutcliffe, 2004) a system can be categorized along these extremes or is a hybrid system (figure 1), creating models like 0-1-0. For example, “alarms” (1-1-0) are notifications systems which are identified by their high interruption rate and their ability to cause a fast response to their message, while "ambient" media (0-0-1) are characterized by their low-threshold interruption to the main task and a high comprehension of their message.

3. Instructional Awareness Support for Collaborative Argumentation

In this section we introduce the first draft of the Argue(a)ware. In the first phase of development of the Argue(a)ware tool, we built support for the content space of collaborative argumentation with the help of a pedagogical face-to-face macro-script with argument scaffold elements and an argument mapping tool. Furthermore, we extended the use of the script for supporting the relational space of collaboration by embedding a combination of Metacognitive and process prompts (i.e., awareness prompts) in the script. The scripts aim at prompting the engagement in the metacognitive processes (i.e., regulation, reflection, evaluation) during regular breaks from collaboration in the script. To identify relevant awareness aspects for supporting the relational space of collaboration, we looked into types of awareness associated with aspects of social interaction in the relational space of collaboration i.e. behavioral and social awareness (Pifarré, Cobos, & Argelagós, 2013; Janssen, Erkens, and Kirschner, 2011).

Following, we designed two variations of the same pedagogical face-to-face macro-script which differ with respect to the type of group awareness information prompts they used for supporting the relational space of collaboration i.e. behavioral and social. These will be referred to as “Awareness-oriented Argumentation Scripts” (AOAS) henceforth. The Behavioral Awareness Script (BAS) variation included discussion-based process triggering prompts for regulating, reflecting on and evaluating the behavioural aspects of social interaction i.e., planning collaboration processes, performing participation check, performance

comparisons and coordination checks. These prompts should help students engage in the related metacognitive activities and thereby produce and exchange awareness information about the learners' activities in the group i.e., perceived participation levels, perceived progress with the plan for collaboration (Janssen, Erkens, & Kirschner, 2011). This information can be used to foster the social regulation (i.e., group functioning) and thus the cognitive performance of the group. Group awareness supported by this tool is intended to foster social regulation activities and to increase group performance by stimulating the rate and the equality of participation.

The Social Awareness Script (SAS) variation included discussion-based process triggering prompts for regulating, reflecting on and evaluating inter-relational aspects of social interaction i.e., taking-up a role, evaluating performance in the role, encouraging active participation. These prompts should help students engage in the related metacognitive activities and thereby produce and exchange awareness information about the learners' activities in the group i.e., perceived friendliness levels in the group and feelings about their role (Phielix et al, 2011; Pifarré, Cobos, & Argelagós, 2013). This information can be used to regulate the social interactions (i.e. group functioning) and enhance the social performance and thus the cognitive performance of the group.

In the following sub-section, we explain the design rationale of the Awareness-oriented argumentation scripts as instructional support for the content and the relational space of collaborative argumentation in detail. Moreover, we introduce the use case

3.1. Awareness-oriented Argumentation Scripts

The awareness-oriented argumentation scripts were designed to be used as a multi-pillar instructional strategy for computer supported collaborative argumentation sessions with Argue(a)ware. The first two pillars included a) the problem-based learning units in the form of ill-structured problem cases and b) the support for the content space of collaboration in the form of argument scaffolds embedded in the script and an argument mapping tool (figure 3.1.). These two pillars were designed for supporting the construction and visualization of arguments and thereby for assisting the learning of the basic elements of an argument according to a simplified Toulmin model for argumentation (Toulmin, 2003). The third pillar of the instructional design of scripts is the support for relational space of collaborative argumentation. The supporting mechanisms include regular breaks from collaborative argumentation for

regulating, reflecting on and evaluating the metacognitive collaborative processes. These processes were prompted by discussion- based process-triggering prompts, which we call awareness prompts

The scripts were designed in line with the small-group instructional training method (Piskurich, 2015). This method "places the responsibility for learning on the student through participation in small groups divided out of a larger class" (Piskurich, 2015, p. 165). In our case the tutorials for the large lecture class for "Multimedia-Based Learning Environments" in the Master's Degree at the Media Informatics department (University of Munich) were partly replaced by a smaller group-based learning class model. The aim of the tutorials was to build a bridge between theoretical insights on learning and practical application of technologies. This change in the delivery format of information in the tutorials allowed students to work on problem-based educational tasks. These tasks were designed to help students practice their knowledge on lecture topics such as learning theories (i.e., Behaviourism as learning theory) as applied in the context of technology-enhanced learning environments.

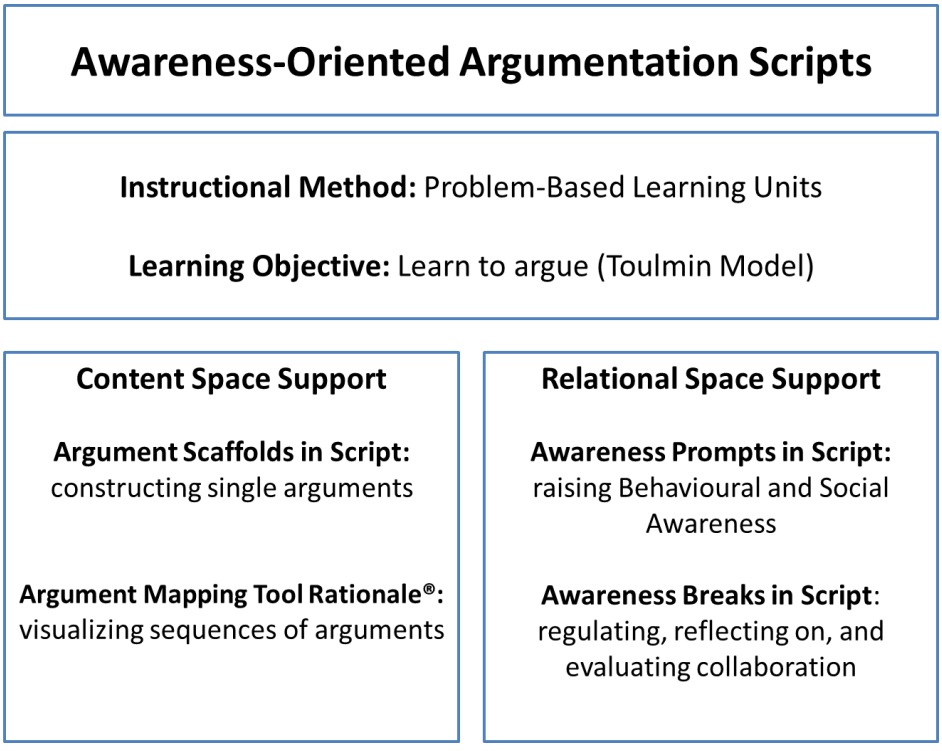


Figure 3.1. The three pillars of the „awareness-oriented argumentation scripts" in the first phase of the development of Argue(a)ware.

These problem-based educational tasks corresponded some of the learning units of the large lecture on the "Multimedia-Based Learning Environments" and were, in turn, influenced by the Problem-based Learning (PBL) theory (Barrows, 1996). As part of our scripted problem-based learning instructional design for the tutorial classes of "Multimedia-Based Learning Environments" lecture, we drafted problem cases for some of the topics and compiled theoretical texts from verified literature sources to illustrate the concepts that were taught. In the four sessions for collaborative argumentation we presented students with the four problem cases (appendix A) for applying the knowledge on the theories discussed in the class the day before the practice course. Students engaged in the following problem-based learning (PBL) units for solving ill-structured problems or problems with unclear or incomplete descriptions in small groups, and then present arguments in support of their solution in the form of argument maps with the help of the argument mapping tool Rationale®. The main learning task was to learn about the structural parts of arguments, based on the Toulmin model for argumentation i.e., claims, counterarguments as well as about the conventions of the argument mapping tool for producing formally correct argument maps with high quality evidence (Toulmin, 1958;2003)

Argue(a)aware uses the awareness- oriented argumentation scripts as an instructional approach to raising awareness of collaboration related issues among students with support for the content and the relational space of collaborative argumentation at the same time. The scripts allow for monitoring and evaluating the collaboration flow on the spot, as well modifying one's thinking about the collaboration flow and even comparing it to their peers with the help of different discussion- based process-triggering awareness prompts and the awareness breaks. The underlying assumption behind the design of the scripts is that by enhancing students' metacognitive skills (regulative, reflective and evaluative skills) on the relational space of collaboration we can, in turn, influence the perceived team effectiveness and the quality of collaborative argumentation at the content space. This assumption is drawing heavily on the team effectiveness theory that sees these metacognitive processes as mediating variables for supporting the team performance and effectiveness. These mediating variables could be set in motion with the help of the different awareness prompts (Fransen et. al, 2011).

Finally, the design of the awareness-oriented argumentation scripts was also informed by the framework of Buder (2011), regarding the support of displaying and monitoring activities in group awareness tools. We attempt to raise awareness of collaborators' activities with the behavioral awareness script variation and of their social functioning with the social

awareness script variation by prompting them to take regular breaks from arguing for regulating, reflecting upon and evaluating the collaboration. During these scripted awareness breaks students had to assess the collaboration and coordination efforts, as well as their participation rates openly in the group. In Buder's terms, the scripted awareness breaks promoted explicit, repeated and enforced processes of feedback (i.e., awareness information) display (2012). With respect to the monitoring processes, the scripted awareness breaks were introduced as secondary tasks (i.e., side-tasks) that aimed at fostering social comparison through the explicit rating of participation and collaboration.

Upon designing the AOAS as instructional support for the content and the relational space of collaborative argumentation, we conducted a multiple case study to investigate how different awareness prompts (behavioural and social) influence the metacognitive collaboration processes of regulation, reflection and collaboration in the group. In the next step, we examined how these processes impact the quality of collaborative argumentation outcomes. Moreover, we looked into the power of scripted awareness breaks as an instructional technique for designing social interactions with respect to the empirical issues related to group awareness tools as defined by Buder (2011). Furthermore, as "team effectiveness is not only expressed by the quality of team outcomes, but also includes the quality of team performance, as well as the perceived satisfaction of needs of individual team members", perceived team effectiveness was examined here for having a full picture of the effectivity of these scripts for supporting collaborative argumentation (Fransen, Kirschner & Erkens, 2011, p. 1103)

We intended to use the results of this study for informing the design of Argue(a)ware" in the next phase of development. We aimed at gaining useful insights on the role of awareness as a mediating mechanism for the social performance of collaborative argumentation and the functionality of awareness prompts and awareness breaks as techniques for enhancing students' reflective and metacognitive skills.

In the next chapter, we present a study on the use of the awareness-oriented argumentation scripts for facilitating Metacognitive collaboration processes (i.e., regulation, reflection, evaluation) in collaborative argumentation. A description of the scaffolds for the content and the relational space of collaboration is provided. Following, we present the rationale for the concurrent nested mixed methods design, where the qualitative analysis is the main method of analysis and guides the project, while the quantitative analysis is "nested" in it. Last but not least, we present the results of the post- study feedback survey on the experience

with the instructional setting. We conclude with a discussion on the results of the study and their connection to our research.

3.2. Study on Awareness-oriented Argumentation Scripts for Facilitating Collaborative Processes

Research in CSCL has employed group awareness and scripting tools, separately or in combination for supporting metacognitive collaboration processes. Scripting and group awareness tools are mainly used as complementary approaches for supporting metacognitive collaborative processes and outcomes in online CSCL environments. Collaboration scripts are used for guiding collaboration directly (i.e., defining the next steps, offering ontologies for argumentation), whereas, group awareness tools, work at the side for supporting the visualization of information for the relational and the content space of collaboration. The latter offer information about social interactions at content (i.e., knowledge contributions) and the relational space (i.e., participation levels) of collaboration and social aspects of collaboration. This information can, in turn, influence metacognitive, socio-cognitive and socio-emotional collaborative processes and outcomes (Janssen & Bodemer, 2013; Janssen, Erkens, & Kirschner, 2011; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011).

Scripts, when combined with group awareness support for the content space of collaboration (i.e. information on group members' prior and current knowledge) can help students acquire deeper understanding of domain concepts (Gijlers, Weinberger, van Dijk, Bollen, and van Joolingen, 2013). In a study by Tsovaltzi, Puhl, Judele, and Weinberger (2014) on how group awareness support and argumentation scripts influence learning in social networking sites like Facebook, we see that a combination of argument scripts with scaffolds for the ontology of arguments (i.e. claims, counter-arguments, etc.) with support for raising participants' group awareness of their arguments with the prospective of future debate with peers in Social Networking Sites, resulted in higher quality arguments. A study by Miller and Hadwin (2015) has investigated the potential of combining group awareness and scripting tools for regulating collaborative learning. Miller and Hadwin (2015) supported the regulation of collaboration with augmented phases for planning, enactment, and reflection in a macro-script for collaboration, which included question prompts and sentence starters for further structuring their collaboration both on the individual and group level. In these studies, scripting and group awareness tools are used as complementary approaches for supporting collaborative processes

and outcomes in online CSCL environments. Micro and macro-scripts are used for guiding collaboration directly (i.e. defining the next steps, offering ontologies for argumentation), whereas, group awareness tools, which are less direct-guiding by nature, worked at the side for supporting the visualization of information for the relational level of collaboration, about behavior, knowledge, and social aspects of collaboration that can, in turn, influence

While there is a lot of research on combinations of group awareness tools and scripts for supporting the cognitive performance at the content space of collaborative argumentation, little is known as to how group awareness tools and pedagogical scripts for collaboration can be used for supporting social performance at the relational space of collaborative argumentation. Thereby, little is known about how the awareness of social interactions at the relational space of collaboration can be facilitated through pedagogical scripts for argumentation and collaboration. Moreover, while the influence of cognitive and social awareness tools on the relational space of collaborations has been tested, the role of behavioral awareness remains under researched in that respect.

The focus of the first study is on designing and regulating the interactions in the group. We attempt to raise awareness of collaborators' activities with the behavioral awareness variation and of their social functioning with the social awareness script variation by prompting them to take regular breaks from arguing for reflecting on their own collaboration. During these scripted awareness breaks students had to assess the collaboration and coordination efforts, as well as their participation rates openly in the group. In Buder's terms, the scripted awareness breaks promoted explicit, repeated and enforced processes of feedback display. With respect to the monitoring processes, the scripted awareness breaks were introduced as secondary tasks ("side-tasks") that aimed at fostering social comparison through the explicit rating of participation and collaboration.

In a longitudinal exploratory multiple-case field study, (four meetings in terms of a master's course on"Multimedia-Based Learning Environments" (n = 28, in ten groups of three or two; each group is conceptualized as a "case") we investigate how different awareness prompts influence the quality of collaborative argumentation when embedded in a collaborative argumentation script. To meet this need we created the „Awareness-oriented Argumentation Script" variations; two variations of the same pedagogical face-to-face epistemic script combining argument scaffold elements with different team awareness prompts. The first script variation included behavioral awareness prompts for informing students about their activities in the group (i.e., prompts for performing participation check, performance comparisons and

coordination checks) (Janssen, Erkens, & Kirschner, 2011). The second one included social awareness prompts for informing students about the functioning of the group as perceived by their collaborators (i.e., prompts for assigning roles, keeping an open mind and being friendly in the group, openly evaluating their performance) (Phielix et al., 2011; Pifarré, Cobos, & Argelagós, 2013,).

In comparing the different awareness-oriented argumentation scripts over four sessions of 70 minutes each for collaborative argumentation we want to shed light on the effects of different awareness prompts for enhancing (a) collaborative metacognitive processes i.e., regulation, reflection, and evaluation (b) the relation between collaborative metacognitive processes and the quality of collaborative argumentation as well as (c) the impact of the two script variations on perceived team effectiveness and (d) what was experience with the different parts of the script variations in the two groups and how this fits into the design framework by Buder (2011).

Before explaining the processes, the analytical approaches and the results of this study, we present the instructional decisions for the design of two pillars of the content and relational space support of collaborative argumentation as part of the awareness-oriented argumentation scripts.

3.2.1. Support for the content space of collaborative argumentation.

The support for the content space of collaboration with the awareness-oriented argumentation scripts aims at helping students learn about the basic concepts of argumentation while elaborating on the material and interacting for solving complex and ill-defined problems as part of small group problem-solving activities. In the following sub-chapters, we discuss the rationale behind employing and combing an awareness mapping tool for visualizing argument sequences and argument scaffolds embedded in the script for supporting the generation of single arguments.

3.2.1.1. Argument mapping tool- Rationale ®

Argument mapping is often applied in problem-based learning situations where it transforms the process of finding a solution to an unfamiliar task using the knowledge they have into an argument based on informal reasoning (van Bruggen, Boshuizen, Kirschner, 2003). There are many argument mapping tools supporting computer supported argument

visualization (CSAV) currently available in the market. In his work on computer supported argument visualizations, Buckingham-Shum (2003) is categorizing argument mapping tools based on their stakeholders they appeal to (education, science, business etc.), the different argumentation models they embody for the representation of arguments (i.e., Toulmin's model, Wigmore or Bayesian) and the trade-off they make between expressiveness and usability. Given the progress in the field of CSAV tools and their availability in the market, we looked for an off-the-shelf argument mapping tool that would fit the need for supporting the visualization of the arguments produced in the group while solving the problem cases in Argue(a)ware. The market research yields a strong candidate; the argument mapping tool Rationale® based on its prior successful use in scientific studies, its affordability and the positive reviews from users in the education sector (van Gelder, 2013). Rationale® came out in 2006 as an heir to Reason!Able argument mapping tool by van Gelder and Bulka the from the University of Melbourne. Research studies with the use of Rationale® indicated strong benefits of the system for improving critical thinking skills in higher educational settings (van Gelder, 2013).

The system uses a simplified Toulmin model for representing arguments, where arguments are perceived as statements (i.e., premises) joined together to result in claims (i.e., conclusions) (Toulmin, 2003). First, users need to break up their arguments into claims (reasons) and counter- reasons (objection) for supporting or objecting the main claim (contention) and use the lines, boxes, colours and location to indicate the relationships between the various parts. The basic elements of an argument map (figure 3.2.) in the browser-based argument mapping software Rationale ® evolve around the contention (or position) box, which is marked in white and located at the top of the map. The reasons (pro-arguments) for supporting the contention are located underneath the position and are outlined in green while objections are red (counter-arguments or objections). The rebuttal (objection to an objection) is marked in an orange box. The resulting map allows us to see exactly how each part of an argument is related to every other part.

Finally, Rationale® introduces some rules and conventions specific to using the argument map efficiently in the systems. These are basic, semi-formal constraints on the adequacy of an argument as presented in an argument map and are meant to assist students in distinguishing the parts of an argument (van Gelder, 2013). In a separate meeting prior to the study students were trained in the use to the argument mapping tool Rationale® and practiced arguing for solving ill-structured problems based on the Toulmin model and the conventions

of the argument mapping tool. First, students were presented with definitions and examples of argument parts i.e., contention, reason etc. (figure 3.2.) and then they practiced with the argument map conventions for the advanced syntax of an argument map (figure 3.3.). These conventions were presented as rules for ensuring that the premises and contention of an argument are tightly connected with each other in the maps. Examples of rules include the "Rabbit Rule" which dictates that any significant word or phrase appearing in the contention of an argument must also appear in at least one of the premises of that argument or the "Holding Hands Rule," which decrees that any significant word or phrase appearing in one of the premises must appear either in the contention, or in another premise. For practicing the syntax, we used the tutorial material from the Rationale platform, which can be found in the appendix B.

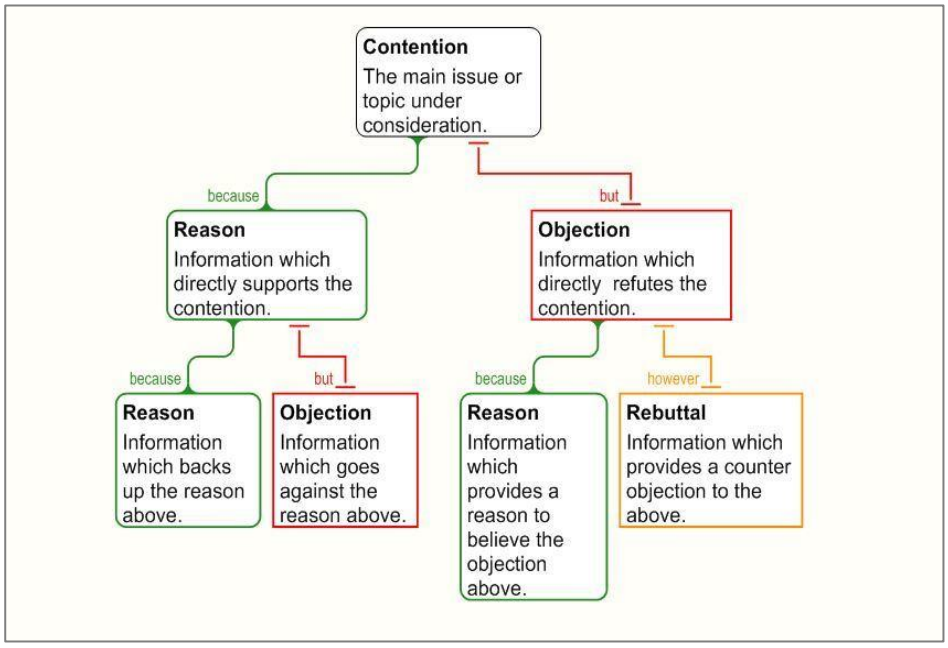


Figure 3.2. Example argument map in Rationale®.

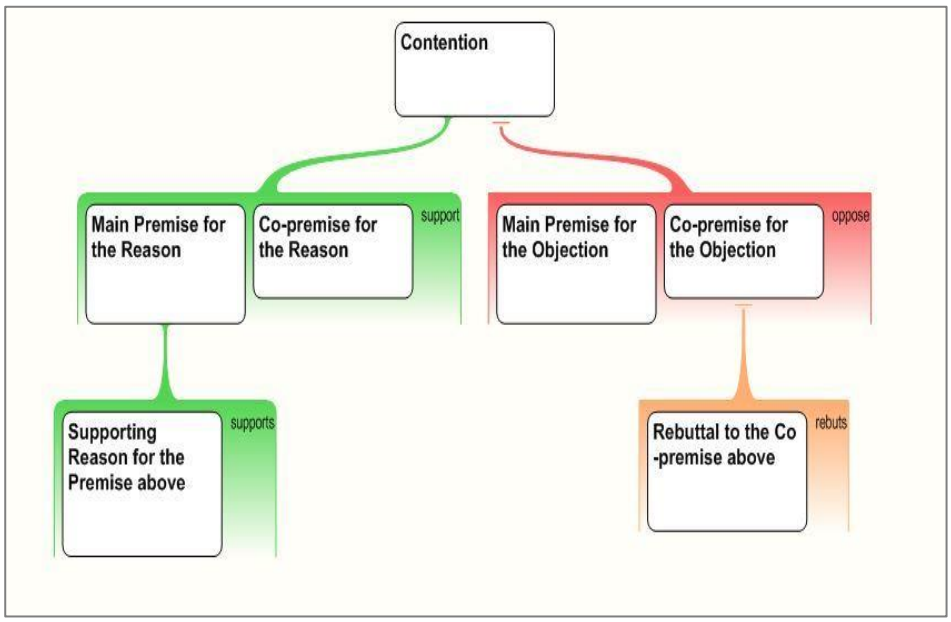


Figure 3.3. Example Syntax of an Advanced Argument Map.

3.2.1.2. Argumentation Scaffolds

The next type of argument scaffold was embedded in the „Awareness-oriented Argumentation script" and was based on the question asking method for triggering fruitful argumentation in collaborative learning situations (Veerman, Andriessen, and Kanselaar, 2002). Open-answer questions as well as deep- and counter- reasoning questions aimed at triggering the discussion around the causes and consequences of the problem at hand are embedded in the «Awareness-oriented argumentation scripts » (figures 3.5 and 3.6.). These questions are meant to generate more questions within the group that will lead students to acquire better insight in causes and effects of the problem and use these insights to create more sound justifications and counter arguments for their claim.

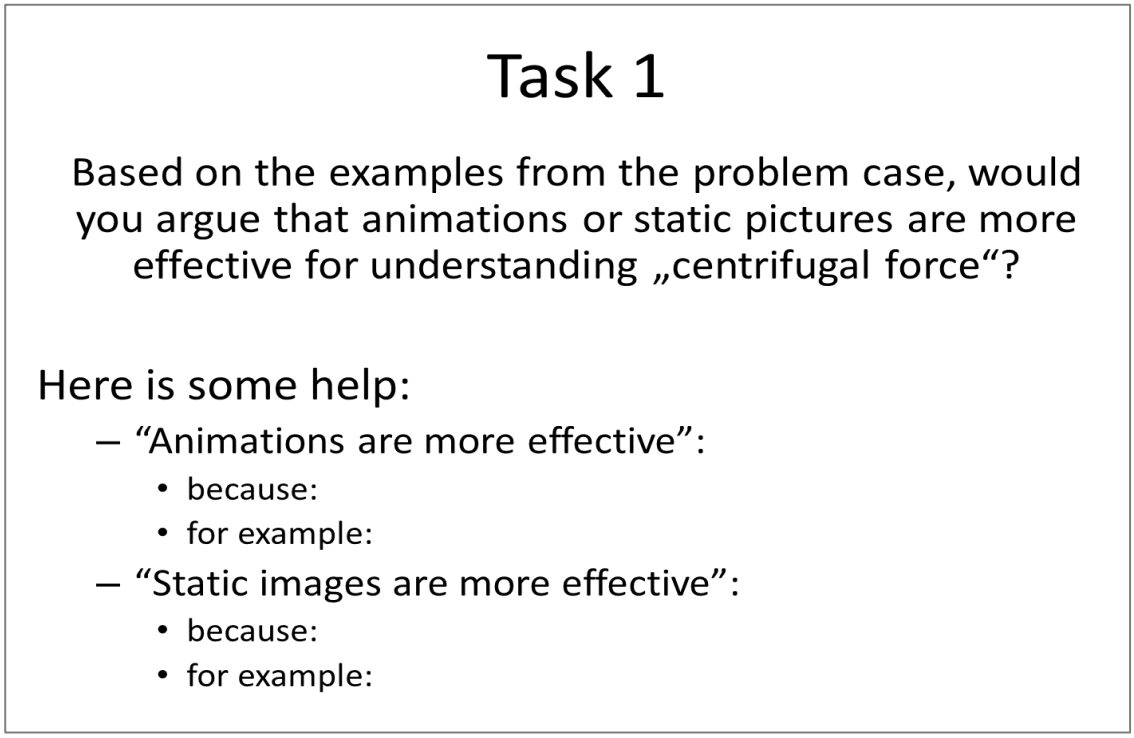


Figure 3.4. An example of an AP1script card with an open answer reasoning questions and sentence openers for reasons- same for both scripts.

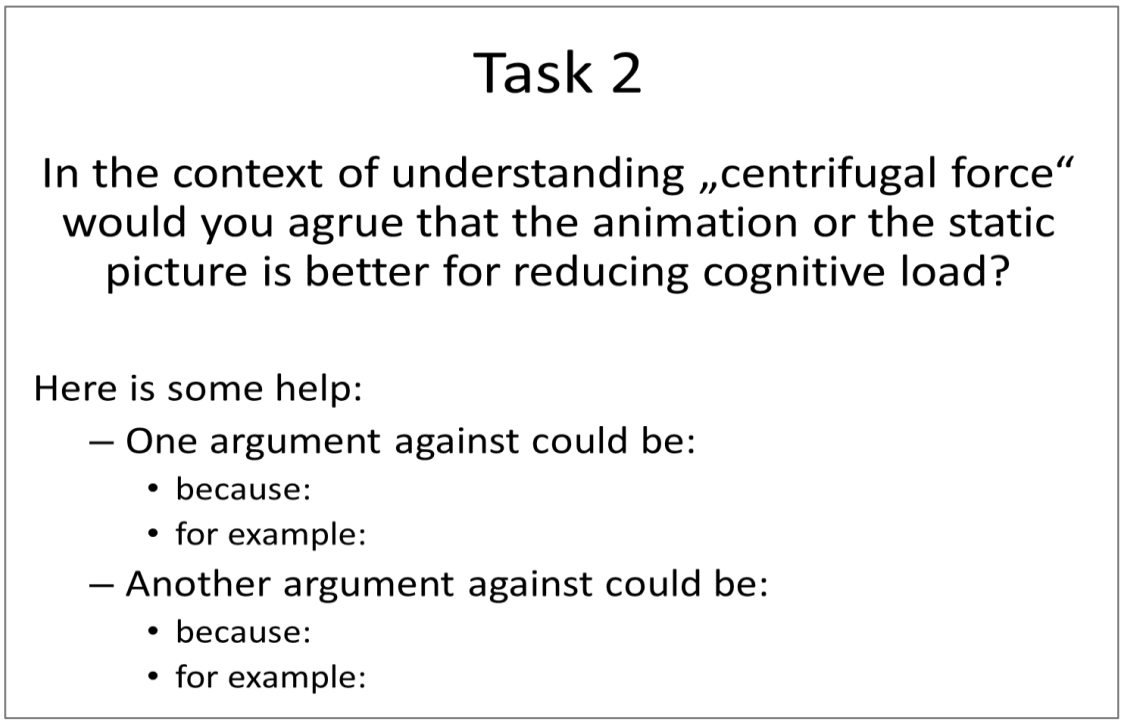


Figure 3.5. An example of an AP2 script card with an open answer reasoning question and argument scaffold for objections - same for both scripts.

Complementary to the open answer and counter- reasoning questions asked in the script (figure 3.4.), we provide students with standardized sentence openers. A sentence opener is defined as "a set of compound words that offers the pre-defined ways to start a sentence" (Lee and Kim, 2003 p.223). In line with the use of sentence templates by Kim and Lee (2003), our argumentation script cards with the combination of open answer and counter- reasoning questions and standardized sentence openers i.e., "One argument against could be" with key words such as "because" and "for example" (figures 3.5. and 3.6.) aimed at enhancing the quality of arguments produced during the argumentative discussion phase of collaboration. The cards were to be distributed at the beginning of each argumentative discussion phase and mark the start of the discussion on the open answer and counter- reasoning questions as part of the bigger problem-solving processes. The sentence openers were created based on a simplified version of Toulmin's model for argumentation for generating reasons to support the contention (figures 3.4.) or reasons against the contention (objections) (figure 3.5.) as well as for matching the structure of arguments in the argument mapping tool- Rationale where the construction and connection of multiple reasons and objections as well of examples for backing up these reasons is essential.

Students could also use the open space next to these sentence openers for writing down notes before transferring the argument into the map. The use of sentence openers, unlike to the use of the open answer questions for discussion, was conceived and marked as additional help offer and was not to be enforced in the collaboration. Lastly, the sentence openers were designed to be domain specific and more so, topic specific, as they were adjusted to the question at hand in every problem case (figures 3.4. and 3.5.) and aimed at assisting the process of constructing formally and semantically sound arguments (together with Rationale) for gaining argumentative and domain-specific knowledge (Andriessen, 2006).

3.2.2. Support for the relational space of collaborative argumentation.

In collaborative learning settings knowing more about one's own work status as well as about collaborators' activities is crucial for completing a collaborative task successfully (Belkadi, et al, 2013). Raising the awareness of group dynamics (i.e., social functioning) can lead to better learning outcomes in the group and prevent negative collaboration phenomena i.e., social loafing, free-rider effect (Kirschner, Jochems, Dillenbourg & Kanselaar, 2002). Moreover, awareness of collaboration could ensure at least a minimal level of shared

understanding by sharing expectations about how the problem can be represented and which operators and reasoning schemas are admissible for solving the problem. This is considered a precondition for successful collaborative problem solving. In the following sub-chapters, we discuss the rationale behind employing awareness prompts to be discussed within the scripted awareness breaks.

3.2.2.1. Awareness prompts.

In the study, students communicate face to face and the awareness prompts in each script variation encourage desired modes of communication in multiple ways. The design of the prompts is based on literature about metacognitive and process prompts as part of reflection tools from the CSCW field as well as on literature about reflection and elaboration prompts from the CSCL field (Lin et. al., 1999; Hmelo, & Lin, 2000; Ge & Land, 2004). In the Social Awareness Script, the awareness prompts are meant to ensure equal and active and interdependent participation by asking each member to take up certain roles (writer, reviser, and controller), explaining the tasks of each role and allowing reassigning the roles for increasing group efficiency (Strijbos, Martens, Jochems, & Broers, 2004). These roles could be classified as functional roles (Strijbos et al., 2004) since they provide insights and guidance for the collaboration on the argumentative task on a practical level. Thereby, the writer is responsible for typing the arguments into the map, the reviser is responsible for checking for logical inconsistencies and meaning ambiguities and the controller is mainly responsible for reading the arguments and controlling for grammar and syntax mistakes, as well as for misuses of the argument mapping rules. Provoking individual accountability by discussing and evaluating one's own performance in the group is also part of the social awareness prompts (Morris et al. 2009).

In the case of the Behavioural Awareness Script the awareness prompts aim at resolving possible problems with free riding or social loafing effects by prompting group members to discuss their participation in the group discussion so far. Prompts for creating and revising a plan to facilitate common understanding of the task at hand and define the next steps for solving the problem are also provided to help students keep track of their collaboration and stay focused on the task. Last but not least, creating a sense of responsibility for the progress of the group is prompted by asking students to evaluate their contribution to the collaboration processes and compare it to the one of their group mate.

The awareness prompts take various forms. They come as thought-provoking questions and are accompanied with prompts for engaging in discussion as well with friendly reminders of the importance of the processes. These process prompts are meant to trigger the discussion on the group around not only the information about the individual learner's context, but also on the context of the whole learning team thus supporting the members' fruitful interaction in the group in the relational level of collaboration. In each script three script cards were delivered that included various combinations of process prompts (Appendix C) for engaging in: a**)** reflective group discussion with questions (i.e., S2), b) evaluative group discussion with question and reflection time (i.e., B2), c) regulative group discussion with action triggering prompts and reminders of importance (i.e., B1). Some cards also included reminders for the importance of regulating certain aspects of collaboration (i.e., B1 and S2). These combinations of prompts aimed at prompting the reflection and discussion on several aspects of collaboration and the immediate action-taking for the regulation thereof.

Additionally, these prompts could influence the perceived team effectiveness in the group in numerous ways. The prompt for creating a plan where the explaining necessary steps the completion of the task while creating a plan for collaboration (B1 in table 1) and the defining how successful collaboration in the group (S3 in table 1) could help build shared mental models. Mutual trust among group members can be established with the prompts for discussing one's own participation where the outing of any collaboration problems on the spot is facilitated (B2 in table 1) and with the prompt for encouraging the sharing of information without reservation in the group in a friendly manner (S2 in table 1). Mutual performance monitoring skills can be developed with the help of the prompt for comparing one's own collaboration and coordination to other group members (B3 in table 1) and the prompt for making remarks for improving collaboration in the next session (B3 and S4 in table 1).

In the behavioural awareness variation (BAS), students worked on prompts for planning and adjusting the collaboration work-flow as well as for evaluating the participation openly. In the social awareness variation (SAS), students were prompted to take up specific functional roles in the collaboration (as writer, reviser, and controller), were reminded to stay respectful to others' opinions and finally evaluate their performance in the role and make remarks for improving their collaboration next time. By embedding two different sets of awareness prompts (behavioural and social) in the same basic script for collaborative argumentation we want to shed light on the role of different awareness prompts appearing for influencing the

metacognitive processes of regulation, reflection and evaluation and for enhancing collaborative argumentation processes and outcomes.

3.2.2.2. Awareness breaks.

In this study, we focus on designing and regulating the interactions in the group with the help of awareness breaks based on the "pausing principle" (Verpoorten & Vestera, 2014; Bachhel & Thaman, 2014). The breaks from arguing to solve the problem on the argument map are interspersed with the awareness-oriented argumentation scripts. Thereby, we attempt to raise awareness of collaborators' activities (in the behavioural awareness script) and of their social functioning (social awareness script) by prompting them to take regular breaks (max. 5 min.) from arguing to regulate, reflect on and evaluate their own collaboration. During these scripted awareness breaks students had to assess the collaboration and coordination efforts, as well as their participation rates openly in the group. In Buder's terms, the scripted awareness breaks promote explicit, repeated and enforced processes of feedback display. With respect to the monitoring processes, the scripted awareness breaks were introduced as secondary tasks ("side-tasks") that aimed at fostering social comparison through the explicit rating of participation and collaboration.

3.2.3. Methods

In this section we present the processes of the study. Furthermore, we present the research questions of the study and our approach for analysing them.

3.2.3.1. Processes.

This study employs a longitudinal, embedded multiple-case study design (van Echtelt, Wynstra, van Weele, and Duysters, 2008; Yin, 2009), in which, each of the ten groups of Media Informatics master students (n = 28, in ten groups of three or two) is conceptualized as a 'case'. In a separate meeting prior to the study students were trained in the use to the argument mapping tool Rationale® and practiced arguing for solving ill-structured problems based on the Toulmin model and the conventions of the argument mapping tool (Toulmin,1958).

Students' main task was to argue for and agree on the best solution to the problem and then transfer their arguments into a joint argument map using the online argumentation mapping tool Rationale® while collaborating. Half of the groups were supported by a

behavioural awareness script (behavioural awareness script variation). This script included behavioural awareness prompts, i.e., reminders for performing participation check, performance comparisons and coordination checks. The other half of groups was supported by a social awareness script (social awareness script variation). This script included social awareness prompts, i.e., reminders for assigning roles, keeping an open mind and being friendly in the group, openly evaluating their performance.

The learning task for all groups was to argue over four sessions of 65 minutes each on ill-structured problems. Firstly, they were provided with the problem case on a learning related problem, the task description and the theory at hand in paper form. Their main task was to argue for and agree on the best solution to the problem and then transfer their arguments into a joint argument map using the online argumentation mapping tool Rationale® (www.rationaleonline.com) while collaborating. At regular intervals during the collaboration students were given either social or behavioural awareness prompts depending on their variation and had to discuss them during the awareness breaks. The video recordings from the collaborative argumentation sessions as well as the argument maps produced throughout each session are being analysed using qualitative methods.

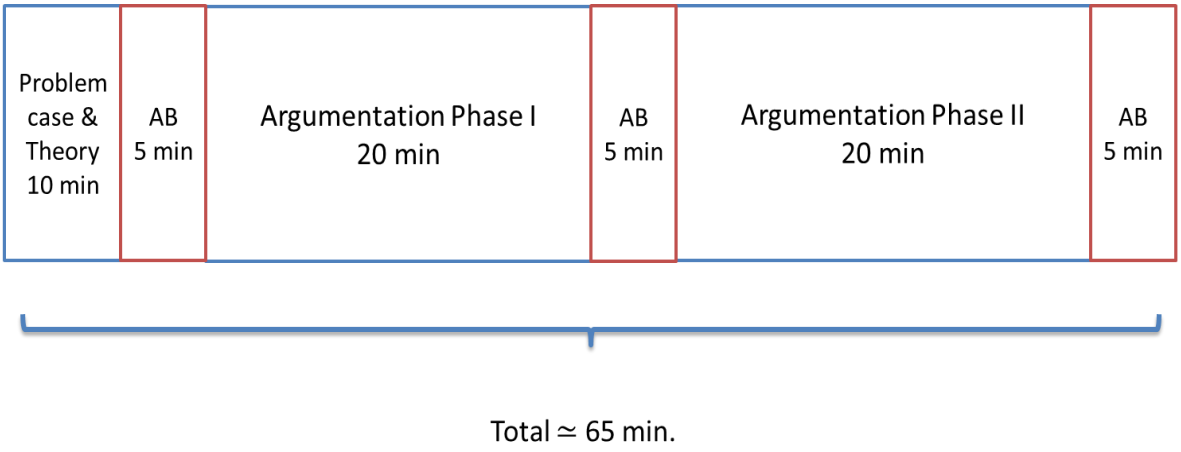


Figure 3.6. The basic instructional design of awareness-oriented argumentation scripts.

At the beginning of each session, students were provided with the problem case, the task description and the theory at hand. The problem cases were built to match the contents of a masters' class on "Multimedia-Based Learning Environments" and dealt with topics such as constructivist theory and cognitive load of animations. Following, students received help for building their arguments on the map. The argumentation part of the scripts was divided in two

argumentation tasks and was presented in two cards with thought provoking questions for triggering the argumentative collaboration on them. The cards were also enhanced with additional argument building help in the form of sentence openers. Furthermore, counter argument support and support for creating back-up of claims and bringing examples was included in the cards (figures 3.4. and 3.5.). Students had twenty minutes time in each of the argumentation phases (AP1 and AP2) for working uninterrupted on each subtask upon receiving the argumentation script card (figure 3.6.). The awareness breaks took place every time a paper card with the awareness prompts of each script variation was handed out to the group members by the facilitator of the learning process. The first Awareness Break (AB) took place after reading the problem case and before entering the first argument phase (figure 3.7.) and included discussion on the prompts of the awareness script card B1 for the BAS variation and S1 and S2 for the SAS variation. The second awareness break took place immediately after the end of the AP1 and before entering AP2 and included discussion on the prompts of the awareness script card B2 for the BAS variation and S3 for the SAS variation. Finally, the third awareness break occurred after the end of the AP2 and included discussion on the prompts of the awareness script card B3 for the BAS variation and S4 for the SAS variation.

Either before or after the students had worked on the argumentative subtasks in the argument phases, they received cards with social or behavioural awareness prompts on paper depending on their variation and they had to discuss them in the group for five minutes. The breaks took place every time a paper card was handed out to the group members by the facilitator of the learning process (figure 3.1.). In each condition three awareness script cards were delivered that included various combinations of process prompts for engaging in: a) reflective group discussion with questions (2.1.), b) evaluative group discussion with question and reflection time (2.2), c) regulative group discussion with action triggering prompts and reminders of importance (2.3). Some cards also included reminders for regulating group aspects without explicit group discussion (2.4). These combinations were meant for prompting the reflection and discussion on several aspects of collaboration and the immediate action-taking for the regulation thereof.

In the Behavioural Awareness Script Condition- BASC, students worked on prompts for planning and adjusting the collaboration work-flow as well as for evaluating the participation openly. In the Social Awareness Script Condition- SASC, students were prompted to take up specific roles in the collaboration (as writer, reviser, and controller), were reminded to stay respectful to others' opinions and finally evaluate their performance in the role and

make remarks for improving their collaboration next time. Half of the groups argued on ill-structured problems following the Behavioural Awareness Script (BAS) variation and the other half following a Social Awareness Script (SAS) variation. The awareness script cards included one or two questions for the whole group and a prompt for discussing them. Some prompts included also suggestions for coordinating the group work and friendly reminders for the value of the prompts.

The script cards in the Behavioural Awareness Script variation prompted students to perform participation checks and coordination checks throughout the collaboration and evaluate the participation and coordination efforts at the end of every session. Whereas, the script cards in Social Awareness Script variation prompted students to assign roles at the beginning of every session, keep an open mind and be friendly throughout the collaboration, and finally evaluate each other for the performance of the roles. At the end of every session for collaborative argumentation, students were asked to fill out a questionnaire on team effectiveness aspects.

3.2.3.2. Analytical approach.

Case study research is suited for "the in-depth study of instances of a phenomenon in its natural context and from the perspective of the participants involved in the phenomenon" (Gall et al., 1996, p.545). Multiple case studies have the power to strengthen the results of a study by replicating the patterns thereby increasing the robustness of the findings (Yin, 2014). We invest on literal replication of cases of collaboration over four sessions with the same script variation on a different ill-structured problem each time for establishing the replication logic. Furthermore, we view the multiple case study design as a way for elaborating and increasing our understanding on pre-existing theories on how Group Awareness Tools influence collaboration based on the observed events from the cases using the "«Awareness-oriented argumentation scripts »" (Ridder, 2016). In that sense, our study bares similarities to an instrumental case study according to the theory by the constructivist researcher Starke, (2005), and opts for the suggested purposive sampling of cases for maximizing what we can learn about the processes and the dynamics of a phenomenon under investigation (Ridder, 2016).

Yin (2013) puts a strong emphasis on four quality criteria for testing if a case study rigorous and solid. With respect to the construct validity test, we collected and triangulated the data from many sources i.e. video recordings, argument maps, team effectiveness

questionnaires and feedback survey. The aim was to build a better understanding of the interconnected phenomena in this study from different levels, within the single cases and across the multiple cases. For enhancing the internal validity of this study, we employed various analytical techniques such as a cross case syntheses for exploring and comparing patterns within and across the multiple cases (i.e., case-based and time-based matrixes for the application of awareness prompts) and a pattern-matching logic for comparing empirical patterns as observed in the video data to predicted patterns (Ridder, 2016; Miles and Huberman, 1984). In our case, the main qualitative analytical approach here is the exploratory content analysis (Krippendorff, 1989) of video data from the sessions for collaborative argumentation. This approach is used as tool for identifying the connections between the use of different awareness prompts from the two script variations and the collaborative metacognitive processes and group outcomes more thoroughly, with losing interesting insights to the processes by quantifying mass responses into statistically inferable data. The video data is coded with respect to the mediating variables for collaborative metacognitive processes of regulation, reflection, and evaluation that were prompted in the different scripts and subsequently, for revealing the relationships between these constructs with respect to the theoretical assumptions (Bodemer and Dehler, 2011; Janssen and Bodemer, 2013). Finally, the external validity of this study is secured by the multiple- case (collective) logic which affords for replication of the same phenomenon and the reliability of the study is strengthened by rigorous documentation of the process with a study protocol (overview, data collection procedures etc.).

In this study, we present analyses that address these five questions:

RQ 1: How do students apply the different awareness prompts during the awareness breaks over time?

RQ 2: How do different prompts for awareness influence different metacognitive collaboration processes i.e., regulation, reflection, and evaluation?

RQ 3: How does the quality of different collaboration processes influence the group performance (quality of argumentation outcomes)?

RQ 4: What is the impact of two script variations on perceived team effectiveness?

RQ 5: What is the experience with the different parts of the instructional setting in the two groups?

For answering these questions, we employ a mixed – methods approach for the analysis of data. More specifically, we follow the concurrent nested mixed methods research design by Creswell (2003), where both quantitative and qualitative data are collected simultaneously, and the qualitative analysis is the main method of analysis and guides the project, while the quantitative analysis is "nested" in it. The nested quantitative analysis served two purposes; one the one hand it was used for defining extreme cases of from both script variations (most and least successful groups in terms of levels of argumentation) that were then analysed qualitatively with respect to the explorative questions (RQ1, RQ2, RQ3). On the other hand, it was used for addressing the question on the perceived effectiveness of the collaboration script (RQ4). Both quantitative and qualitative data were collected with a feedback survey and were analysed for answering the question about the experience with the different parts of Argue(a)ware.

The video recordings from the collaborative argumentation sessions and the argument maps produced in each session, as well as the user experience results from post-study survey were analysed using mixed methods. An overview of the analyses that are presented in seven sections is provided here:

1. In the first section, we present the pre-processing of the group performance data (argument maps) of all ten groups that worked with either the Behavioural Awareness Script or the Social Awareness Script over four sessions for collaborative argumentation from the four sessions. We explain the coding scheme and how we derived the levels of argumentation for measuring the quality of group performance based on their argumentation (low, medium or high) based on criteria of Formal Correctness and Evidence Sufficiency of the arguments in the maps and the comparison to the model argument maps.
2. Based on the changes in the levels of FC and ES in the argument maps from the first to the fourth session for collaborative argumentation, we distinguished the two most and the two least successful cases from both script variations for qualitative content analysis with respect to the questions of this study (subchapter 1.3.2.). Here, we introduce the collaboration profiles of the participants of each group. Their main activities and characteristics are summarized with Role-ordered matrixes and associated to the group dynamics in the four sessions for collaborative argumentation.

3. As first step towards understanding the power of the different discussion-based process prompts for triggering collaboration processes we consider the application of the different awareness prompts from each script within the respected awareness breaks from collaborative argumentation phases in the four cases. Thereby, we consider both the reaction to the prompts and content of discussion on these prompts over time for categorizing their application as "no application, wrong application, partial application, and successful application" over time with the help of a Time-ordered matrix.
4. For answering the question on how the different prompts for awareness influence the different collaboration processes, we first present a coding scheme that aggregates all relevant responses to the different prompts within the awareness breaks and within the first five and last five minutes of the argument phases into related collaboration processes. Following, we present collective diagrams of the collaboration processes per case as well as the content analysis of reactions to example prompts pro collaborative process in a Case-ordered Matrix.
5. We continue with a qualitative content analysis on how the different collaborative metacognitive processes (regulation, reflection, evaluation) are connected to level of argumentation based. A Case-ordered Matrix on the quality of the discussion per prompt/collaborative process based on Formal Correctness and Evidence Sufficiency of arguments that were co-coded with the collaborative metacognitive processes during the awareness breaks and the first and last five minutes of the argumentation phases is presented.
6. For investigating the impact of working with the two script variations on perceived team effectiveness, we analysed the answers to the team effectiveness questionnaires that were distributed at the end of each of the four sessions for collaborative argumentation.
7. Finally, students' feedback on their experience with the argumentation and awareness script parts as well as with Rationale® as collected in post-study survey is analysed quantitatively and qualitatively with respect to the empirical issues of Group Awareness Tools (Buder, 2011).

3.2.4. Results

In the following subsections we present the results of the several analyses for answering the research questions of the study.

3.2.4.1. Quality of collaborative argumentation.

To measure the quality of collaborative argumentation from the argument maps, we investigated two aspects of arguing with an argument mapping tool that were explained and trained in the training session prior to the sessions for collaborative argumentation. The first aspect was about the Formal Correctness (FC) of ontology elements with respect to the conventions of argument mapping with Rationale. The second aspect examined the sufficiency of evidence used for supporting reasons and counter arguments in the maps based on their connection to the theory and/or relevant scientific sources or personal experiences. Half of the argument maps (20 maps) were coded by two coders until a Cohen's Kappa value of .70 was reached. Subsequently, all argument maps from all four sessions across the ten groups (40 maps in total) were coded for each group for each of the four 70 minutes session individually to assess the change in quality of collaborative argumentation over time.

For deciding on the level of collaborative argumentation (low, medium or high,) we coded the argument maps (element-wise) with respect to criteria of Formal Correctness and Evidence Sufficiency (appendix D). The coding schema included the categories of Formal Correctness (i.e., correct ontological labelling for boxes and adherence to argument mapping rules within each box and each simple argument) one reason with two co-premises, full declarative sentences) and Evidence Sufficiency (i.e., correct and relevant evidence from text, from personal experience or other scientific sources) of arguments. For every match with the criteria in the categories one point was given for the map. The collection of points from the model argument maps that were created as ideal solutions to each problem case helped us define the levels of quality of collaborative argumentation with respect to the two criteria for Formal Correctness and Evidence Sufficiency as following:

Table 3.1.

Points pro Level of Collaborative Argumentation (Argument Maps) for Formal Correctness and Evidence Sufficiency of Arguments

	High	Medium	Low
Formal Correctness	100 – 150 p.	50 – 99 p.	0 – 49 p.
Evidence Sufficiency	20 – 30 p.	10 – 19 p.	0 – 9 p.

In the next step, we controlled for any changes in the quality of collaborative argumentation between the groups that worked with the two scripts by comparing the argument maps from the first session to the ones from the fourth session (20 maps from 10 groups) and found the following changes in the levels of quality of argument outcomes:

Table 3.2.

Changes in the Levels of Quality of Arguments Between the First and the Fourth Session for Collaborative Argumentation

	Formal Correctness	Evidence Sufficiency
BAS	Medium → High	Low → High
SAS	Low → High	Low → Medium

When comparing the points for Formal Correctness (FC) and Evidence Sufficiency (ES) of all ten groups (group= case) from the argument maps of the first and the fourth session for collaborative argumentation, we could observe the differences in the progress they made based on the "Awareness-oriented Argumentation Script" variation (BAS or SAS) they were using (figures 8 and 9). The groups which worked BAS variation are marked here with a capital letter B and a number (B1, B2, B3, B10, B11), whereas the groups which worked with the SAS variation are marked with a capital letter S and a number (S4, S5, S6, S8, S9). We observed that all cases with the SAS variation improved both with respect to their levels of Formal Correctness and of Evidence Sufficiency. The "S4" case stood out as the one with the least impressing improvement between sessions (sustained a medium level of FC and ES), while the "S6" case was one of the most impressing ones in terms of improvement in both FC and ES levels (from low to high). In the groups that worked with the BAS variation, we observed that two out of five groups scored lower in both FC and ES levels from the first to the fourth session

of collaboration (B1 and B10) and the rest managed either a striking improvement in their levels of FC and ES (B2 and B11) or remained within the medium level of FC and ES (B3).

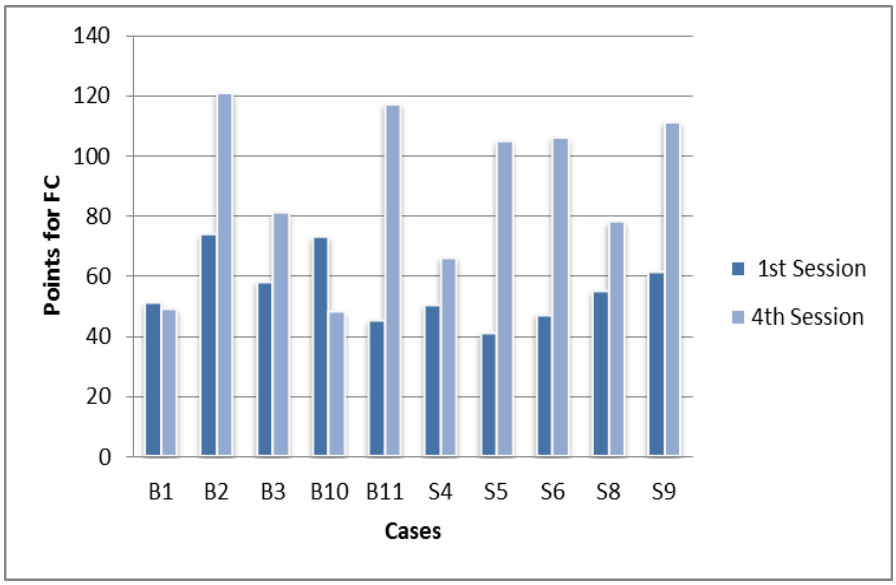


Figure 3.7. Changes in the levels of Formal Correctness in all cases from 1st to 4th session for collaborative argumentation.

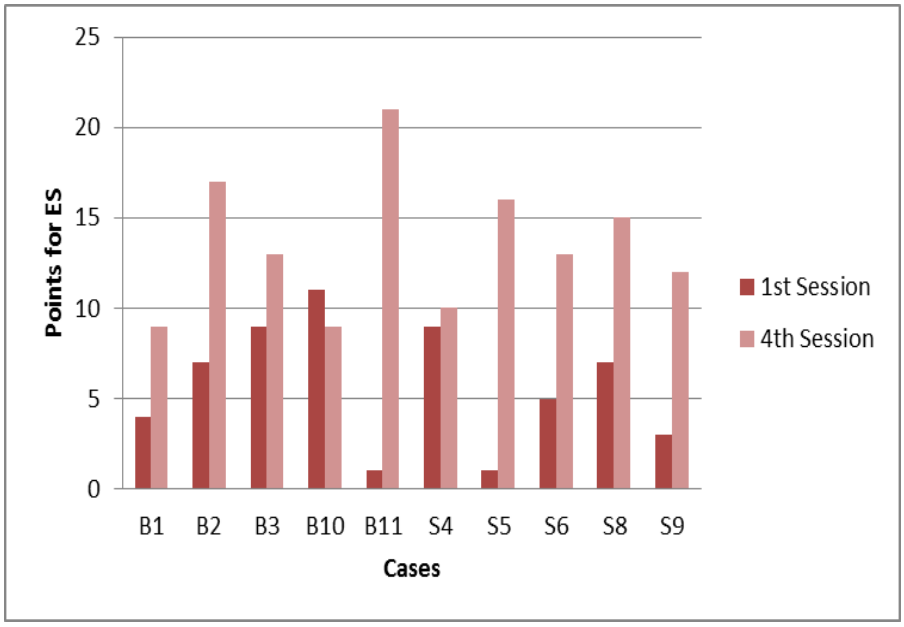


Figure 3.8. Changes in the levels of Evidence Sufficiency in all cases from 1st to 4th session for collaborative argumentation.

The “S4”, “S6”, “B2” and the “B10” cases were chosen as indicative of extreme improvement or deterioration (most and least successful) with respect to the criteria of Formal Correctness (FC) and Evidence Sufficiency (ES) and were analysed in depth for answering the questions of this exploratory study (figures 3.7. and 3.8.) The Groups “B2” and “S6” are marked with a + (plus) for indicating their positive progress, whereas “B10” is marked with a – (minus) for indicating negative progress and “S4” is marked with (+) for indicating medium progress in the in the levels of collaborative argumentation.

3.2.4.2. Collaboration profiles of the most and least successful cases.

We introduce the participants in the four most and least successful cases of collaborative argumentation with the two script variations with the help of Role-ordered matrixes (Miles, Huberman and Saldana, 2014). First, we summarize their main contributions to collaboration and their typical behaviors with respect to the task of collaborative argumentation i.e., coordinating, explanation seeking etc. Then, we enlist some of their salient characteristics that are of importance for understanding the group dynamics i.e., criticizing or joking with others’ arguments, imposing opinions or methods of work, conflict seeking/resolving behaviours or feeling of insecure or undermined in collaboration. These two lists include some of the observations that were made both during the collaboration sessions (unstructured field notes) by the facilitator of the sessions and while viewing the videos of the four groups in terms of the qualitative content analysis (Krippendorf, 2004). Moreover, we provide a summary of collaboration over time based on the field and analysis notes for capturing the dynamic interplay in the discourse among participants over time. The names of participants have been changed to pseudonyms and no age or other demographic characteristics are presented here for keeping the real identity of participants private.

Case "B2+"

Summary of collaboration over time

Table 3.3.

Script Applied: Behavioural Awareness Script - No Roles Assigned

Participants	Main Contributions	Salient Characteristics
Olga	Summarizing and questioning arguments, reflecting on previous collaboration patterns	Dominant opinions on collaboration procedures and on contents and structure of argument map
Ansgar	Asking for explanations of topic/task, rephrasing/ repeating arguments of others	Insecure about his own contributions, resisting changes in the work-flow between sessions
Sandra	Coordinating - especially when acting as a writer	Supporting opinions on collaboration procedures

A salient aspect of this group's interaction was the dominant exchanges between the girls. Olga and Sandra would be the first to read the contents of the script cards, translate them in German, and decide on the next steps. Ansgar, on the other hand, would rarely oppose or enhance their collaboration plans and would also silently assume the role of controller of the arguments in the map. When he was the writer, in the second session, he decreased his contributions even more and realized himself during the awareness breaks where the reflection prompts where discussed. Most of times, he would just repeat the arguments of Olga and Sandra in other words but bring less new arguments into the discussion. In the first two sessions, he took more interest in evaluating the collaboration by means of direct comparison of coordination and collaboration efforts in the group. Thereby, he stressed out the need for more equal collaboration. Sandra acted mostly on the side of Olga when she had to coordinate the collaboration and was often convinced by Olga's arguments to change her mind during the argumentation phases. In the third session, she took up a more active role in coordination after

remembering her remarks for making changes in collaboration at the end of last session. Lastly, Olga was clearly the dominating person in the group. She would be the first to create a plan, delegate tasks among her peers and also the one to reflect on previous collaboration processes.

No conflicts among participants were observed, despite the numerous interruptions while talking. The participation in the discussion was judged as equal by the girls. Ansgar, however, did complain about his contributions being overheard in the group. The group would be normally on time for finishing with their arguments within the argumentation phases but would sometimes skip the discussion on prompts for reflecting on and evaluating their collaboration. More specifically, they would often agree to explicitly skip the evaluation of collaboration and continue with their argumentation during the awareness breaks for adding a finishing touch in their argument map before the end of the session.

Case "B10–"

Summary of collaboration over time

Table 3.4.

Script Applied: Behavioural Awareness Script - No Roles Assigned

Participants	Main Contributions	Salient Characteristics
Pablo	Producing arguments, structuring arguments in the map, coordinating and reflecting on the collaboration, praised contributions of others	Dominant opinions on contents and structure of argument map
Clemens	Focused on explaining the task	Short answers, demotivated in the last two sessions
Tom	Questioning Arguments	Supporting opinions on collaboration procedures, re-directing the discussion

The interaction in this group evolved around one person; Pablo. Clemens and Tom played supporting roles in the group both for contributing in the enhancement of the map and for coordinating the collaboration. Pablo would be the one to read the contents of the script

cards, translate them in German, and decide on the next steps. He would also be the one to encourage the discussion on the arguments when there was silence in the group. Tom was more active in counter argumentation and Clemens was often taking time for preparing his arguments without commenting much on the arguments of his peers. They all started with a negative attitude towards the collaborative argumentation setting and expressed progressive demotivation with the procedures, the task and the technology provided i.e., Rationale®.

The participation in the discussion was judged as equal by all in the first two sessions. Clemens, however, accused Pablo in the third session of dominating the discussion and excluding him and Tom from the formation of the map. Pablo defended himself by saying that "I thought that, if I present something to you (both), you will jump in (the discussion) and contribute more" (laughing). Pablo also admitted that is was hard to judge his own collaboration and coordination efforts and asked for help from his groupmates only to be comforted by Tom's general remark on how well the group did. The group would often complain for being interrupted by the announcements for the distribution of awareness script cards and would go on to finish discussing their arguments before focusing on the discussion of the prompts. By the third session, the group had started skipping the breaks for reflecting on and evaluating their collaboration almost upon receiving the script card and started discussing irrelevant topics i.e., difficulties with exams and assignments in other courses. The superficial responses to the prompts for reflective and evaluative discussion were connected to statements about feeling uncomfortable with the concept of open evaluation in the group and with lack of external criteria for evaluation.

Case "S6+"

Summary of collaboration over time

Table 3.5.

Script Applied: Social Awareness Script - Roles Assigned

Participants	Main Contributions	Salient Characteristics
Carla	Structuring the arguments in the map (when acting as writer), coordinating the collaboration.	Most active person in coordination of collaboration.
Christoph	Producing arguments, controlling form of arguments (when acting as controller) reflecting on the collaboration.	Relatively quiet in the argumentation phase, sceptical about the collaboration flow.
Daniel	Producing arguments and questioning theories at hand.	Often confused about the right way for dealing with a task at hand. Restricted by the role of writer.

The most salient characteristic of this group was its consistent application of the original plan that was reinforced by all members alike. Starting from the second session, Christoph suggested taking some time for individual preparation before discussing on arguments as a response to the prompt for making remarks for improving collaboration next time. This suggestion was accepted as a collaboration plan by the group (not prompted) and implemented in the next sessions except for the last session for collaborative argumentation. In this session, Daniel reflected on the lack of prior plan and complained about him failing to convince his group mates to revise the collaboration flow. Individual preparation time was associated with more balanced individual contributions to the argumentation map by the students. Carla and Daniel often took time for dwelling on the contention and this was perceived as a problem by the group members for the quality of the map (i.e., fewer arguments). This problem was not resolved until the last session; it was, however, justified by the members as a "necessary evil"

because of the approach they took for putting quality over quantity in making the argument maps. Daniel triggered argument and evidence generation by: a) questioning the arguments of both Carla and Christoph, thereby creating counter arguments for the contention and b) asking for explanations on the topic and task at hand, thus prompting a more elaborated discussion on the topic.

The interactions in this group were predominately role- and task- oriented. The group members planned to take turns in all different roles for keeping the collaboration fair. They took turns in taking up all different roles in the four sessions for collaborative argumentation for counterbalancing any possible advantages and disadvantages that come with a specific role. Moreover, when called to evaluate their performance in their role (intermediate evaluation) they agreed it was an easy and intuitive task and that they did not want to reassign the roles amongst them for the second half of collaboration. Daniel was the only one who complained that he was restricted by the role of writer (third session) on the ground of his task being so time consuming that he could take much part in the conversation. Moreover, Carla suggested replacing task-oriented roles (prompted by script) with content- based roles i.e., one should be responsible for the producing reasons, but her suggestion was ignored by the others. In most sessions instead of evaluating their own performance in the role they evaluated the group performance in a positive way. Daniel and Christoph used this break for discussing their difficulties to express their mind, whereas Carla expressed her problems with the collaboration as wishes for improvement at the beginning of collaboration in the break for defining the successful collaboration (first two sessions). Finally, while Carla was the only one to encourage the open evaluation of friendliness and open-mindedness in the group with direct questions to her group mates, Daniel and Christoph had trouble attesting to her positive opinion about the collaboration without elaborating on their objections though.

Case "S4 (+)"

Summary of collaboration over time

Table 3.6.

Script Applied: Social Awareness Script - Roles Assigned

Participants	Main Contributions	Salient Characteristics
Maria	Few contributions of arguments, mostly typing in the arguments	Least active in coordinating the collaboration
Nikolas	Producing arguments, revising contents of arguments, reflecting on the collaboration	Dominant opinions on contents and structure of argument maps, encouraging the discussion
Carlos	Producing arguments, controlling form of arguments	Supporting opinions on collaboration procedures

The analysis of the collaboration of this group revealed that it evolved around the dominant exchanges between Nikolas and Carlos. The two students mainly engaged in debating on the form of arguments. Nikolas would be the one offering the basis of the argument and Carlos the one to build on this and refine it. Maria would rarely contribute to the content of the argument but would sometimes appropriate its form based on the rules for argument mapping. Upon reading the problem case and the theory at hand they would start discussing the topic and derive their pro arguments and counter arguments. They would then debate on the right form of argument and the connection to other arguments in the map and question the validity of their arguments. This process was rather time consuming and forced students to make rushed decisions for wrapping up their discussion towards the end of the second argumentation phase in each session. Nikolas and Carlos would also be the ones deciding on the last changes in the map while Maria would be the one implementing the changes. Moreover, the group had problems supporting their contention because of the lack of a predefined position on the topic.

Several strategies for dealing with the problems were suggested during the second awareness break and as an indirect response to the prompt for reassigning roles among the group mates if needed. Nikolas suggested spending equal time on forming pro and counter arguments for the contention, but this suggestion was never implemented.

The role assignment has also influence on the interaction in the group. In the first session, the decision on the assignment of roles was partly based on a discussion about their strengths and weaknesses i.e., Nikolas asked to be the reviser because he claimed he is not good with grammar and syntax, but he is better in checking the content. Maria wished for the writer's role and Carlos willingly accepted the role of reviser. The students took up the same roles every time, although Nikolas and Carlos acknowledged the drawbacks from acting only as a writer (i.e., low participation in discussion) and offered Maria to take up her role. They engaged only in superficial evaluation of their performance in the role. Moreover, they produced scarce reflection statements on collaboration flow which focused on the need for applying the rules of argument mapping as well as their own rules for the collaboration more strictly. The need for more equal participation is stressed in response to the prompt for making remarks for next time but no active measurements in this direction were taken; Nicolas and Carlos continued to dominate their discussion and Maria remained silent in her role as writer. However, no complaints about the friendliness levels and the open mindedness levels in the group were expressed. The only complaint came from Carlos, who felt his opinion was ignored by the group and that this resulted in fewer contributions from his side in the first session and was resolved in the next sessions.

3.2.4.3. Application of awareness prompts in awareness breaks.

The application of different awareness prompts was examined using qualitative content analysis (Krippendorff, 1989). First, we identified all relevant reactions to the prompts within the awareness breaks (3x5 min in each video) and coded all relevant discourse contents directly in the respected parts of the videos with the help of the qualitative data analysis tool MAXQDA®. Thereby, we used meaningful speaking turns (complete sentences, no nods or mumbles) and relevant action taking turns that could be clearly identified in the videos as segments. The coding scheme for the awareness prompts conceptualized all reactions to these prompts i.e., relevant discourse contents and subsequent action taking as awareness processes. For example, the prompt for "Creating a plan" was turned into a code and was assigned to parts

in the video every time a participant was, for instance, delegating tasks or was writing the writing down the discussed rules for collaboration on a paper. Only the codes coming for the prompts from the script applied in each case were coded. The complete coding scheme for awareness prompts and awareness processes is provided in appendix E. Afterwards, for answering the question about how do students apply the different awareness prompts during the awareness breaks over time, we defined the degrees of application of prompts based on a combination of quality criteria (i.e., no mentioning of the prompt, elaborated talk and actions as a response to the prompt) and looked into all the coded segments from the awareness breaks over the four sessions for collaborative argumentation.

The degrees of application were defined as following:

"No Application": absence of any engagement in the prompted collaborative metacognitive processes i.e., prompt is ignored by the students.

"Wrong Application": ill-fitting application based on the original scope of the prompt i.e., praising group coordination efforts instead of comparing coordination efforts in the group.

"Partial Application": simple mentioning of prompt (i.e., reading aloud the prompt from the prompt card) or simple acknowledgement of task distribution in the group but no further discussion or action taking in response to that or discussion on parts of the prompt.

"Successful Application": elaborated (meaningful and purposeful) talk and action taking as reaction to the different awareness prompt i.e., the prompt for "Discussing the topic" triggered the discussion on topic related issues for explaining the theory at hand.

Following, we present of prompts and illustrate their application degree in the extreme cases over the four sessions for collaboration with the help of Time-ordered matrixes (table 4 and table 5) and colour conventions for depicting the degree of application of these prompts over time. Red is used for "No Application", yellow is used for "Wrong Application", and light blue is used for "Partial Application", and finally green is used for "Successful Application". Areas in grey depict the absence of data for the third session in the "S4 (+)" case. The * sign is used for indicating a special form of prompts-the reminders that were expected to influence students outside the awareness breaks and therefore, relevant segments from the entire discussion.

When comparing the most and least successful cases from the Behavioural Awareness Script condition with respect to the application of different combinations of process prompts, we observe few differences in the way that "B2+" and "B10-"applied the prompts for regulative group discussion i.e., prompt for discussing the topic and the action-triggering prompts i.e., prompt for creating a plan (figure 3.9.) The biggest difference between the groups is the "B10-"group has focused less on the prompt for creating a plan and that it has ignored the prompt for revising the plan over time. With respect to the prompts for reflective group discussion, we see that students in the "B2+" group engaged in elaborated reflection on their plan in all four sessions as opposed to students in the "B10-" group who engaged only in superficial reflection on their plan. An exception to this pattern, is the application of the prompt for making remarks for improving collaboration next time, which was applied successfully only in the first session by "B2+" and then completely ignored it, whereas it was least partially applied by "B10-"in the most sessions for collaborative argumentation. The prompts for evaluative group discussion i.e., comparing own coordination and collaboration efforts to the ones in the group, although they were generally not successfully applied by both groups, in the case of "B10-"they were at least partly successfully applied and often also wrongly applied. The prompts for discussing own participation during the second awareness break was applied successfully only one in the "B2+" case. Finally, no references to the reminders of the value of checking on participation and making a plan were found in the collaboration of the two cases.

When comparing the most and least successful cases from the Social Awareness Script condition with respect to the application of different combinations of process prompts, we observe differences in the way that "S6+" and "S4(+)" applied the prompts for regulative group discussion i.e., prompt for assigning and re-assigning roles in the collaborative argumentation (figure 3.10). While "S6+" successfully applied the prompt for assigning roles in the first awareness break and it engaged in only partial discussion for re-assigning roles in the second awareness break, the "S4(+)" applied the prompt for assigning roles partially in the first awareness break and it engaged in more for re-assigning the roles in the second awareness break. The prompt for encouraging participation and the expression of opinions on topic was applied successfully by members of the "S6+" and "S4(+)" alike. With respect to the prompts for reflective group discussion, we see that students in the "S6+" group engaged in elaborated reflective discussion for defining successful collaboration in the first awareness break in most of the four sessions whereas the students in the "S4(+)" ignored the prompt in their last session. With regards to the application of the prompt for making remarks for improving collaboration

next time, we observe mixed reactions in both groups. The prompt was applied successfully only in the first sessions of “S6+” and “S4(+)“,and then it declined till it was completely ignored in the last session for collaborative argumentation. The application of prompts for evaluative group discussion is more successful in the “S6+” case, with the exception of the prompt for evaluating own performance in the role which was applied wrongly in all four sessions. In the “S4(+)“group, we observed that students responded to these prompts interchangeably. Finally, no references to the reminders of the value of keeping an open mind to the opinions of others and sustaining a friendly atmosphere were found in the two cases.

BAS Prompts	Extreme Cases	Sessions			
		1st	2nd	3rd	4th
Discussing the topic	B2+				
	B10-				
Discussing the task	B2+				
	B10-				
Creating a plan	B2+				
	B10-				
Revising collaboration plan	B2+				
	B10-				
Reflecting on the plan	B2+				
	B10-				
*Referring to the value of making a plan	B2+				
	B10-				
*Referring to the value of checking participation	B2+				
	B10-				
Making remarks for next time	B2+				
	B10-				
Discussing own participation	B2+				
	B10-				
Comparing own coordination efforts to others	B2+				
	B10-				
Comparing own collaboration efforts to others	B2+				
	B10-				

Figure 3.9. Time-ordered matrix for the comparison of the degree of application of BAS awareness prompts in Awareness Breaks in the "B2+" and "B10-"cases over time.

SAS Prompts	Extreme Cases	Sessions			
		1st	2nd	3rd	4th
Assigning roles	S6+				
	S4(+)				
Reassigning roles	S6+				
	S4(+)				
*Encouraging participation/opinion expression of other (silent) members	S6+				
	S4(+)				
Defining successful group collaboration	S6+				
	S4(+)				
*Referring to the value of keeping an open mind to opinions of groupmates	S6+				
	S4(+)				
*Referring to the value of friendly atmosphere in the group	S6+				
	S4(+)				
Making remarks for next time	S6+				
	S4(+)				
Evaluating performance in role	S6+				
	S4(+)				
Evaluating friendliness levels in group	S6+				
	S4(+)				
Evaluating open mindedness levels in the group	S6+				
	S4(+)				

Figure 3.10. Time-ordered matrix for the comparison the degree of application of SAS awareness prompts in Awareness Breaks in the “S6+” and “S4(+)“ cases over time.

3.2.4.4. Awareness prompts for collaborative metacognitive processes.

As an extension to the coding scheme for the awareness processes we grouped the prompts based on the type of discussion or action they were aiming at triggering i.e., regulatory, reflectional, and evaluative (Appendix F). These actions correspond to the main collaborative metacognitive processes i.e., regulation, reflection, evaluation in CSCL systems that are targeted by Group Awareness Tools.

In the first step, we used the coded segments from all videos of four cases where the reactions to the prompts i.e., relevant discourse contents and subsequent action taking as awareness processes. Next, we applied the codes from prompts of the two scripts in all four cases and looked for these prompts both in the awareness breaks and in the time before and after the awareness breaks (5-minute slots). In that way, we controlled for the influence of awareness processes that occurred without the specific prompts or as a response to other prompts on the collaborative metacognitive processes and for the importance of specific prompts for the collaborative metacognitive processes in the first and the last five minutes of the argumentation phases (AP1 and AP2), where the influence of the discussion (regulative, reflective, or evaluative) was expected to be prominent.

In the following diagrams, we illustrate the changes in the collaborative metacognitive processes (regulation, reflection, evaluation) based on the sum of coded segments of all related prompts from both scripts (figure 3.11. and figure 3.12.) in the different phases of collaborative argumentation. Regulation processes are depicted in blue, reflection processes in red and evaluation processes in green. The numbers (i.e., B1, S2) of the script cards are used for indicating what the students worked on during the respected awareness breaks, as well as verbal indications of the next interesting time point (first/last five minutes of AP1/AP2).

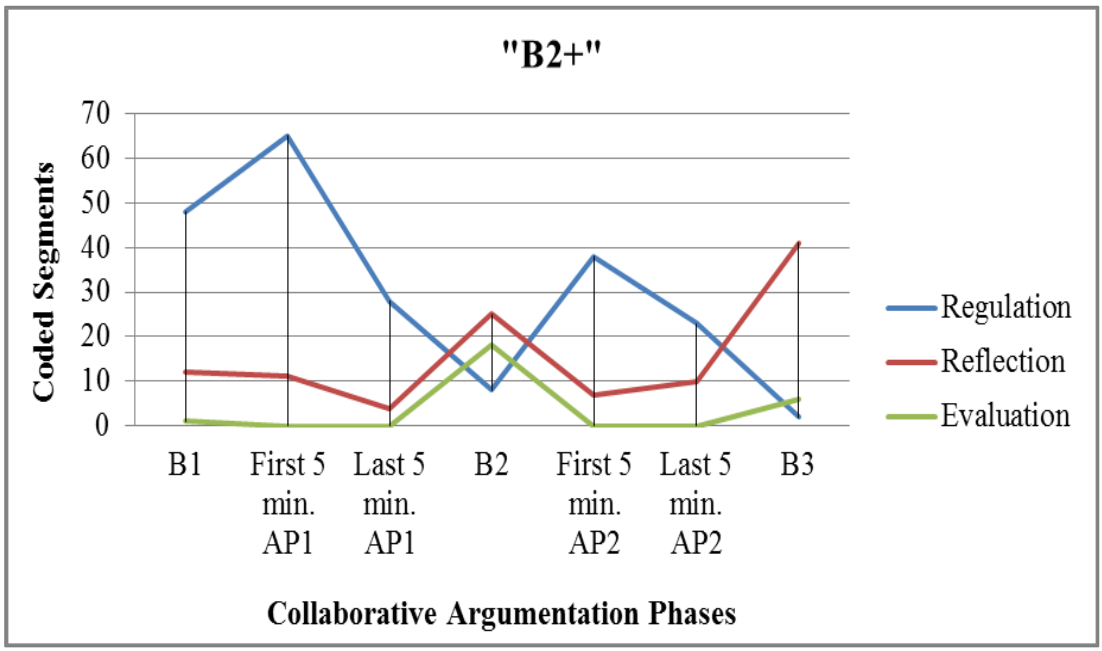


Figure 3.11. Changes in the collaborative metacognitive processes during collaborative argumentation phases in the four sessions of "B2+".

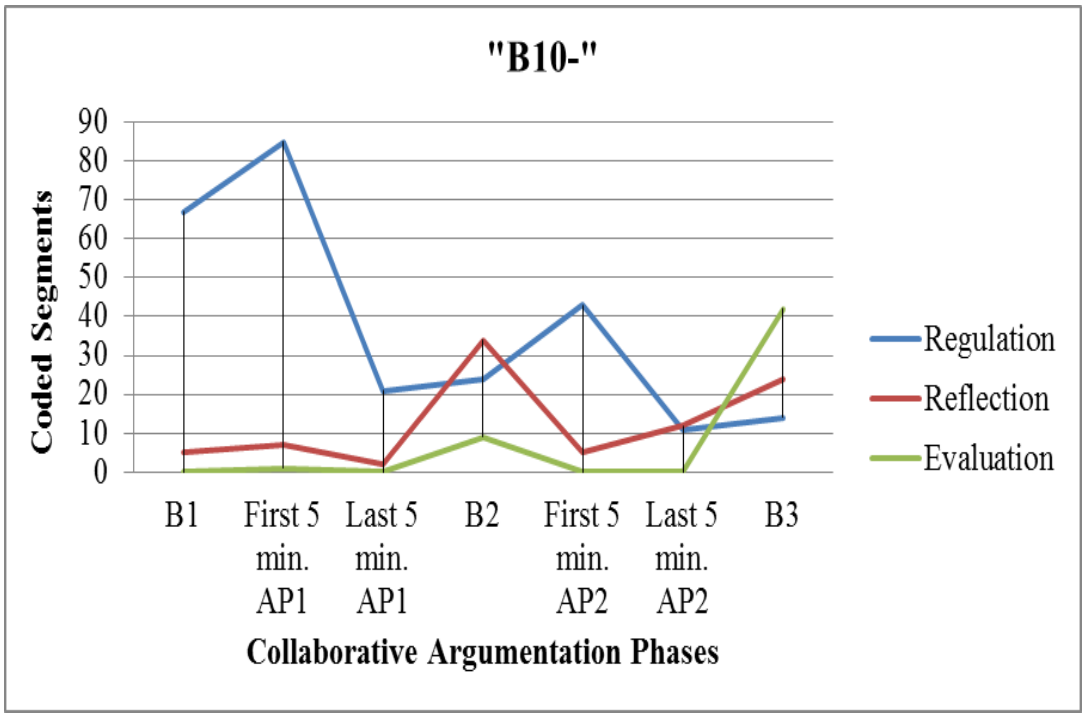


Figure 3.12. Changes in the collaborative metacognitive processes during collaborative argumentation phases in the four sessions of "B10-".

We observed that the regulation processes in the “B2+” and the “B10-“cases (figures 10 and 11) tend to reach similar high peaks in the first 5 minutes of the first argumentation phase, following the awareness break for constructing a plan and discussing the topic at hand. Regulation processes reach a peak at the first 5 minutes of the second argumentation phase in both cases. Differences between the two groups can be found in the changes in their reflective and evaluative processes, as “B2+” presents more increased levels of reflection after the second awareness break (B2) for discussing own participation and into the second phase of argumentation till the third awareness breaks (B3) for making remarks for improving collaboration next time. Finally, the “B10-“group seems to respond better to the evaluative prompts for comparing collaboration and coordination efforts in the group in the third awareness break (B3).

The levels of the regulation processes in the “S6+” and the “S4(+)” cases reach their highest peak in the first 5 minutes of the first argumentation phase, following the awareness break for assigning role and defining successful collaboration (figure 3.13. and figure 3.14.). Regulation processes in the “S6+” are higher in the first 5 minutes of the second argumentation phase than in the “S4(+)” case. With respect to the changes in evaluative processes “S6+” and the “S4(+)” cases are increasing their evaluation similarly during the second awareness break (S3) for evaluating their performance in decreasing it in the second phase of argumentation. The reflection processes in both groups are rising in the third awareness breaks (S4) for making remarks for improving collaboration next time, but the “S6+” group is engaging more actively in reflection and evaluation of collaboration than “S4(+)” at the same time point.

A closer look into the contents of students’ discussion within the awareness breaks and the first and last five minutes of the argumentation phases revealed how students respond to the different prompts for awareness and how these influenced the changes in the different metacognitive collaboration processes i.e., regulation, reflection, and evaluation. The most influential awareness prompts for the changes in the collaboration processes are examined in detail across the four sessions of collaborative argumentation in each group and are contrasted across the four extreme cases with the help of a Case-ordered matrix (figure 3.15.). Regulation processes in the “B2+” and the “B10-“cases have been influenced mostly by the prompt for creating a plan from the Behavioural Awareness Script. However, students in the “S6+” and “S4(+)” cases created also plans for collaboration without being prompted to do so by the Social Awareness Script, often in conjunction with their response to the prompt for defining successful collaboration. Here, we observe that the successful groups “B2+” and “S6+” created

plans which included extended written and oral lists of arguments for supporting a contention and even allowed for individual preparation time of arguments and followed them till the end of every session. Whereas the least successful groups "B10-"and "S4(+)" tended to drop their plans for collaboration and "argue with the flow" i.e., change their opinion in favour or against a certain contention in the light of a new argument formed with evidence from the theory text or brought up by the group members.

The most influential prompt for triggering reflection processes in of all four cases was the one for making remarks for improving collaboration next time. This prompt was part of both the behavioural and social awareness script variations and appeared in the third awareness break on B3, S4 script cards respectively. The "B2+" and the "B10-"groups reflected on the need for more clear labour division in the group and better defined roles in the group, while the "S6+" and "S4(+)" groups emphasized the need for keeping up with the role tasks and being careful not to oppress the opinions of others in the group respectively. In general, all groups ended up forgetting about their remarks and only in the "S4(+)" case we observed an improvement on opinion suppression between sessions. Evaluation processes in the "B2+" and the "B10-"cases have been influenced mostly by the prompt for discussing one's own participation in the second awareness break. In the "B2+" group, it triggered the discussion on individual weaknesses, which students were not able to overcome in the next sessions. In the "B10-" group, the prompt was wrongly applied and led to discussing group efforts and thereby revealing group dynamics issues, which were also not resolved in the next sessions for collaboration. The most influential prompt for the evaluative processes in the "S6+" and "S4(+)" groups was the one for evaluating ones' own performance in the role. Surprisingly, the "B2+" group engaged in evaluating ones' own performance in the role in their second session for collaboration, after having assumed roles without being instructed to do so by the behavioural awareness script. The evaluation of ones' own performance in the "S6+" group, although not elaborated, led to some revelations about the role dynamics, while it revealed complaints about ignored contributions from members of the "S4(+)".

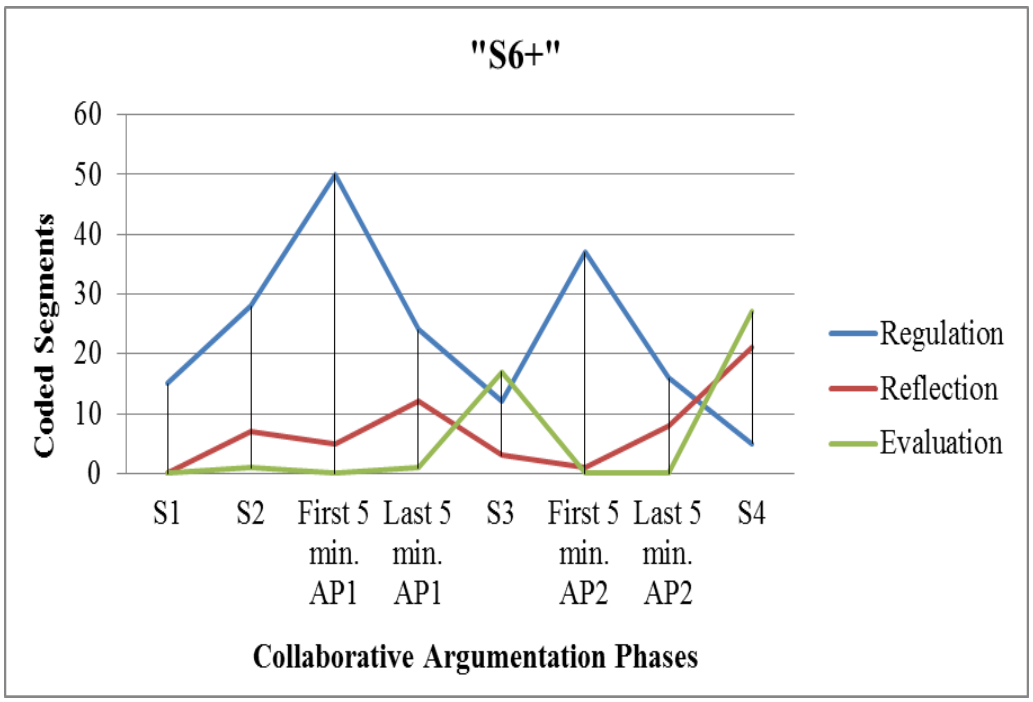


Figure 3.13. Changes in the collaborative metacognitive processes during collaborative argumentation phases in the four sessions of "S6+".

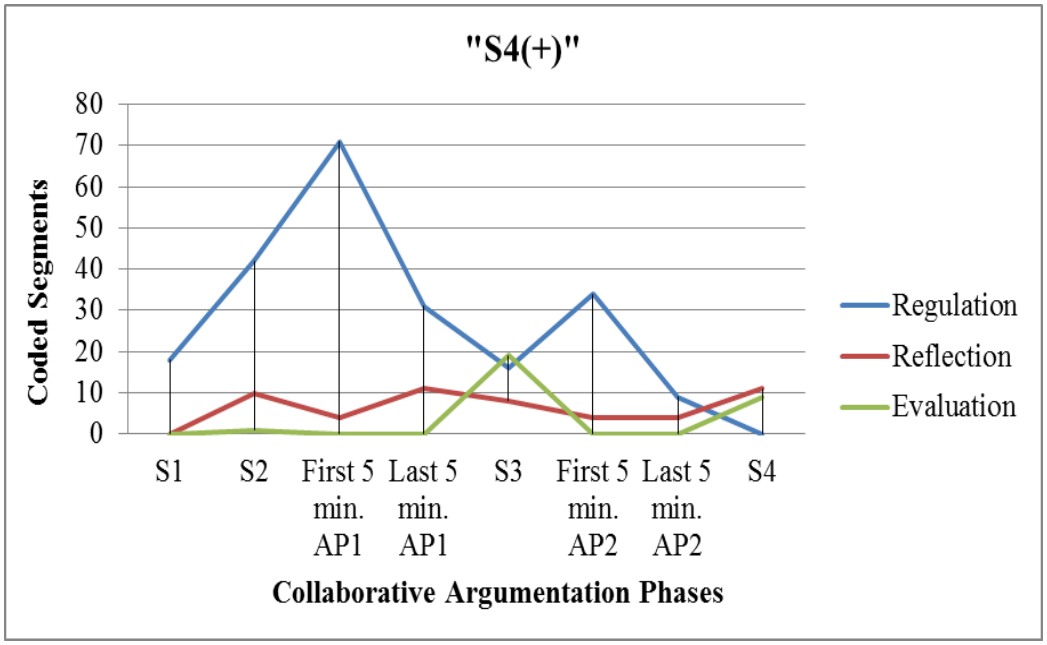


Figure 3.14. Changes in the collaborative metacognitive processes during collaborative argumentation phases in the four sessions of "S4(+)".

		Extreme Cases			
Collaborative Processes	**Example codes (prompts)**	**B2 +**	**B10-**	**S6 +**	**S4 (+)**
Regulation	**Creating a plan (BAS)**	Pick contention, written and oral lists of arguments. **Often used.**	Oral list of arguments→ **Not followed.** Argue with the flow.	Pick contention-individual preparation of „pro and contra"→ **rich list**	Plan as they go. **Frequent debates on contention and connections between arguments.**
	Defining successful group collaboration (SAS)	x	x	Equal contributions-Control for relation to theory. Prompt in two last sessions **ignored**.	Equal participation-Hearing out all opinion. Prompt in two last sessions **ignored**.
Reflection	**Making remarks for next time (BAS + SAS)**	Plan for labor division→ **not followed.**	Labor division, Role exchanging, Need for a "controller" → **not followed in the next sessions.**	Labor division, Keep in role, Need for a moderator → **not followed in the next sessions.**	Careful not to suppress opinions → **applied. Ignored the prompt mostly.**
Evaluation	**Discussing own participation (BAS)**	Mainly perceived as balanced. Individual awareness of weaknesses→ **Not resolved.**	**Discussing group efforts instead. Group dynamics issues revealed→ not resolved.**	x	x
	Evaluating performance in role (SAS)	Assuming roles silently -2nd session **explicitly.** Writer-works more+ learns more.	x	Feel good with roles (no re-assignment). Writer feels restricted. **No real performance evaluation.**	Happy with their performance-no elaboration. Complaints for ignored contributions.

Figure 3.15. Case-ordered matrix with analysis of contents as reaction to prompts (examples) for each collaborative process.

3.2.4.5. Metacognitive collaborative processes for quality of argumentative discussion.

In the next step, we employed a coding scheme for analysing the levels of argumentative discussion based on the arguments that were brought up during the discussion on collaborative metacognitive processes (regulation, reflection and evaluation) in the awareness breaks and the first and last five minutes of the argumentation phases. The same segments as the ones for the analysis of collaborative metacognitive processes were used for the analysis (figures 3.14 and 3.15.). The coding scheme differentiated between the discussion on the Formal Correctness (FC) of arguments i.e., discussion on forming or revising a contention, pro-arguments, contra-Arguments etc. and the discussion on the Evidence Sufficiency (ES) of arguments i.e., forming or revising evidence from theory or personal experience. The level of argumentative discussion was defined as "Advanced" when the discussion led to the forming or revising arguments and evidence through elaborated (meaningful and purposeful) talk which included references to the correctness criteria (i.e., correct ontological labelling for boxes and adherence to argument mapping rules within each box and each simple argument) and Evidence Sufficiency criteria (i.e., correct and relevant evidence from text, from personal experience or other scientific sources) that were applied for coding the quality of argument maps. The next level of discussion on the FC and ES of arguments during collaborative metacognitive processes included forming or revising arguments and evidence but no reference to the Formal Correctness and Evidence Sufficiency criteria from the coding scheme for the quality of argument maps and was characterized as "Basic". Finally, a code for "No discussion" was assigned when no discussion on forming or revising arguments and evidence was found in the discussion on the collaborative metacognitive processes.

With the help of a Case-ordered Matrix (figure 3.16.), we analysed the levels of argumentative discussion which occurred while students were working on some example prompts and are related to the three collaborative metacognitive processes. Here we present on the quality of the argumentation discussion per prompt/collaborative process and across cases, thereby distinguishing between discussion on Formal Correctness (FC) criteria and Evidence Sufficiency criteria (ES) with the use of colour conventions for depicting the level of discussion. Green is used for depicting the advanced argumentative discussion, orange for basic level of argumentative discussion and last, grey is used for indicating the absence of discussion on arguments ("No Discussion").

We observe that the levels of argumentative discussion, both in terms of Formal Correctness (FC) criteria and Evidence Sufficiency criteria (ES) were characterized as advanced in all four cases, when the students discussed the topic and created or revised their plan for collaborating as a response to the related prompts. This indicates that regulative processes of collaboration are associated to higher levels of discussion on arguments that could enhance the quality of written arguments as well. Not many references to Formal Correctness (FC) criteria and Evidence Sufficiency criteria (ES) of arguments were found during the reflecting discussion on the plan or while making remarks for improving collaboration next time. An exception to this pattern, is the „S4(+)" case, where students formed or revised arguments with explicit references to Formal Correctness (FC) criteria and Evidence Sufficiency criteria (ES) while reflecting on their collaboration plan. Finally, no discussion for forming or revising arguments and evidence was found during the discussion on the prompts for engaging in evaluative processes through discussion on ones' own participation and evaluation of performance in the role.

Collaborative Processes	Example Prompts	B2 +		B10 -		S6 +		S4 (+)	
Regulation	Discussing the topic	FC	ES	FC	ES	FC	ES	FC	ES
	Creating/Revising a plan	FC	ES	FC	ES	FC	ES	FC	ES
Reflection	Reflecting on the plan	FC	ES	FC	ES	FC	ES	FC	ES
	Making Remarks for next time	FC	ES	FC	ES	FC	ES	FC	ES
Evaluation	Discussing own participation	FC	ES	FC	ES	FC	ES	FC	ES
	Evaluating performance in role	FC	ES	FC	ES	FC	ES	FC	ES

Figure 3.16. Case-ordered matrix with analysis of levels of argumentative discussion on Formal Correctness. (FC) criteria and Evidence Sufficiency criteria (ES) associated to the discussion on example prompts for collaborative process.

3.2.4.6. Perceived team effectiveness.

In this study, we investigated the perceived team effectiveness in the collaboration in the groups in both conditions using the standardized questionnaire of Fransen et al. (2011) (Appendix G). We explored the effect of the two different script variations (BAS and SAS) on the perceived Team Effectiveness over time (4 sessions) based on the responses of students from both cases to the questionnaire constructs of Shared Mental Models (SMM), Mutual Trust (MT), Mutual Performance Monitoring (MPM) and Team Effectiveness (TE) at the end of every session for collaborative argumentation. Because of a relatively small sample size (N = 26), uni-level analyses were used. Therefore, four 2 (Condition: BAS vs. SAS) x 2 (Time: Four measurement points) mixed ANOVA repeated measures on the last factor analyses were conducted with each of the four dimensions of the team effectiveness questionnaire (SMM, MT, MPM, TE). Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each cell of the design and homogeneity of variances was assessed by Levene's test. There were no outliers, residuals were normally distributed ($p > .05$) and there was homogeneity of variances ($p = .061$).

The interaction effect between Time and Condition (BAS vs. SAS variations) on Shared Mental Models (SMM) was not statistically significant, $F(3, 72) = 1.383$, $p = .255$, partial $\eta 2 = .054$. Therefore, an analysis of the main effect of Time on SMM was performed, which showed that there was a significant main effect of Time ($F(3, 72) = .33$, $p < .001$, $\eta p\ 2 = .585$) on Shared Mental Models (SMM), with BAS (mean = 1.60) and SAS (mean = 1.39) performing different overall.

To learn more about when these differences occurred, we consulted the Pairwise Comparisons table (post hoc). All pairwise comparisons were run with reported 95% confidence intervals and p-values are adjusted with Bonferroni correction technique. A repeated measures ANOVA determined that there was a decrease in SMM values from the first session ($M = 1.92$, $SD = 0.57$) to the second session for collaborative argumentation into the exercise intervention ($M = 1.47$, $SD = 0.51$), a statistically significant mean decrease of 0.45, $SE = 0.136$, $p < .001$. Similarly, there was a decrease in SMM values from the second session ($M = 1.47$, $SD = 0.51$) to the fourth session for collaborative argumentation into the intervention ($M = 1.29$, $SD = 0.45$). This was a statistically significant mean decrease of 0.18, $SE = 0.136$, $p < .001$. From looking at the graph (figure 3.17.) we can see that students'

development of Shared Mental Models (SMM) diverged between script variations similarly over time. In the last session, we observe that students with the BAS variation regained some their Shared Mental Model but not to the point they started off their collaboration in the first session. On the contrary, students with the SAS variation, declined further in every session in terms of their development of Shared Mental Models. With respect to the awareness prompts for reflective and evaluative discussion from the two script variations (BAS and SAS) the results indicate that they failed to help students build and update Shared Mental Models (SMM).

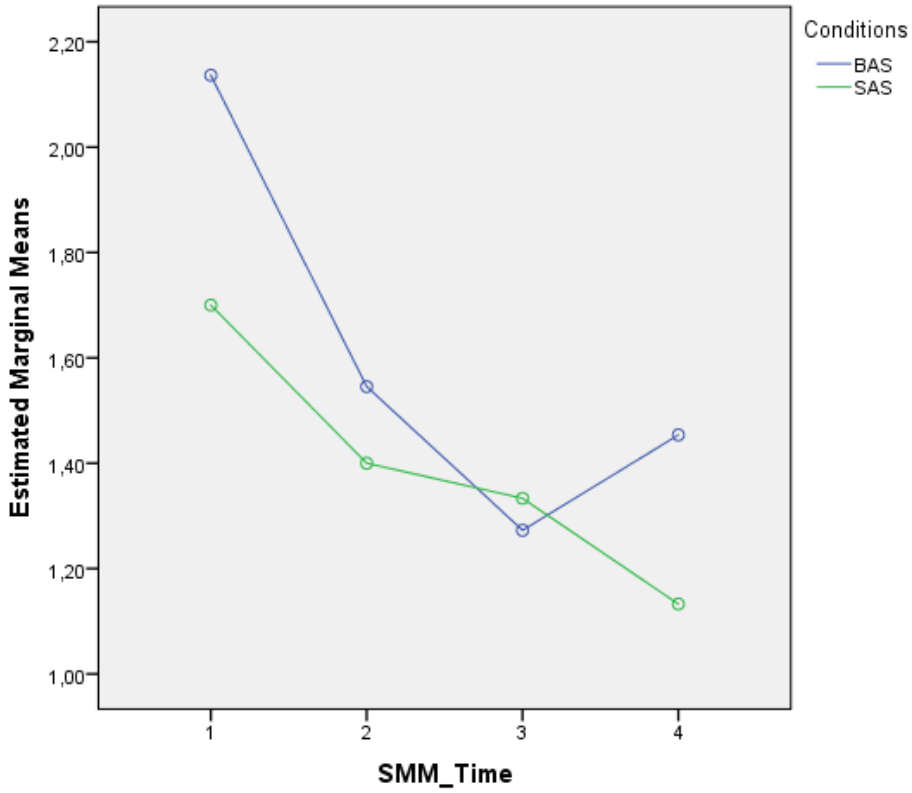


Figure 3.17. Main effects of time on shared mental models.

The interaction effect between Time and Condition (BAS vs. SAS variations) on Mutual Performance Monitoring (MPM) was not statistically significant, F (3, 72) = .663, p = .577, partial η2 = .027. Therefore, an analysis of the main effect of Time on MPM was performed, which showed that there was a significant main effect of Time (F (3, 72) = 4.69, p < .001, ηp 2 = .163) on, with BAS (mean = 2.1) and SAS (mean = 1.85) performing different overall.

For understanding better when these differences occurred, we consulted the Pairwise Comparisons table (post hoc test). All pairwise comparisons were run with reported 95% confidence intervals and p-values are adjusted with Bonferroni correction technique. A repeated measures ANOVA determined that there was a decrease in MPM values from the first session (M = 2.19, SD =0.80) to the second session for collaborative argumentation into the exercise intervention (M = 1.75, SD = 0.45), a statistically significant mean decrease of 0.44, SE = 0.138, $p < .005$. Similarly, there was a decrease in MPM values from the first session (M = 2.19, SD =0.80) to the fourth session for collaborative argumentation into the intervention (M = 1.76, SD = 0.71), a statistically significant mean decreases of 0.43, SE = 0.149, $p < .005$. From looking at the graph (figure 3.18.) we can see that students' development of Mutual Performance Monitoring practices diverged within each script condition (BAS vs. SAS variations) over time in similar ways. With respect to the awareness prompts for reflective and evaluative discussion from the two script variations (BAS and SAS) the results indicate that the prompts failed to help students build their Mutual Performance Monitoring (MPM) skills.

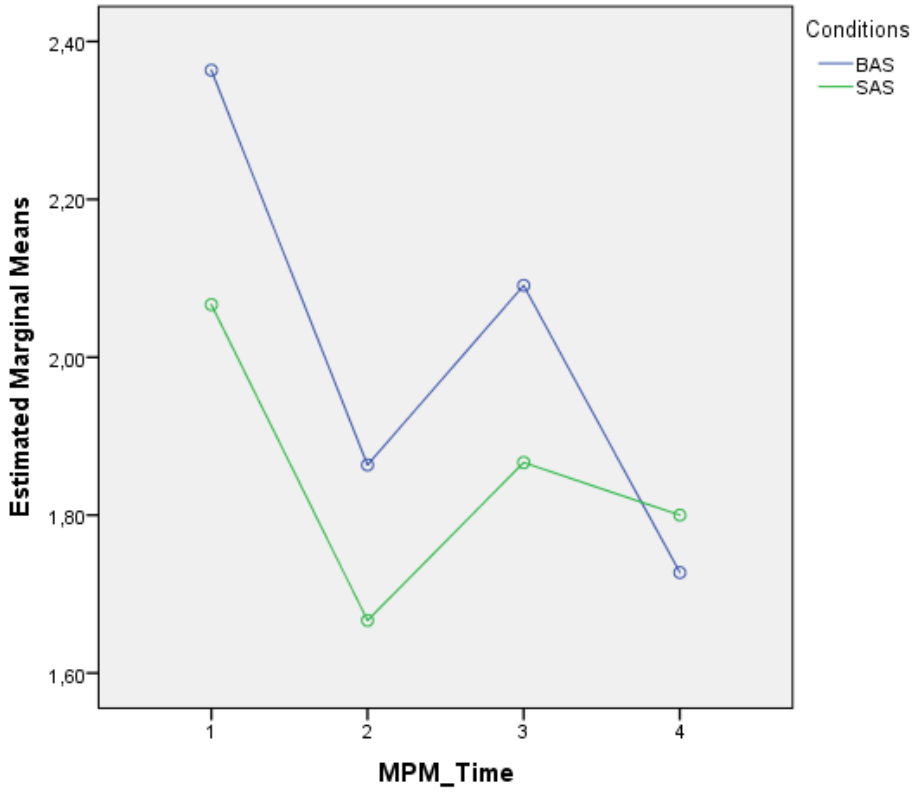


Figure 3.18. Main effects of time on mutual performance monitoring.

There were no statistically significant interaction effects between Time and Condition (BAS vs. SAS variations) on Mutual Trust (MT) ($F(1, 24) = .138$, $p = .714$, partial $\eta 2 = .006$) and Team Effectiveness (TE) ($F(3, 72) = .039$, $p = .806$, partial $\eta 2 = .013$) respectively. The analyses of the main effect of Time on Mutual Trust (MT) ($F(1, 24) = 2.97$, $p = .097$, partial $\eta 2 = .110$) and Team Effectiveness (TE) ($F(3, 72) = .757$, $p = .522$, partial $\eta 2 = .031$) respectively showed that there were no statistically significant main effects either.

3.2.4.7. Feedback Survey

The survey included five items on the usefulness of the "side-tasks", which a) asked for explicit rating of the usefulness of various types of prompts for reflection, evaluation, regulation with or without group discussion based on the variation. The second and third item asked for students' opinion on the most and least useful "side-task" for collaboration in open answer format. The fourth and fifth open-ended items inquired the perceived usefulness of the "side-tasks" as breaks from collaboration (helpfulness or disruptiveness) and the sufficiency of the time offered for completing the task respectively.

With respect to the most and least helpful awareness prompts in the BAS and the SAS variation, we present the results from the open-ended questions (figures 3.16 and 3.17). In the BAS variation, students expressed themselves positively about the prompts for regulative group discussion, specifically for the coordination checks throughout the collaboration. The regulative prompts for creating and following a plan for the collaboration made them "think about why we weren't as successful as we wished and "forced" us to think about how to change it." The regulative group discussion prompts for running a participation check in the group received mixed comments. One student stated: "we did not discuss it much in the group, but it helped me personally to reflect whether I am rather quiet today". Lastly, the prompts for engaging in group discussion for evaluating the participation as well as the coordination efforts at the end of every session were not perceived well by the BAS students. For example, one student mentioned that "it feels wrong to compare yourself to your teammates while they sit around you". Moreover, with respect to the experience with the evaluative group discussion prompts students reported that: "Everyone usually said something like "yeah, I said enough", "No one is going to admit that they didn't collaborate enough" and „When you have to discuss how much everyone has contributed because nobody wants to say that someone didn't contribute as much as they would like them to, to not look like a bad guy".

Students in the SAS variation gave their own feedback on the most and least useful awareness prompts of their script. They commented positively on the prompt for assigning roles and agreed that "it gave the collaboration a good structure and everyone knew what to do or what tasks to push". However, they did not refer positively to the prompt for discussing and evaluating their performance as writers, revisers or controllers in the group e.g. "reassigning the roles amongst you, if needed - because all participants contributed in the same way to all of the roles." Furthermore, students often stated in their answers that the prompts for keeping an open mind and being friendly throughout the collaboration helped them "get different minds together" (figure 3.19 and figure 3.20.).

Regarding the timing of the appearance of the prompts, students in both variations referred to it as rather disruptive for the collaboration. The time assigned for working on the prompts (5 minutes for each prompt) was found to be „more than enough" in most cases. The students in both variations were also asked about the use of the additional argument scaffold provided by the script. Most students agreed that sentence openers and the thought-provoking questions were helpful to them but not the counter argument support or the support for creating back-up of claims and bringing examples. Finally, referred to the time slots for working on the argumentative tasks positively: "20 minutes is enough to sketch out some pros and cons for the argument".

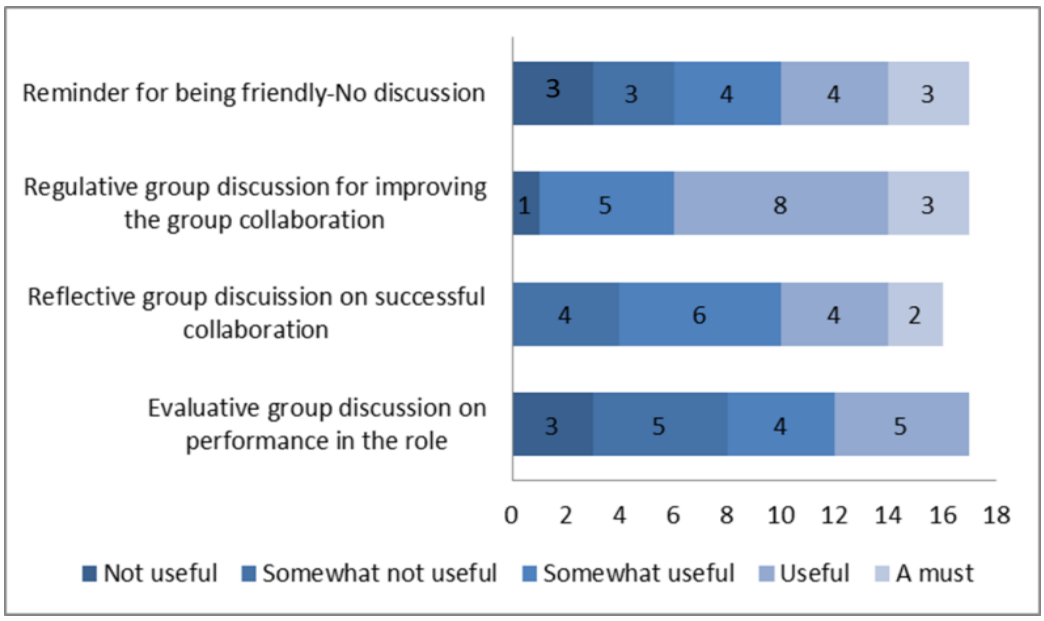


Figure 3.19. Results of 5-point Likert scales for some prompts in SAS (1: strongly disagree, 5: strongly agree, N=17).

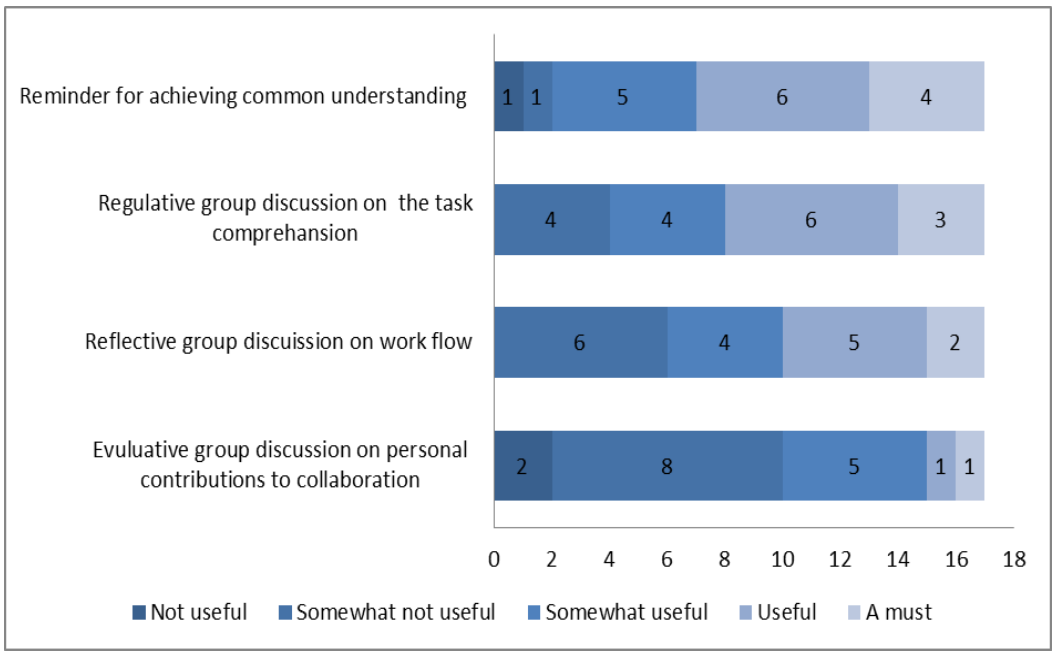


Figure 3.20. Results of 5-point Likert scales for some prompts in BAS (1: strongly disagree, 5: strongly agree, N= 17).

3.2.5. Discussion and Limitations

In this chapter, we will discuss the main results of the different analyses that were conducted for addressing the five research questions of this study. Some of the analyses were conducted for questions that can be answered only by combining the results of different analysis from the previous subchapters.

First, we discuss the results from the analysis of the quality of argument outcomes based on criteria of Formal Correctness (FC) and Evidence Sufficiency (ES) of the arguments in the maps the argument maps of all ten groups that worked with either the Behavioural Awareness Script or the Social Awareness Script over four sessions for collaborative argumentation. The results showed that the both scripts led to an improvement of groups' FC and ES levels of argumentation from the first to the fourth session for collaborative argumentation. The individual differences in the progress helped us identify the two most and two least successful cases with the two script variations that were used for further analysis. The participants and the group dynamics in the "B2+", "B10-", "S6+" and "S4(+)" cases were then presented in more detail. The analysis of their main activities and characteristics with Role-ordered matrixes and the summary of collaboration progress indicated that the prompted roles in SAS variation helped the most successful group ("S6+") to structure their contributions and their coordination

efforts based on their role. The existence of only one dominant person per group inhibited substantive argumentation and lowered the engagement from other members in the discussion, thereby leading to "free-loafing" behaviours over time ("B10-"). These behaviours can partly explain the decrease in the argumentation levels of the groups from the first to the fourth session for collaborative argumentation. However, when dominant persons were interacting in the group this often led to fruitful discussion on arguments ("S6+", "S4(+)") but no social conflict (i.e., disagreements or competitive behaviours) was observed. These results are in partial agreement with the research on the influence of group dynamics on collaborative argumentation, which shows that the dominance of single members in the discussion can inhibit substantive argumentation, but social conflict can promote it (Ryu & Sandoval, 2015). More research on the role on awareness support for promoting social conflict is needed.

The interactions in the group were often role-driven and the most decisive role was found to be the one of the writers. The role of writer was implied by the SAS variation, but was also assumed spontaneously by groups with the BAS variation. The writers in the most successful groups exhibited more coordination related behaviours, whereas writers in the least successful group were focused on the task at hand (i.e., typing the arguments into the map) and often refrained from the discussion on arguments. This difference could be explained by the demanding character of the writer task which proved hard to combine with active participation in the discussion and by individual character differences i.e., dominant persons felt empowered by their role as writer for controlling the form of arguments whereas less active persons or ambivalent persons took up "secretary" tasks.

The application of different awareness prompts was examined using qualitative content analysis (Krippendorff, 1989). In this analysis, we considered the application of the different awareness prompts from each script within the respected awareness breaks from collaborative argumentation phases in the four cases. Thereby, we considered both the reaction to the prompts and content of discussion on these prompts over time for categorizing their application as "no application, wrong application, partial application, and successful application" over time with the help of a Time-ordered matrix. When comparing the most successful to the least successful cases, independent of script condition, with respect to the application degree of the awareness prompts, we see that the most successful cases make more consistent and elaborated use of the awareness prompts for engaging in regulative group discussion and for reflective group discussion case as opposed to the least successful cases where the same prompts fade out progressively. The fading-out of the prompts could be the result of demotivation from the

repeated character of the task in line with "Over-scripting" phenomenon as described by Dillenbourg (2002) (i.e., increased complexity of the script which results in less spontaneous actions and demotivation) or an indication that students have internalised the script and do not need the prompts for engaging in the respected typed of discussion within the awareness breaks.

Interestingly, prompts for engaging in evaluative group discussion i.e., prompt for comparing coordination efforts in BAS and for evaluating friendliness in the group in SAS were applied either wrongly, partially or were not applied at all in both the most and the least successful cases. This indicates difficulties with the concept of open comparison or evaluation of one's work in the group and a tendency to turn to more "safe" practices such us reflecting on group progress and praising of the group work or making impersonal comments about the problems of collaboration. Finally, no references to the reminders importance of the prompts of both scripts were found in the collaboration of the four cases, indicating thus that students in both "B10-"and "B2+" felt no need to remind their fellow group members and themselves of the importance of these actions and making a case for investigating further the use of constant reminders of importance of actions in scripts.

For answering the question on how the different prompts for awareness influenced the different collaboration processes, we examined the collective diagrams of the collaboration processes per case as well as the results of the content analysis of reactions to most influential prompts pro collaborative process with the help of a Case-ordered Matrix. The levels of regulation processes seem to remain high in the first five minutes of each argumentation phase both when prompted in the awareness break before and when not prompted, whereas reflection and evaluation processes seem to be triggered mostly in during the awareness breaks where the prompts for regulation and evaluation of collaboration are discussed. On the one hand, this speaks for the effectiveness of the discussion-based processes prompts in the awareness breaks for triggering the discussion pressing issues of collaboration (limited by the "Over-scripting" effect). On the other hand, it indicates the regulation processes are more natural and even more important to students for managing their collaboration than the reflective and evaluative ones; therefor they are occurring more often during the argumentation phases, as well. However, this is not to underestimate the importance of the reflective and evaluative discussion in collaboration, since when applied properly, they led to some revelations about the role dynamics, which were mostly not resolved. In combination with the results on the wrong application or the fading out of application of reflective and evaluative discussion-based prompts, we could see the need for alternative awareness supporting mechanisms that focus on

a more objective delivery of such information (i.e., through external evaluation of efforts) and the facilitation of these processes (i.e., with the help of participation visualizations).

The question on how the different collaborative metacognitive processes (regulation, reflection, evaluation) are connected to level of argumentation was analysed qualitatively also. We employed a coding scheme for analysing the levels of argumentative discussion based on the arguments that were brought up during the discussion on collaborative metacognitive processes (regulation, reflection and evaluation) in the awareness breaks and the first and last five minutes of the argumentation phases. We observed that the levels of argumentative discussion, both in terms of Formal Correctness (FC) criteria and Evidence Sufficiency criteria (ES) were characterized as advanced in all four cases, when the students worked on the prompts for discussing the topic and creating or revising their plan for collaborating but not when they were reflecting or evaluating their collaboration. This indicates that the regulative processes of collaboration could enhance the quality of written arguments as well but can only partly explain the differences in the argumentation levels among the four cases and call for further investigation of the contents of the argumentative discussion from the entire session for collaborative argumentation.

For investigating the impact of working with the two script variations on perceived team effectiveness, we analysed the answers to the team effectiveness questionnaires quantitatively. Four 2 (Condition: BAS vs. SAS) x 2 (Time: Four measurement points) mixed ANOVA repeated measures on the last factor analyses were conducted with each of the four dimensions of the team effectiveness questionnaire (SMM, MT, MPM, TE). The results indicated that there were no statistically different interaction effects between Time and Condition (BAS vs. SAS variations) on any of the mediating variables defined by Fransen and colleagues (2011). However, there were two main effects of Time on Shared Mental Models and Mutual Performance Monitoring (MPM) constructs of students. Post-hoc test indicated that students' Shared Mental Models and Mutual Performance Monitoring (MPM) decreased gradually from the first to the fourth session for collaborative argumentation decreased. In the last session, we observe that students with the BAS variation regained some their Shared Mental Model but not to the point they started off their collaboration in the first session. On the contrary, students with the SAS variation, declined further in every session in terms of their development of Shared Mental Models. These results indicate that both the prompt for creating a plan (BAS) and the prompt for defining successful collaboration in the group (SAS) didn't help students build stronger shared mental models over time. Similarly, the prompts for comparing one's

own collaboration and coordination to other group members (BAS) and the prompt for making remarks for improving collaboration in the next session (BAS and SAS) did not assist the Mutual Performance Monitoring skills over time.

Finally, the prompts for discussing one's own participation (i.e. where the outing of any collaboration problems on the spot is facilitated) (BAS) and the prompt for encouraging the sharing of information without reservation in the group in a friendly manner (SAS) had no influence on increasing the interpersonal trust among students, which is considered conditional for building Shared Mental Models. These results agree with the results of Fransen et al. (2011) who supported that the effect of trust on learning-team effectiveness is negligible. Our findings, however, could not be used for approving or disproving the assumption by Fransen et al. (2011) that learning teams perceive themselves as more effective when shared mental models increase and mutual performance monitoring is adequate since the inconsistent use of the prompts over time does not allow us to make conclusions about their influence the on the team effectiveness constructs.

When reviewing the results of the post-study feedback survey on students' experience with scripted awareness breaks in conjunction with the empirical issues for displaying and monitoring awareness by Buder, (2011) some of results can be explained. The low satisfaction with the breaks for explicit rating of participation and collaboration can be traced back to similar reactions to group awareness tools that employed explicit rating of self and others of i.e., the Radar and Reflector tools by Phielix et al. (2011). However, the problems with the scripted awareness breaks for evaluative group discussion go beyond the literature on problems with the subjectivity of feedback provided (Sangin, Molinari, Nüssli, and Dillenbourg, 2011), or the observed high level of distraction from the learning tasks because of the disruptive timing of the breaks. The low satisfaction can be better explained by the overly high normative pressure from comparing one's participation and contribution to the other members openly. The open evaluative discussion format was meant to prevent any free-riding or social loafing phenomena from taking place, but the feelings of uneasiness it created to the students have led to the reported evaluation apprehension phenomena (Buder, 2011, Cottrell, 1972).

The rather high satisfaction levels with the breaks for regulative discussion on planning and improving the collaboration on the go, as well as the high appreciation for taking up specific roles aligns with the literature recommendations for strengthening guidance and directivity for better coordination in the group without diminishing learner autonomy (Buder, 2011). The reminders for regulating group aspects with or without triggering group discussion

(i.e., reminder for achieving common understanding and being friendly) were also appreciated by the group as they triggered help-giving behaviours, without overemphasizing the comparison of performances in the group. Finally, most students in both variations reported positive tendencies for future use of the Rationale® system. However, many of them criticized the system for the fact that "only one person can work with the mapping tool at a same time. "

4. Enhanced Awareness Support for Collaborative Argumentation

In this section we explain how the results of the first study have informed the design of Argue(a)ware in the second phase of development. Moreover, we explore related work to form the design workspace and for the second phase of development of Argue(a)ware.

Awareness prompts for regulating collaboration (i.e., making a plan for collaboration, and assigning roles) during the awareness breaks for regulation were associated with increased instances of regulative collaboration processes (i.e., discussion on the topic) in the argumentative discussion. These effects were facilitated by the consistent and successful application of prompts. Moreover, the prompted regulative processes were associated with higher levels argumentative discussion in the most and the least successful groups of the study. Finally, most students appreciated the open display format (i.e., discussion-based format) of the prompts for regulating participation within the awareness break.

Awareness prompts for reflecting upon and evaluating the collaboration processes of the group during the awareness breaks had no clear influence on the collaborative processes of reflection and evaluation in the argumentative discussion. Moreover, no clear influence of these processes on the collaborative argumentation processes could be stated. These results were mediated by the rather inconsistent and partial application of the prompts for reflection and evaluation and the low appreciation of these prompts by students. The latter can be explained by the fact that students had to generate awareness information in an explicit feedback display (i.e., ratings) on the coordination and collaboration efforts among group members based only on their observations. Moreover, the open discussion in the group (i.e., open display format) for reflecting upon and evaluating the collaboration, resulted in evaluation apprehension phenomena (Cottrell, 1972) and evaluation bias as users may have not assessed themselves or others frankly (Ghadirian et al., 2016).

Buder (2011) suggests that the designers of awareness tools for learning should determine if their tool supports the explicit or implicit display of feedback. In a review by Ghadirian et al. (2016), we see that 63% of Group Awareness Tools in CSCL is displaying awareness information explicitly, independent of the group awareness type supported by the system (behavioral, social or cognitive). Our results contradict this extensive focus to displaying information explicitly (e.g. self- and others assessment of participation) in the group. The explicit awareness display format in our study was based on subjective awareness information, which in turn led to evaluation apprehension phenomena (Cottrell, 1972) and evaluation bias (users may have not assessed themselves or others frankly) (Ghadirian et al., 2016). Finally, it resulted to lower acceptance of the tool.

We see the need for counterbalancing the effects of the explicit feedback display with subjective awareness information from the scripted awareness breaks and the awareness prompts by taking a mixed feedback approach. Along these lines, the Behavioral Awareness Mechanism tool by Medina et al. (2015) provided personal and social awareness information for enhancing social interactions and task performance. The BAM tool utilized a mixed feedback approach, where implicit feedback was automatically and unobtrusively collected via application logs and smartphone-based sensing. Moreover, explicit awareness information was collected via self-assessments and surveys. We argue here that students using Argue(a)ware could also merit from a mixed feedback approach. Argue(a)ware should provide students with implicit feedback on their participation and progress based on preset criteria and in an unobtrusive way e.g. through an anonymous, role-based participation visualization. This implicit feedback mechanism should be combined with explicit feedback mechanisms (e.g., with a short self-assessment questionnaire) as a means of reflecting on one's own progress in the work.

Furthermore, the results of the first study indicated the need for re-examining the scripted awareness breaks and the awareness prompts for reflection and evaluation of collaborative processes with respect to their repeated display character (i.e., every 15 minutes an awareness break was introduced during the argumentative phase of collaboration). Buder (2011) suggests that awareness tool designers for learning should also care about a frequent display of awareness information without interfering, if possible, with the main task of collaboration. The scripted awareness breaks and the awareness prompts in the first study made sure that the awareness information stayed up-to-date during the course of the collaborative

argumentation session but felt rather disruptive to the main task arguing for solving the ill-structured problem.

Moreover, according to Buder (2011), both closed (i.e., rating on pre-defined scale) and open display formats (i.e., rating through discussion) can have advantages and disadvantages for the users. The open display format of the scripted awareness breaks and awareness breaks did allow for colorful exchange of information on the group, however, it was only used properly and somewhat consistently by the high achieving groups. Additionally, students often felt overwhelmed by the open-end task of evaluation and wished for more concrete and measurable evaluation tasks on the basis of external "hard" criteria. Therefore, we argue that a combination of a tool for dynamic display of awareness information (i.e., an awareness visualization tool) together with a closed display format for reflecting upon and evaluating personal progress (i.e. with short self-assessment questionnaire) could be a less disruptive and more efficient way of monitoring personal and group performance in the next phase of development of Argue(a)ware.

The decision for employing tools to support explicit feedback displaying activities is also based on research about group awareness tools for displaying both social and behavioral awareness information. The tool developed by Janssen, Erkens, and Kirschner (2011) focuses on behavioral context information i.e. participation rates. It offers implicit feedback on group members' participation and displays it in a dynamic fashion that allows for high interpersonal comparability of performances in the group in a rather obtrusive manner though (via an extra window for monitoring the activity levels). On the other hand, the Radar and Reflector tools (Phielix et al., 2011) address mainly social context information i.e. friendliness or the productivity of collaborators. These tools employ explicit feedback techniques such as assessments of self and peers, which are displayed periodically via open and closed display formats. The Reflector tool used text fields for awareness information while Radar used rating on a pre-defined scale, with students acknowledging the method they were most likely to use. With respect to the issue of encouraging or even forcing learners to display, these tools seem to be stricter as they allowed participants to access their awareness information only upon completion of their ratings.

Furthermore, the awareness prompts for reflection and evaluation did reveal frictions in the plan and in the group dynamics. However, the prompts were not powerful enough to trigger the desired changes in the behaviors of the students. According to Buder (2011), group awareness tools with high directivity are more likely to cause changes in the behaviors of the users and thus influence their performance. Dehler, Bodemer, Buder, and Hesse (2009) have

also indicated the need to provide more explicit awareness information (through the use of tool-generated recommendations or through scripting mechanisms) for supporting the coordinating activities effectively, thereby increasing the directivity of the system. Based on literature recommendations, we would like to considerer the use of explicit recommendations generated by the tool or with scripting mechanisms for increasing the directivity of in Argue(a)ware. Thereby, we would like to test its potential for triggering behavioral adaptation. Therefore, we examine literature on awareness tools for coaching collaboration and on awareness notification systems for supporting self-regulation of students.

Moreover, the analysis of case studies descriptions payed closer attention to the role of group dynamics to account for the variability in collaborative outcomes. The results indicated that dominant presence phenomena inhibited substantive argumentation in the least successful groups. The phenomena of presence of dominance of single members were mostly corroborated by "free-riding" behaviours of other group members. Moreover, this analysis indicated that awareness prompts for reflecting and evaluating own collaboration and coordination (in the role) did not provoke individual accountability (Morris et al., 2009).

In the next phase of development of Argue(a)ware, we would like to structure the support for the content space of collaboration around the assignment of roles for collaboration as parts of the collaborative argumentation scripts. In doing so, we want to redefine the scripted roles used in the Social Awareness Script variation (from the first phase of development of Argue(a)ware) for making them an integral part of the collaboration. One way of doing so is by introducing cognitive roles relevant to the collaborative argumentation task. Students' reflections on the use of roles in collaboration from the first study along with the low levels of evidence sufficiency in the group argumentation outcomes (in spite of the use of argument scaffold for backing-up arguments) point out the need for introducing support not only for the "doing" of task but for the "thinking" towards the task (O'Donnell, Hmelo-Silver, & Erkens, 2005).

While scripted functional roles, such as the writer or corrector, help reduce the process losses (i.e. coordination problems) (Strijbos et al., 2004; Weinberger, Stegmann, Fischer, 2010), cognitive roles could help enhance cognitive engagement with the task by defining and assigning learners with relevant types of thinking and action-taking in the collaborative argumentation context (Morris et al., 2010; Gu, Shao, Guo, and Lim, 2015). Typical examples of cognitive roles include the roles of "feedback provider", "summarizer", "questioner",

"clarifier", "challenger/asker" or "tutor" and "tutee" (De Wever et al., 2010; Morris et al., 2010; Gu, et al., 2015; Chou et al., 2002).

Thereby, we would like to examine how combinations of functional and cognitive roles help students regulate their participation, when paired with the awareness support for implicit and explicit feedback, as well as with support for directivity. Literature on combinations of group awareness tools and roles show promising results (Gu, et al., 2015).

Summarizing the proposed changes in the awareness elements of the Argue(a)ware for supporting the relational space of collaboration, we conclude a) the need for taking a mixed feedback approach with implicit feedback on participation from the tool and explicit feedback from the students on their progress and b) the call for increasing the directivity of the tool for triggering behavioral adaptation. For realizing the mixed feedback approach, we consider Group Mirror tools (Jermann & Dillenbourg, 2008) for their potential to visualize awareness support in an explicit, dynamic and unobtrusive way as well as scripted awareness breaks for self-evaluation by means of a short self-assessment questionnaire. Furthermore, we suggest structuring the collaboration around the assignment of functional and cognitive roles and connecting the roles to the awareness mechanisms for the mixed feedback approach and directivity. This approach is conceptualized here as the "Role-based Awareness-Oriented Argumentation Script" (explained below). Finally, we consider technical solutions for facilitating the increase in the directivity of the tool. Awareness notification systems are studied for their potential to deliver explicit recommendations to the students individually. Moreover, they are studied for their potential encouraging active participation in the collaboration processes and trigger behavioral adaptation. Additionally, the introduction of new tools (Group Mirror and awareness notification system) for monitoring awareness raises questions regarding the use of multiple display monitors (i.e. shared and private) for facilitating their use in the CSCL environment for argumentation.

In the next sections, we present the design decisions for creating a "Role-based Awareness-Oriented Argumentation Script", as well as for adjusting a Group Mirror tool by Tausch, Ta, and Hussmann (2016) to a be used as role-based awareness visualization tool. Moreover, we present the design of a mock-up system for text-based awareness notifications via smartwatches. Combinations of these tools are compared in terms of the study on "awareness scaffolds for role-based collaborative argumentation" (figure 4.1.).

The study investigates the influence of different degrees of awareness scaffolds (basic vs. enhanced) for raising awareness of collaboration and triggering behavioral adaptation in

collaborative argumentation. Following, we present the rationale for the mixed methods design of the study and the results of the post-study feedback survey on the experience with the instructional setting. We conclude with a discussion on the results of the second study and their connection to our research framework as well.

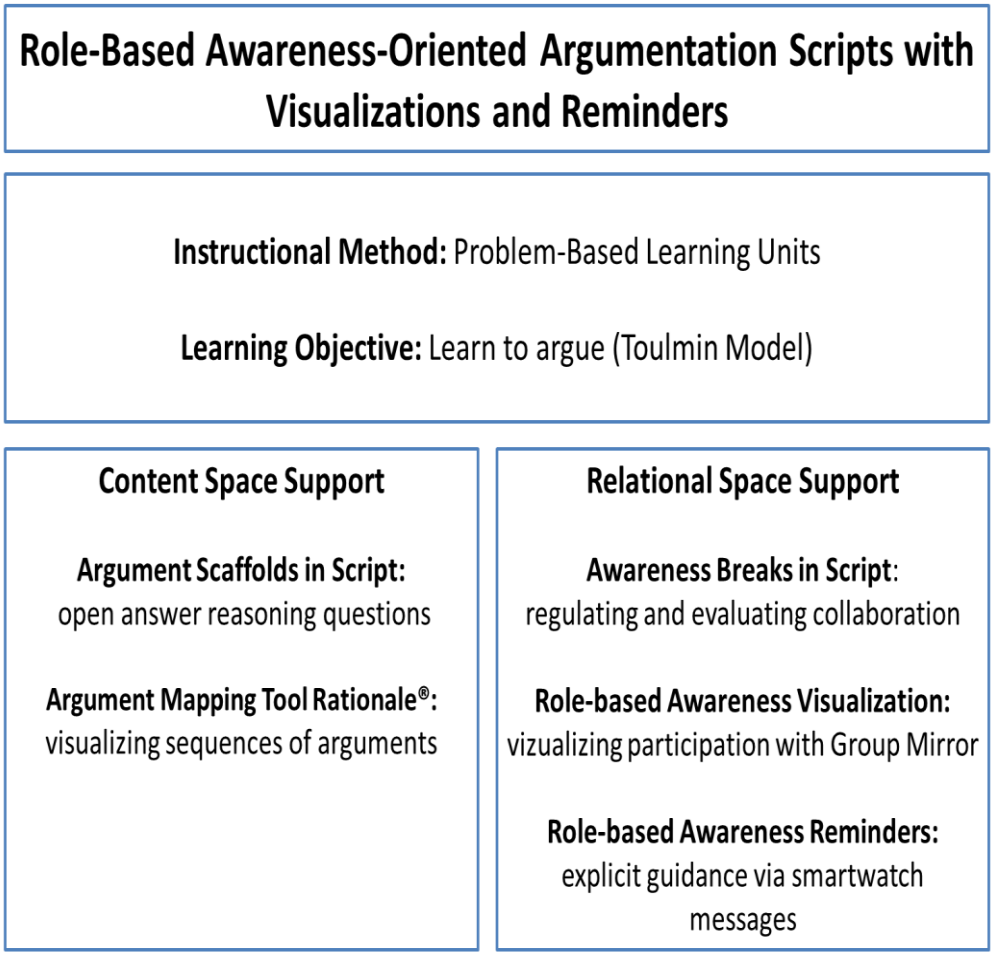


Figure 4.1. Support for role-based collaborative argumentation in the second phase of development of Argue(a)ware.

4.1. Study on Awareness Scaffolds for Role-based Collaborative Argumentation

In the second study, the focus of Argue(a)ware is on structuring and regulating social interactions in the relational space of collaborative argumentation by means of scripted roles and role-based awareness scaffolds. Thereby, we compare an Argue(a)ware variant with support for mirroring participation in the role (i.e., a role-based awareness visualization) and

support for monitoring participation, coordination and collaboration efforts in the role (i.e., self-assessment questionnaire) vs. a second Argue(a)ware variant with additional support for guiding participation in the role i.e., role-based reminders.

Regarding the monitoring procedures, the group mirror aimed at making group norms of participation visible to the group members in a non-obtrusive way, thus enabling the interpersonal comparability of performances to be measured by the self-assessment questionnaire. The role-based awareness visualization and the self-assessment questionnaire are interdependent and offer the basic awareness support for regulation by combining mirroring and monitoring functions. Finally, a mock-up system (low-fidelity prototype) for delivering text-based awareness notifications via smartwatches was employed here. The awareness notification included messages which reminded students of their role duties and of the need to monitor their performance in the role-based awareness visualization. These messages aimed at guiding students directly to adhere to their role-specific behaviors in the collaborative argumentation setting is tested here as part of the enhanced awareness version of Argue(a)ware.

The two variants are compared with respect to how they influence a) awareness of role based-active participation, b) argumentation processes c) and perceived team effectiveness. Additionally, we explore the experience with the different media (large display, laptops and smartwatches) for facilitating awareness scaffolds with the two prototypes of the technology-enhanced instructional settings for Argue(a)ware. The main aim of this study is to evaluate the impact of awareness scaffolds for mirroring and monitoring for raising awareness for promoting active participation in the role and to study the surplus value of introducing awareness reminders.

Ongoing active participation is considered a crucial factor for success in collaborative learning (Chavez & Romero, 2012). Negative participation phenomena such as social loafing or the “free-rider” effect have been identified among the most frequent pitfalls for social interaction in computer-supported collaborative learning (Kreijns, Kirschner & Jochems, 2003). Suggested remedies to these problems include assigning specific roles as well as making individual performance identifiable (King, 1998; Gammage, Carron, & Estabrooks, 2001). Regulation of participation can be achieved with the help of systems for distributing metacognitive information such as monitoring, mirroring and guiding tools (Jermann & Dillenbourg, 2008), While mirroring tools and monitoring tools support learners in the basic awareness support for regulation by collecting interaction-related data and diagnosing interaction problems respectively, coaching systems offer enhanced support for collaboration

by proposing remedial actions based on a computational assessment of the situation, there triggering behavioral adaptation (Jermann, Soller, & Muehlenbrock, 2001; Jermann & Dillenbourgh, 2008). Most group awareness tools (mirroring, monitoring and guiding) aim at behavioral adaptation, which is considered pivotal for effective learning, but it can be argued that tools support different degrees of matching monitored information with immediate action (Buder, 2011).

Research on combinations of different roles with awareness support for collaboration has yield promising results. A study by Gu, et al., 2015 has employed a combination of functional and cognitive roles (i.e. starter, Supporter, Arguer, Questioner, Challenger, and Timer) with the product and process orientation (Strijbos and De Laat, 2010) as part of an asynchronous discussion tool. The study examined the roles for their potential to engage students in active role-based participation in a collaborative problem-solving learning situation. The findings of the study yield positive influence of the role structure on promoting interdependencies and individual accountability (Seo,2007; Spada, 2010), as well as for increasing participation similar to other studies in the field rates (Schellens et al., 2007; De Wever et al.,2010; Strijbos & Weinberger, 2010). The results of this study also indicated possible positive effects of mixing cognitive and functional roles for supporting the discussion of students by keeping their focus on the issues under discussion and thereby reducing process losses, similar to studies where only functional roles (Strijbos et al., 2004, 2007) or content-based roles (Weinberger, Stegmann, & Fischer, 2010) were employed.

However, to date, there has been little research on the effects of different awareness scaffolding mechanisms (i.e., mirroring, monitoring, and guidance) on raising awareness of role-based participation and promoting active participation in terms of engagement in role-specific duties. Moreover, there is little data on how guiding mechanisms for engaging in role-specific behaviors interfere with the main task of argumentation i.e. argument building activities.

Here, we address these issues by designing instructional and tool support for structuring, mirroring, monitoring and directing role-based participation. First, we adopt a role-based approach for structuring collaboration with a mix of functional and cognitive roles in a script for collaboration. This script is enhanced with an on-paper self-assessment questionnaire for reflecting on and evaluating one's own collaboration and coordination efforts in the role. Next, the Group Mirror tool by Tausch, Ta, and Hussmann (2016) was adopted and used here as a dynamic visualization of participation per person in their role (writer, corrector, devil's

advocate) and per group and offered implicit feedback in a closed display format with the metaphor of growing balloons. This role-based awareness visualization tool aimed at facilitating the mirroring the ongoing active participation by visualizing the progress of students in the role and rewarding their role-specific behaviors with an open-end mixed rewards system (no ultimate score provided), thus also indirectly promoting the role-specific behaviors in the group. The role-based visualization and the self-assessment questionnaire are interdependent and offer the basic awareness support for regulation by combining mirroring and monitoring functions. Finally, a mock-up system for delivering text-based awareness notifications via smartwatches that aimed at guiding students directly to adhere to their role-specific behaviors in the collaborative argumentation setting is tested here as part of the enhanced awareness version of Argue(a)ware.

Argue(a)ware now comprises of a role-based awareness-oriented argumentation script with an awareness break for role-assignment followed by a break for planning collaboration at the beginning, and another break explicit self-assessment (i.e., questionnaire), a role-based awareness visualization tool and an awareness notification prototype for issuing role-based awareness reminders. The awareness scaffolding mechanisms (technical and non-technical) aim at increasing students' awareness of participation in the role (i.e., self-assessment and role-based awareness visualization tool) and guiding active-participation in the role by prompting behavioral adaptation (i.e., role-based awareness reminders). Increased awareness should mediate the metacognitive activities such as self- and co-regulation of participation and ultimately the collaboration outcomes (Jermann, Soller, & Muehlenbrock, 2001).

Moreover, Argue(a)ware employs different graphical displays on different devices for assisting the use of the role-based awareness tool (i.e., display on the wall) and the role-based awareness reminders (i.e., smartwatches). Moreover, we employ the large display on the wall for the facilitation of the script for collaboration and private personal computers for the visualization of argumentation with the argument mapping tool Rationale.

Combining shared and private displays are known to support equality of participation in face-to-face collaboration (Looi et al., 2008), as well as to facilitate knowledge sharing in script-based learning environments (Streng, et al., 2010). Multi-device ecologies in co-located settings include combinations of multiple personal devices (e.g., laptops, tablets) and larger, shared displays, such as digital walls or tabletops. As these multi-device environments grow more popular due to more affordable prices and technical advances in the field, questions about the effects of these multi-display environments on awareness of communication and

coordination in CSCL environments are raised (Scott et al., 2015). Multi-display environments (MDE) have been studied with respect to how different display attributes, i.e., size, number or arrangement in the room or different interaction techniques, i.e., tapping affect the collaboration processes. The combination of personal (i.e., laptops or tablets) and shared workspaces (i.e., large shared display) has been studied for its potential to facilitate the processes of creating, accessing, and sharing information and media from a variety of sources to facilitate group discussions in a seamless way (Haller et al., 2010). To the best of our knowledge, previous work has not examined user experience with different displays for facilitating the structuring, monitoring and guiding of collaborative tasks in collaborative argumentation settings.

In an experimental lab setting, ten groups of three university students each (n = 30, Mage =22y, mixed educational backgrounds) received the same instructions from the "Role-based Awareness-Oriented Argumentation Script" (displayed on cards on the upper left part of a big display screen) for arguing on an ill-structured problem (1 meeting x 45 min) and transferring their arguments to argument map with help of the Rationale argument mapping tool. Half of the groups worked only with the role-based awareness visualization and the self-evaluation questionnaire (Basic Awareness Condition-BAC) while the other half groups received additional text-based awareness notifications via smartwatches that were sent to students privately (Enhanced Awareness Condition- EAC). We investigate here how the different degrees of awareness scaffolding (basic vs. enhanced) influence the engagement in collaboration by measuring several role-specific behaviors with quantitative content analysis of videos from the most and least successful groups from both conditions. Next, we pair the quantitative content analysis with the remarks from our field notes and analysis memos on the collaborative process and interaction with the awareness scaffolds in the same groups. Following, we examine the impact of the different degrees of awareness scaffold on the perceived team effectiveness (team effectiveness questionnaire) in both conditions. Finally, we want to shed light on the experience with the different awareness scaffolding elements in the two conditions with respect to the design framework by Buder (2011).

It is expected that the explicit guidance from the awareness reminders in the enhanced awareness support condition which builds on the feedback from the role-based awareness visualization to justify the suggested changes in the behaviors of the participant, will make it easier for students to implement the suggested behavioral adaptation, thus resulting in higher engagement in the role and consequently in argumentative knowledge construction processes.

Moreover, we expect that increased awareness of activities engagement will reflect on higher perceived team effectiveness which will result in higher performance in role.

Before presenting the processes, the analytical approach and the results of this study, we present the changes in the design of the awareness support for the content and the relational space of collaboration. The awareness scaffolding elements used in the two variants of the Argue(a)ware tool are explained here in detail. Thereby, we distinguish between instructional (4.1.1) and technical support (4.1.2 and 4.1.3). The awareness scaffolds are presented with respect to their aim (structuring, mirroring, monitoring and guiding) and the medium which was used for facilitating them (i.e., paper, group mirror, text messages on smartwatches) (table 4.1.). Finally, in subsection 4.1.4 we present the instructional setting for collaborative argumentation with Argue(a)ware and address the use of multiple displays and devices for supporting the use of the different awareness scaffolding elements.

Table 4.1.

Awareness Scaffolding Elements and Their Aims Pro Condition (✓: Provided, ✗: Not Provided)

Awareness Scaffolding Elements	Aim	Medium	Basic Awareness Condition (BAC)	Enhanced Awareness Condition (EAC)
Awareness Break for Role Assignment	Structure	Drop-down menu on PC	✓	✓
Awareness Break for Intermediate Self- assessment	Monitoring	Questionnaire on paper	✓	✓
Role-based Awareness Visualization	Mirroring + Indirect Guidance	Group Mirror visualization on shared wall display	✓	✓
Role-based Awareness Reminders	Direct Guidance	Text messages on smartwatches	✗	✓

4.1.1. Instructional support with "role-based awareness-oriented argumentation script".

The "Awareness-Oriented Argumentation Scripts" from the first study have been reformed based on the results of the first study. We have merged the successful parts of the two script variations and omitted or substituted the less successful parts of the scripts for supporting the content and the relational space of collaboration. Main changes in the script include the

shift to role-based collaboration for regulating collaboration (with revised roles and plan making prompts and breaks) and the introduction of an awareness break for monitoring of collaboration with a self-assessment questionnaire. The new role-based awareness-oriented argumentation script is designed to complement the use of awareness tools for explicit feedback display and increased directivity in collaboration.

4.1.1.1. Role-assignment.

As a first step towards regulating active participation, we introduce an instructional role-based approach to structuring and monitoring in the role- participation in collaborative argumentation with the "Role-based Awareness-Oriented Argumentation Script". The script includes a combination of revised functional roles (i.e. writer and corrector) and a cognitive role (i.e. devil's advocate) for structuring collaboration and an awareness break for reflection on the behavior role by means of a self-assessment questionnaire.

Assigning roles as part of a social script for collaboration in collaborative argumentation settings has been found to have beneficial effects on argumentative knowledge construction (i.e. discourse activities on for learning to argue within a domain) (Weinberger and Fischer, 2006). We introduced three roles for collaboration; two revised functional roles (i.e. writer and corrector) and a cognitive role (i.e. devil's advocate). The "writer" is still mainly responsible for writing down the arguments, while the "corrector's" role is a combination of the duties of the "corrector's" and "controller's" roles (figure 4). These roles charge students with duties on the practical level of collaboration (i.e. typing and formatting of arguments in argument mapping tool) next to their script-implied duty of participating in the generation of arguments for solving the problem. The third role is the one of "devil's advocate", a cognitive role, with the main duty of questioning emerging arguments and thereby contributing to the creation of creating counter-arguments and more substantiated reasons. There is ample empirical evidence that shows a "devil's advocate" approach can stimulate students to reason more critically (Scheuer, McLaren, Harrel, and Weinberger, 2011; Asterhan and Schwarz, 2010; Walker, 2004) in collaboration context. Inducing the conflict element in the collaborative argumentation is inspired by instructional design approaches for elaborating new arguments (Jermann and Dillenbourg, 2003) and aims at pushing students to think over their arguments and possibly work harder on improving their justifications.

For realizing the role-based approach in the script, a "Role Assignment" awareness script card was introduced, and it included a suggestion for picking up a role, the names and descriptions of role duties, as well as a 2 minutes timeframe for discussing the role assignment in the group. In a second step, role assignment was then enabled with the help of a drop-down menu (browser-based) on the private screen (laptop) of each student (figure 4.5). Every role was assigned a distinct color (blue: writer, yellow: corrector, pink: devil's advocate) and the screen was colored in this color as a confirmation or the role assignment and a constant reminder of the color of the role thereon. Following, an awareness script card was presented for making a plan for collaboration (figure 4.6.) and it included a prompt for discussing in the group the understanding of the argumentation task, another prompt for creating a joint plan for the collaboration and last a prompt for writing down the plan with the pen and paper provided. The time frame for making a plan was 3 minutes. The prompts for creating a plan aimed at facilitating the common understanding of the task at hand and helping students define the next steps for solving the problem.

4.1.1.2. Intermediate self- assessment

Evaluating ones' own contributions to the collaboration processes and comparing it to the ones of their group mates can enhance students' sense of responsibility for the group progress by training their reflective and critical thinking skills (De Wever, Van Keer, Schellens, & Valcke, 2009; McLoughlin and Luca, 2002). The awareness breaks and the matching discussion-based process-triggering prompts for reflecting and evaluating the collaboration from both script variations of the first study were succeeded by one short awareness break (1 minute) for reflecting upon and evaluating personal progress by means of a short self-assessment questionnaire (appendix H). Self-assessment techniques in collaborative contexts aim at increasing students' critical and perceptive thinking towards their personal contributions and the input of others (Larres et al. 2003; Robinson & Udall 2006), which results in gains in their content-related learning, quality of problem solving and self-reflection (Sluijsmans et al. 1999; McDonald and Boud 2003).

In this respect, the self-assessment questionnaire (SA questionnaire) was introduced in the present study as a reflection tool and was paired with the role-based awareness visualization for helping students become more aware of their participation and more effective at monitoring their own performance in the role (De Wever et al., 2008). The questionnaire was introduced

as an intermediate evaluation with an awareness script card. The script card instructed students to fill-out the paper-based questionnaire which was placed on the desk next to them (flipped).

The self-assessment questionnaire was designed to be carried out privately on paper during a 1-minute awareness break (halfway through the argumentation phase). It included four Likert-scale questions (5-point) on evaluating one's own coordination and collaboration efforts compared to other group members and assessing one's own performance in the role and one's own participation rate in the discussion without comparing to others. In that way, students could identify their weaknesses and strengths and consider making changes for improving themselves in the course of collaboration. An edited version of the same questionnaire (questions in past tense) was distributed at the end of the argumentative phase of collaboration and served as an instrument for comparing the levels of awareness between the two time points within the group.

4.1.1.3. Basic instructional design.

The basis of the instructional design, namely the problem-based learning units in the form of ill-structured problem cases as an instructional method was kept intact. The topic of "Gamification and Motivation in Learning Management Systems" was chosen among the problem-cases from the first study as the most appealing to non-experts on theories multimedia learning. The problem case was also combined with a new theory text with additional information for facilitating the understanding of the topic outside of the framework of masters' class on "Multimedia-Based Learning Environments". Learning to argue was again the learning objective of the scripts and for this purpose, we introduced students to the basic elements of an argument according to the Toulmin model for argumentation (Toulmin, 2003) using a shorter version of the material from the training session of the first study (video format). The Rationale argument mapping tool was employed again for supporting the visualization of the arguments due to the positive feedback from the users in the first study and its compatibility with the Toulmin argument model. The introduction video included short theory definitions (narrative and text) for the ontology parts of the Toulmin argument model (i.e. contentions, reasons) based on worked examples of argument maps as well as examples of the argument mapping visual conventions for constructing and modifying a map as well as for communicating its contents efficiently (van Gelder, 2013) in Rationale (e.g., "Rabbit Rule"). As a way of practicing the newly introduced rules for argument construction in Rationale we created an argument map with missing arguments where students needed to fill in the empty boxes of the map with the

provided missing arguments to complete the argument map, as well as to name the ontology type of the arguments (e.g., first box is a contention).

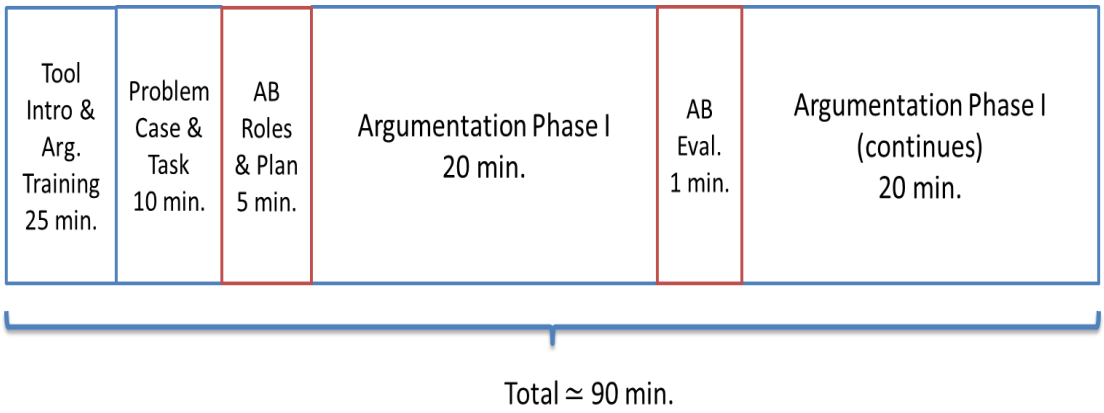


Figure 4.2. The instructional design of "role-based awareness-oriented argumentation script".

With respect to further support for the content space of collaboration in the script, we have preserved the argument scaffold in the form of open answer questions for the map. The open answer question was used here, as in the first study, for initiating the discussion on the problem case and creating a contention. The argument scaffold in the form of sentence openers with parts of the ontology (e.g., "Animation is more effective…because…for example") that was included on the script cards of the awareness-oriented argumentation scripts were omitted due to the low appreciation from the users and the lack of proof of use as sentence templates (Kim & Lee, 2003), or for note taking during the discussion on the arguments. The new script included only one argument script card with one task in the form of an open answer question and information for the assigned task (figure 4.3.), which introduced one 40 minutes long argumentation phase for arguing to solve the ill-structured problem and constructing the argument map. Finally, regarding the script support for the relational space of collaboration, we made changes in the format and the use of the awareness breaks and the awareness prompts from the first study. The regular breaks from collaborative argumentation for regulating collaboration with a plan-making prompt (figure 4.6.) and the role-assignment prompt (figure 4.4.) were now combined in the new script. The awareness breaks for regulating collaboration came (role-assignment and plan making) after the announcement of the task and the contents of the cards were now adjusted according to the feedback from the feedback survey. The role

assignment was then enabled with the help of a drop-down menu (browser-based) on the private screen (laptop) of each student (figure 4.5.).

In summary, the instructional design of the script for role-based collaborative argumentation a.k.a. “Role-based Awareness-Oriented Argumentation Script” included the following parts (figure 4.2.). First, came the familiarization phase with the instructional setting and the tool functionalities, as well as with the argumentation theories and a practice slot with the Rationale argument mapping tool. Next, a 10-minute time slot for reading up on the problem case and the theory text (on paper) and the actual task for argumentation from (on argument script card) (figure 4.2). Following, an awareness break for regulation (role assignment and plan making script cards) was carried out. Consequently, a 40-minute long argumentation phase was launched with the use of the argumentation script card (4.3.) which was interrupted by one-minute awareness break for filling out a self-assessment questionnaire.

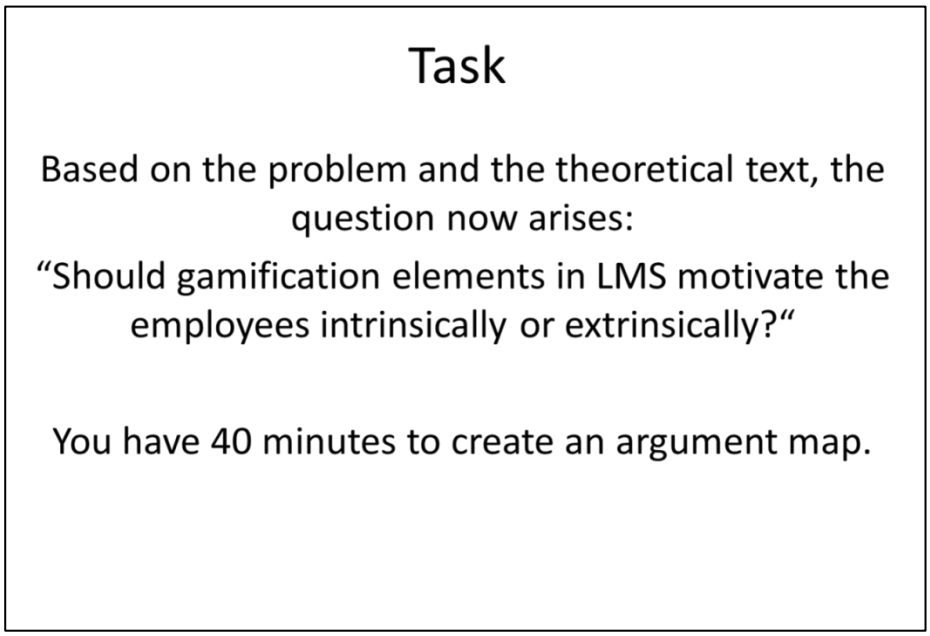


Figure 4.3. Argumentation script card with an open answer reasoning questions and time information on the shared big screen.

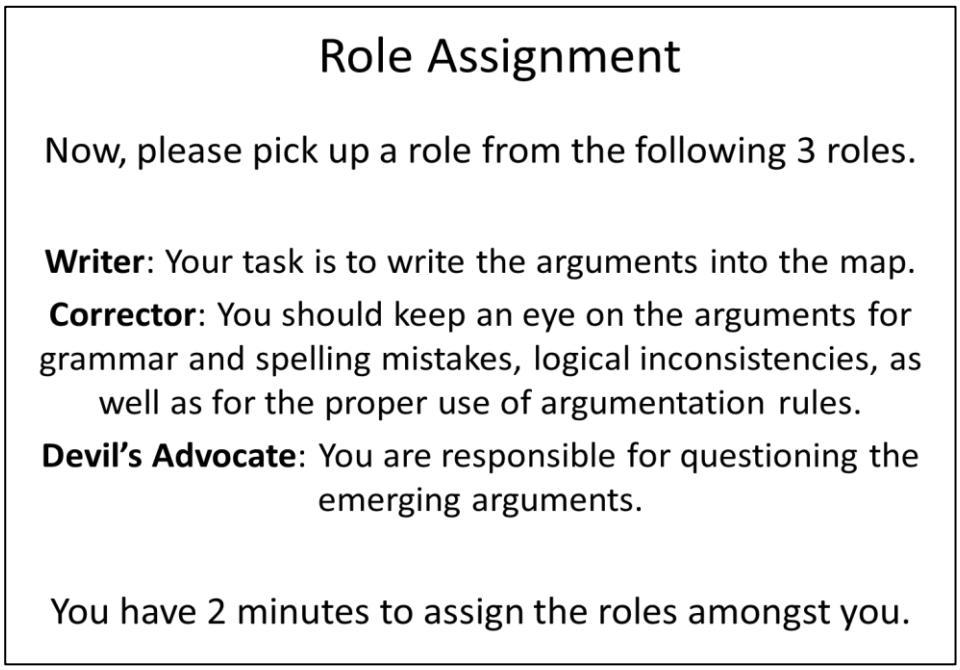


Figure 4.4. Awareness script card with an open answer reasoning questions and time information on the shared big screen.

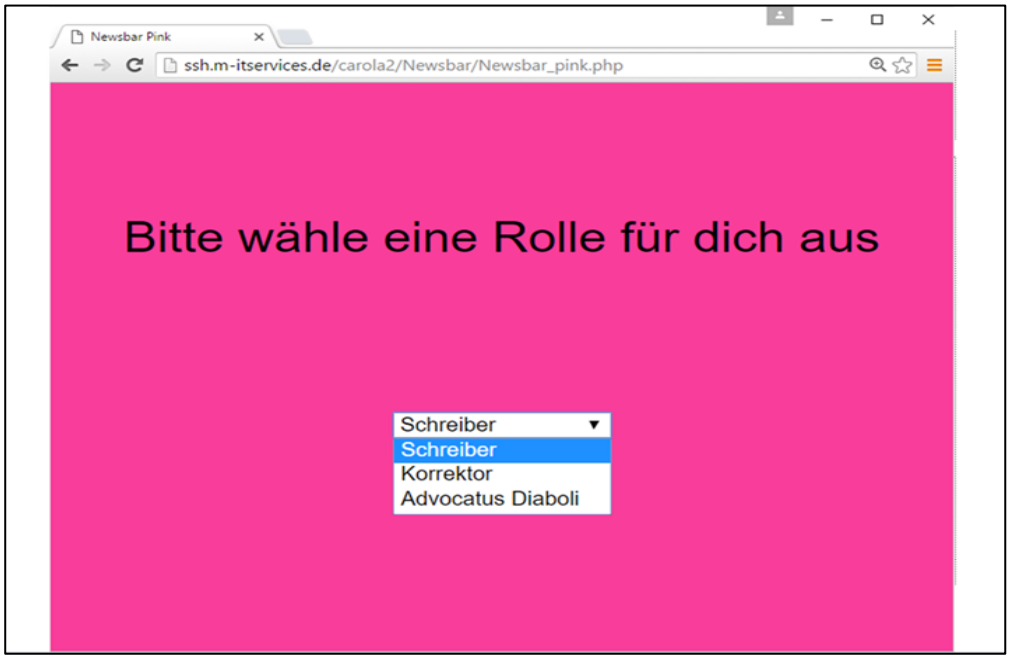


Figure 4.5. Drop-down menu for role-assignment in the original language of the study materials (Schreiber: Writer, Korrektor: Corrector, Advocatus Diaboli: Devil's Advocate).

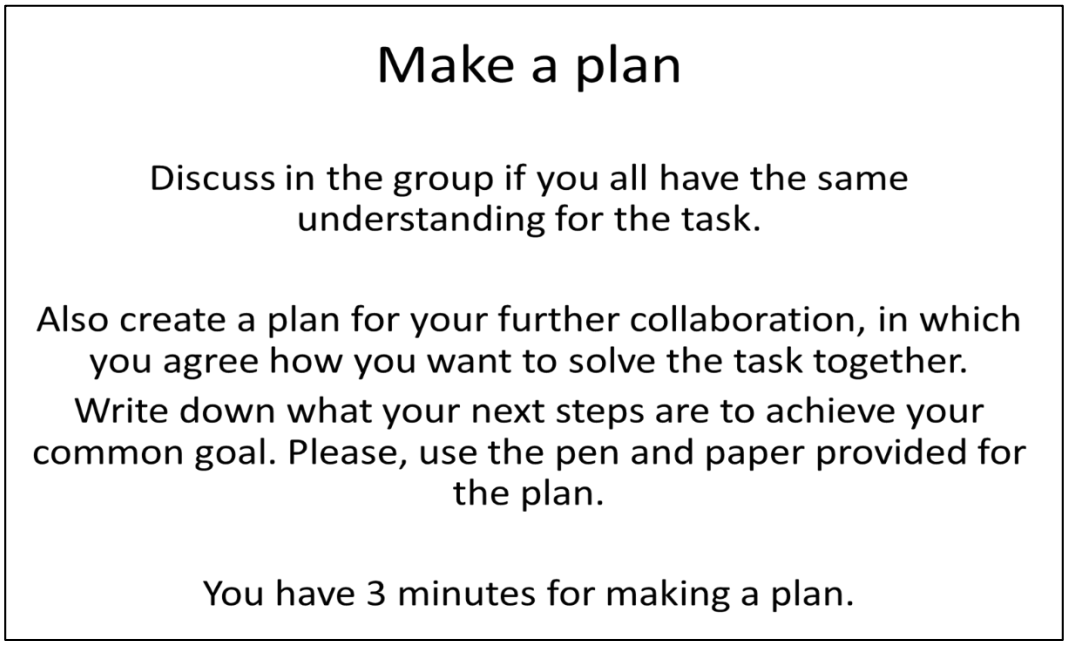


Figure 4.6. Awareness script card with an open answer reasoning questions and time information on the shared big screen.

4.1.2. Role-based awareness visualization.

Group mirror visualizations (aka Group Mirrors) can help regulate collaboration processes a) by mirroring and reflecting implicitly collected data about the collaboration (i.e. speaking rates) b) by providing hints for diagnosing any interaction problems in a metacognitive fashion, and c) by proposing remedial actions to help the learners and even by directly intervening to moderate the group ‘s interaction (Soller, Martinez, Jermann & Muehlenbrock, 2005). Moreover, group mirror visualizations are linked to higher participation rates in learning activities as they help generate a positive impact on the development of group awareness which, in turn, improves the results of learning in collaborative tasks (Chavez &Romero, 2012). Empirical evidence on the design of group awareness visualization tools (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Jermann & Dillenburg, 2008) support the notion that awareness visualization tools can make it easier to collect and interpret complex information with the help of external representations of group-related concepts (i.e. participation rates, number of ideas etc.).

Group Mirror tools often go beyond the simple gathering and reflecting on data about the students’ interactions or performances (i.e., mirroring tools). They afford monitoring the data and collecting relevant information implicitly i.e., generate awareness information

automatically without requiring dedicated learner activities (Buder, 2011). Moreover, they afford diverse types of information visualization (heat map, diagrams etc.), and some indicators for comparing this information to pre-defined standards for ideal collaboration. It is then up to the students or the instructor to interpret the visualized information and decide what actions (if any) to take (Jermann, Soller, Muehlenbrock, 2001). In that sense, Group Mirrors can only be used for guiding collaboration indirectly by exposing students to the collected data (individual and collective) and allowing for systematic reflection on these data.

In line with the empirical evidence, we have employed and adjusted the group mirror tool by Tausch et al. (2016) for visualizing participation per person in their role (writer, corrector, devil's advocate) and per group in our CSCL setting for argumentation. In this respect, we provide students with visualizations of their own behavior and its impact on the group progress and examine if these affect their performance in the role (role-specific behaviors and argument contributions pro role) by increasing students' awareness of their own behavior. The combination of a Group Mirror tool for monitoring participation with self-assessment questionnaires for reflecting on participation aims at balancing the advantages and disadvantages of implicit and explicit feedback for coordination collaboration (Buder, 2011).

The study by Tausch et al., (2016) with the Group Mirror tool indicated that a combination of individual and group performance visualizations leads to increased ideation rates and more balanced participation as opposed to a competitive (only individual performance visualizations or a cooperative visualization (only group performance visualization) in a brainstorming session. The Group Mirror is used here as role-based awareness visualization. Thereby, the individual and group performance visualization affordances of the original tool are used here as to facilitate the dynamic visualization of participation per person in their role (writer, corrector, devil's advocate) and per group based on pre-defined criteria for what counts as role-specific behavior. These criteria were inferred from the description of the role that was made available to the students at the beginning of the session, and they were explained to students along with the functionality of the group mirror at the beginning of the session for collaborative argumentation. More specifically, the writer was responsible for formulating the arguments and transferring them into the argument map, while the corrector looked for spelling mistakes and the correct application of argumentation rules, and finally, the devil's advocate processed critically all arguments and created counter-arguments and rebuttals.

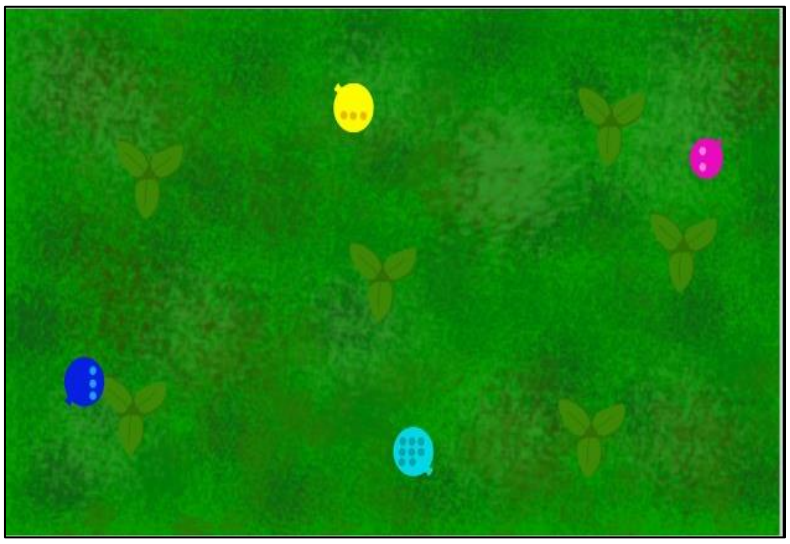


Figure 4.7. Role-based awareness visualization with balloon metaphor. Blue: writer, yellow: corrector, pink: devil's advocate, light blue: group performance.

The design of the role-based awareness visualization is based on the idea of mixed reward structures (Rosenbaum et al., 1980) for increasing group productivity and utilizes a balloon metaphor displayed against a green field, with an assorted color of balloon for every student based on their role (blue: writer, yellow: corrector, pink: devil's advocate) (figure 4.7.). Every time a student behaves according to their role (for more than 30 seconds of related behavior or talk), a small dot appears inside his or her balloon and at the same time inside the big balloon for the group performance (light blue balloon), encouraging thus the recurrence of these role-specific behaviors and giving the feeling of contributing to the group performance. The group mirror provides implicit and qualitative feedback as not every contribution is accounted for increasing the participation rates, but only the role-specific behaviors were rewarded with a dot. Role-specific behaviors are computed by classifying the actions and contributions of users in the discussion as such based on a scheme (table 4.2.). Moreover, the use of metaphoric visualizations is shown to promote faster behavioral adaptation and is preferred by group members over diagrammatic feedback (Streng, et al., 2009). The group mirror was displayed on a large display on the wall, as large displays have been proven to be less disruptive for collaboration than a table display (Streng et al., 2009). The prototype was implemented in the languages Javascript and PHP and run using Firefox on a Windows 10 operating system. The implementation was carried out by Mrs. Meier, a master student in Media Informatics LMU in terms of her master thesis (Meier, 2017). It was operated by the

experimenter on her computer, which was connected to the shared display on the wall (figure 4.8, number 5). For adding a dot inside the balloon, the experimenter had to tap on a button next to the corresponding balloon in the administrator's window on the private display of the experiments' personal computer and then the group could see the changes on the shared wall display.

4.1.3. Role-based awareness reminders.

Notification systems are used for delivering "current, important information to users in an efficient and effective manner without causing an unwanted distraction to ongoing tasks." (McCrickard, Czerwinski, & Bartram, 2003, p. 510). Notification systems have been employed in CSCL research for supporting self-regulation of students by raising awareness of presence, tasks and actions of collaborators, as well as for supporting teachers' feedback provision by raising awareness of students' achievements and weaknesses (Carroll, et al.,2002; Martinez-Maldonado, Clayphan, Yacef, & Kay, 2014). Here, we explore the potential of a low-fidelity prototype of a notification system with smartwatches for regulating the interactions in the group by acting as coaching system (Jermann, Soller, & Muehlenbrock, 2005). Guiding tools (aka advising or coaching systems) build upon the awareness information for comparing current mental shared mental models to ideal ones from mirroring or monitoring systems and extend it by offering direct advice to increase effectiveness of the collaboration process in the same way a teacher would act in a collaborative learning classroom (Jermann, Soller, & Muehlenbrock, 2001). Thereby, the aim is to increase the effectiveness of the learning process, similar to the way a teacher would intervene for guiding collaboration in a collaborative learning classroom.

In this study, the awareness notification system was used as a guiding system, which offers advice based on an interpretation of the progress of the students as depicted in the role-based awareness visualization. This notification system was used for sending awareness reminders (i.e. text-based notifications) via smartwatches for balancing their participation. The notifications alerted the students via sound (different per role) and vibration (felt on their wrist), that they had received a text message on their smartwatches with a reminder for regulating aspects of their collaboration. The text messages included the phrases or "Your balloon is not getting any bigger" or "Try to keep in your role, please" (in German) and were sent when the students were either inactive for longer than 5 minutes or behaving out of their role or when a group member was taking over the duties of their role more than once respectively. The aim

was to trigger more active and balanced participation in terms of their role, prevent an overlap of roles or any free-riding or social loafing phenomena from taking place (Cottrell, 1972), and thus ensure a smoother collaboration process.

The use of the notification system aimed at enhancing provision of behavioral awareness information from the role-based awareness visualization, since the notifications were directing the attention to the group mirror where the student could compare his balloon to the ones of his group mates and have an overview of his contribution the collaborative outcome. In doing so, we wanted to promote positive interdependence as well as the individual and group accountability of the students by high-lightening the importance of equal contributions for achieving the (open-end) goal of successful collaboration through adhering to the role-specific tasks and as represented by the balloon with the accumulated points of all students (Kirschner et al., 2015). The messages were sent from the facilitator's Android smartphone to the smartwatches of the participants via the free messaging application WhatsApp®. This was an attempt to mock-up the functions of push notification technologies (Latif, Hassan & Hasan, 2008). Push technology is known for raising high awareness of updates and its ability to trigger prompter responds to them (Sirisaengtaksin & Olfman, 2014). The WhatsApp® messenger app was preinstalled in three Android smartphones which were connected to the smartwatches via Bluetooth (figure 8 for connection). The implementation of the prototype was carried out by Mrs. Meier, a master student in Media Informatics LMU in terms of her master thesis (Meier, 2017).

4.1.4. Multiple Displays and Devices in Argue(a)ware

For facilitating collaborative argumentation in the two prototypes of Argue(a)ware, we employed a combination of private and shared graphical displays in a small classroom at the Media Informatics department at LMU (figure 4.7.).

For the basic Argue(a)ware prototype (used in the Basic Awareness Condition), we decided to employ a wall- mounted display (LG 65UF8609, 4K/UHD resolution), as a shared visual reference point which encompassed multiple collaborative functionalities. On the one hand, it hosted the role-based awareness visualization with the balloon metaphor for visualizing the participation per role and the impact on the group progress (joint balloon) (n. 14) at the upper right corner (1/4 of the screen). On the other hand, it was used for coordinating the collaboration by displaying the script information through the argument and awareness script

cards on the upper left corner of the screen as well as the problem case script card on the lower left corner (constant display) and a count-down timer for the duration of each phase of the collaboration on the lower right part of the screen. Moreover, the display was used for displaying an introductory video on the use of the several elements of the system (i.e., large-split screen, Rationale mapping tool, argument, and awareness script cards etc.) and the argumentation theories at the beginning of the session. The various parts of the split screen were controlled by the facilitators via two laptops (WLAN connection to the screen and between them). As observed in Figure 4.8., one laptop was used for controlling the shared display parts through mirroring its contents (n.4) and another one was used for controlling the role-based awareness visualization (group mirror) through a web-based server application (n.5). One personal computer was placed in front of each student in (n.1, n.2, n.3). Their laptops were connected via WLAN connection to one another and the TeamViewer® application was used for creating a shared workspace for working on the argumentation map to solve the ill-structured problem. Each student could edit the contents of the map, but the writer was mainly responsible for transferring the arguments into the map and therefore he was equipped with an additional mouse pointer device for increased sufficiency in interacting with the Rationale® argument mapping application (Web-based application). The Rationale® tool was mirrored in the screens of the three students from the third facilitator's laptop (n.6).

In the enhanced Argue(a)ware prototype (used in the Enhanced Awareness Condition), we provided each of the students with a smartwatch (two "Moto 360" smartwatches and an "ASUS ZEN" smartwatch) (n.11, n.12, n.13) which were connected via Bluetooth to a different smartphone each (three "LG Google Nexus 5" smartphones) (n7, n.8, n9). The smartwatches and the smartphones were labeled with matching role label (appendix I). Students were instructed to wear the smartwatch on their wrist and were informed that they will be receiving messages from the system during the collaboration and that they will be alerted by vibration and flashing light on the smartwatch screen upon receiving the message. Each of the smartphones was connected via WLAN to another smartphone, from which the text-based awareness reminders were sent via WhatsApp p®, an instant messaging application (also pre-installed on participants' smartphones and smartwatches).

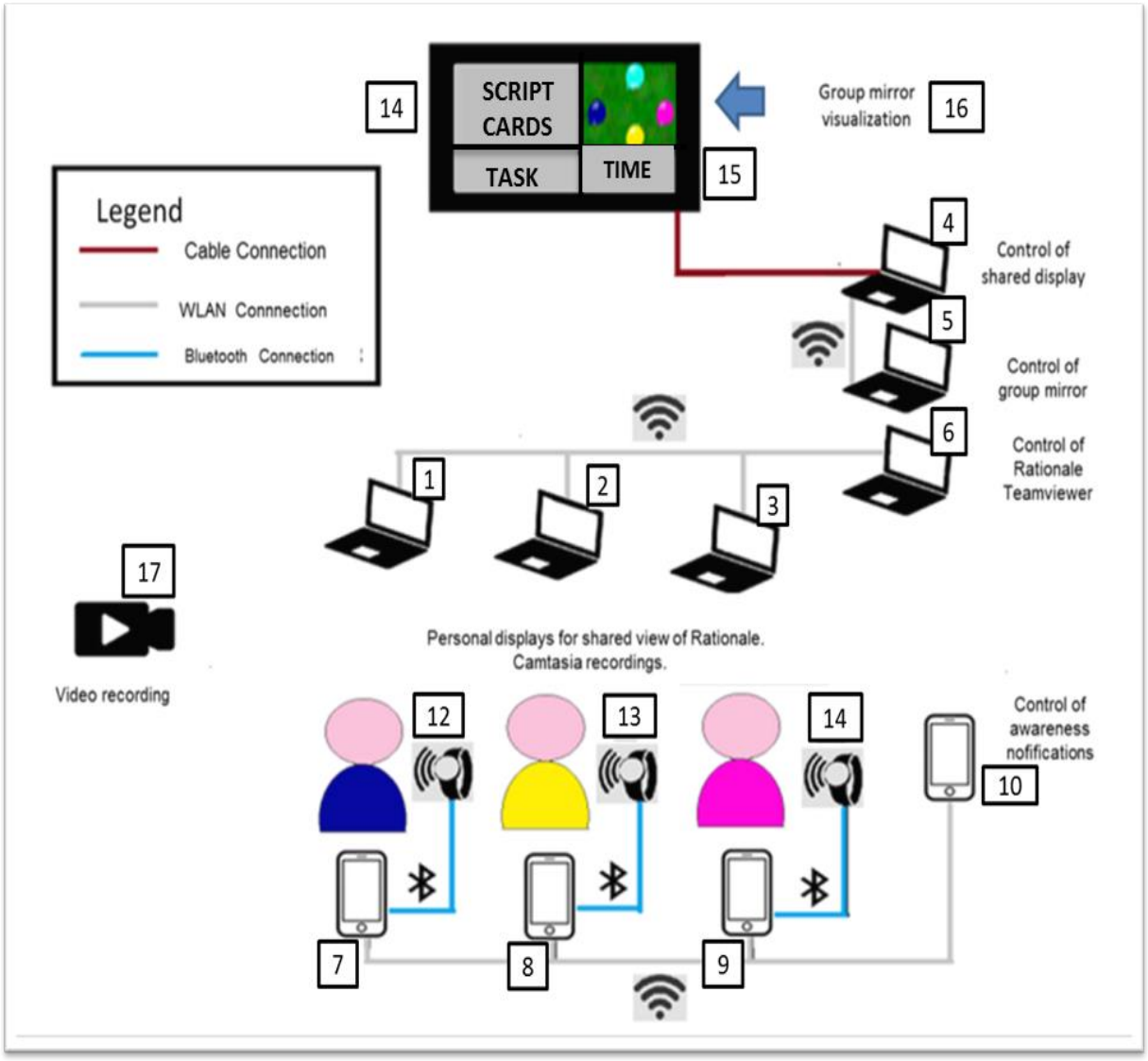


Figure 4.8. Argue(a)ware study setting in EAC with the use and connection of multiple displays on for facilitating the display of script and awareness-related information.

4.2. Processes

For this empirical study on the impact of the role-based awareness visualization and the awareness notification for directing active role-based participation in the collaboration processes (1 meeting for 90 min. including the training on using Rationale), ten groups of three master students from mixed academic fields each (n = 30, Mage=,22y) were tested. They could choose if they wanted to receive 15 Euro in cash or credits for their studies as a refund for their participation. Half of the groups worked only with the group mirror visualization (Basic Awareness Condition-BAC) while the other half groups received additional text-based

awareness notifications via smartwatches that were sent to students privately (Enhanced Awareness Condition- EAC). Their main task was to argue for and agree on the best solution to a learning problem and then transfer their arguments into a joint argument map using the online argumentation mapping tool Rationale. Next, to that, students should monitor their progress in their role with the role-based awareness visualization and the self-assessment questionnaire.

At the beginning of the study, students were introduced to the basic use of the argument mapping tool Rationale, as well as to the role of group mirror on the large wall display and the use of smartwatches (in EAC only) via an explanatory video. Following, they practiced the use of the argument mapping tool on their personal computers that were linked to each other with the help of the free online desktop sharing software TeamViewer®. In the next step, they had to take up their roles for the collaboration as writer, corrector and devil's advocate. At this point, they were informed about the duties of their role and the link to the colorful balloons in the group mirror that helped them monitor their own progress and their contribution to the group.

The problem case and the task description were displayed at the left part of the wall display, while the role-based awareness visualization was displayed at the upper right part of the display and a countdown timer for each task was displayed at the lower right part of the display (figure 4.8). Every time a new task was introduced on the display or one minute before the assigned time for every task was due a different sound signal was issued to attract students' attention to the large display.

During the study, one experimenter was responsible for observing the discussion and attributing points for role-specific behaviors on the role-based visualization and sending out messages to participants' smartphones (EAC only), while the other experimenter was taking notes and making sure the system was running smoothly (observation diaries). Additionally, the study was video-and audio-recorded. One video camera was positioned at the back of the group, for recording their interactions and the changes in the large wall display, while the voices and the personal screens were recorded with help of the Camtasia® Recorder software. The number of role-specific contributions was logged together with a time stamp and the ID of the person. At the end of the argumentation phase, three pen-and-paper questionnaires were handed out to gather information a) on the usefulness of both the group mirror and the awareness reminders, b) on the perceived awareness (edited self- assessment questionnaire) and c) on their perceived team effectiveness (edited TE questionnaire by Fransen et al. 2011).

Table 4.2.

Scheme for Direct Attribution of Points for Role-Specific Behaviors (Rsb) (with Time Restriction) and for Coding Rsb in The Qualitative Content Analysis (Without Time Restriction).

Role	Tasks	Description	Examples
Devil's Advocate	Doubting the arguments/creating counter-arguments	Doubting/contradicting the argument of another group member	"Yes, but ..."
			„On the other hand ...“
			"I do not think so"
		Doubting/contradicting his/her own arguments	
Corrector	Verification of the spelling, semantics, and grammar of the written arguments	Making changes/suggesting changes to the arguments	"This box must be one level higher"
			„This is written with an h“
	Check whether the Rational tool was used correctly	Pointing out logical inconsistences and mistakes in the application of rules	"This is more of a counter-argument"

Writer	Writing down the joint arguments	Writing the plan on paper	Hand-writing of plan
		Inserting new boxes/editing boxes in Rational	Typing the new arguments into Rationale

4.2.1. Analytical Approach

The study follows a mixed method design approach. More specifically, we follow the embedded mixed methods research design (Creswell et al., 2003) where quantitative data and qualitative data are collected and analyzed for answering complementary questions on the outcomes and the processes of the two interventions.

In this study we address the following questions and corresponding hypotheses:

RQ1. What is the impact of different degrees of role-based awareness scaffolding (basic vs. enhanced) on the awareness of performance in the role in both conditions?

H1. We hypothesize that **a)** the self-reported values of awareness in Intermediate Self-Assessment (ISA) and in Final Self-Assessment (FSA) will be higher in the Enhanced Awareness Condition (EAC) than in Basic Awareness Condition (BAC), and **b)** that the self-reported values of awareness between ISA and FSA measurements will increase more within EAC than within BAC thanks to the private reminders for behavioral adaptation, which build upon the awareness visualization to increase the awareness of individual behaviors and guide individuals to engage more in collaboration.

RQ2. What is the impact of different degrees of role-based awareness scaffolding (basic vs. enhanced) on self- perceived team effectiveness in both conditions?

H2. We hypothesize that the self-reported values for **a)** Shared mental models" **b)** "Mutual Performance Monitoring" and **c)** Team Effectiveness will be higher in EAC condition as a side effect of the private reminders for behavioral adaptation, which are issued to students based on their progress in the role as visualized by the role-based

awareness visualization, thereby redirecting the focus on monitoring their own performance with respect to the group performance (Mutual Performance Monitoring) and keeping up with working plan (Shared mental models) for achieving the best possible result (Team Effectiveness).

RQ3. What is the impact of different degrees of role-based awareness scaffolding (basic vs. enhanced) on group performance in both conditions?

H3. We hypothesize that **a)** the Formal Completeness and **b)** the Evidence Sufficiency of arguments in EAC will be higher thanks to the additional reminders for keeping in the role and thereby taking care of the format, the contents (corrector) and the validity of arguments (Devil's Advocate) and their prompt transfer into the argument map (writer).

RQ4. How did the different degrees of role-based awareness scaffolding affect **a)** active participation (i.e., role-specific behaviors and argument contributions) and **b)** how was this related to the group performance and the role performance in the most and least successful groups of both conditions?

RQ5. What was the experience with the different media for facilitating the different awareness scaffolding elements in both conditions?

For answering RQ1, we collected quantitative data on awareness from the self-assessment questionnaires with four questions about awareness of Performance in Role, Contribution in Collaboration, Contribution in Coordination and Participation levels. The questionnaires were distributed at two different time points of the intervention i.e., once as an intermediate self-assessment (ISA) and the second as final self-assessment (FSA) in both conditions. Given the small sample size of the study, an analysis was carried out with two independent-samples t-tests to test for differences in participants' awareness levels in the repeated measurements (ISA and FSA) between conditions (BAC and EAC) and two paired-samples t-tests to test for differences within conditions.

Data on the second question (RQ2) were collected with the help of an adjusted version of an TE questionnaire by Fransen et al., (2011) and were analyzed with multiple independent-samples t-tests with respect to the relevant dimensions of team effectiveness i.e., "Shared mental models" (SMM), "Mutual Performance Monitoring" (MPM) and "Team Effectiveness" (TE). The "Mutual Trust" dimension was measured but was not included in the final analysis,

because the development of mutual trust accurately requires more than one session for collaboration according to the creators of the questionnaire measuring (Fransen et al., 2011). Next, for answering the third question (RQ3) the data from the argument maps were quantified with the use of a previously validated coding scheme and two independent-samples t-test for differences between conditions were run with respect to formal correctness (FC) and evidence sufficiency (ES) criteria.

For gaining deeper insights into how the different awareness scaffolds affect the performance of the group, we investigated the video data from the sessions of the most and least successful groups from each condition. Thereby, we coded the role-specific behaviors and argumentative contributions of participants with the use of two different coding schemes. Following, we compared the groups with respect to their engagement in role-specific behaviors (RSB) and engagement in the argumentative discourse (ARG) pro role (RQ4a and 4b) by means of descriptive analyses and case-ordered matrixes. Finally, the user experience related question (RQ5) is answered based on the descriptive analysis of both quantitative data (5-Point Likert-scale questions) and qualitative data (short-answer questions) from the final user experience survey, as well as based on the remarks of the study facilitators from the observation diary.

4.3. Results

In this section, we present the results of the analyses categorized by questions and hypotheses. All statistical tests were run with the help of the statistical software package “SPSS 24.0” while the quantitative content analysis was realized with the help of the mixed methods software package “MAXQDA analytics pro”.

RQ1: With respect to H1a and H1b, we collected quantitative data on awareness from the self-assessment questionnaires. A mean of the answers to questions about awareness of Performance in Role, Contribution in Collaboration, Contribution in Coordination and Participation levels which were distributed at two different time points of the intervention i.e., once as an intermediate self-assessment (ISA) and the second as final self-assessment (FSA) in both conditions. Due to small sample sizes, two independent-samples t-tests were carried out to test for differences in groups’ awareness levels in the repeated measurements (ISA and FSA) between conditions (BAC and EAC) (H1a).

Table 4.3.

Independent-Samples T-Test of Grouped Data from ISA and FSA between BAC and EAC

	Conditions								
	BAC			EAC					
Measurement Points	M	SD	n	M	SD	n	t	df	p
ISA	3.46	.581	15	3.18	.578	15	1.338	14	.192
FSA	3.51	.847	15	3.41	.631	15	.366	14	.717

* $p < .1$

The self-reported awareness values for the ISA measurement point (table 4.3.), did not differ significantly between the two conditions of BAC (M= 3.4, SD=.581), and EAC (M= 3.2, SD=.578), $t(14) = 1.33$, $p = .19$, $d = 0.48$. The self-reported awareness values for the FSA measurement point, did not differ significantly between the two conditions of BAC (M= 3.5, SD=.847), and EAC (M= 3.4, SD=.631), $t(14) = 0.366$, $p = .717$, $d = 0.13$. Therefore, we cannot reject the null hypothesis and cannot accept the alternative hypothesis (H1a) that students in EAC who received additional reminders (EAC) will report higher awareness values in their intermediate and the final self-assessment compared to students in BAC who didn't receive any additional guidance support through awareness reminders.

Table 4.4.

Paired-Samples T-Test of Grouped Data from ISA and FSA within BAC and EAC

	Measurement Points									
	ISA		FSA			95% CI for Mean Difference				
Conditions	M	SD	M	SD	n		r	t	df	p
BAC	3.46	.581	3.51	.578	15	-0.28, 0.18	.889	-.456	14	.655
EAC	3.18	.847	3.41	.631	15	-0.45, 0.14	.790	-2.288	14	.038*

* $p < .1$.

Moreover, two paired-samples t-tests were conducted (table 4.4.) to determine whether there were statistically significant mean changes between the self-reported awareness values at the two measurement points (ISA) for groups in BAC and EAC respectively (H1b). Regarding the BAC, although the self-reported awareness values were higher in case of FSA (M= 3.5, SD=.578) compared to the ISA (M= 3.4, SD=.581), this change did not prove to be significant, $t(14) = -456$, $p = .65$, $d = 0.08$. Regarding the EAC, the change of self-reported awareness values was significantly higher in FSA (M=3.4, SD=.631) compared to the ISA (M= 3.2, SD=.847), $t(14) = -2.28$, $p = .04$, $d = 0.3$. Therefore, we can reject the null hypothesis and can accept the alternative hypothesis (H1b) that the students' self-reported values of awareness between ISA and FSA measurements will increase more within EAC where students received additional guidance support through the personal awareness reminders (EAC) than in BAC than in BAC where students didn't receive any additional awareness reminders.

RQ2: In this study, we investigated the perceived team effectiveness in the collaboration in the groups in both conditions using an adjusted version of the standardized questionnaire of Fransen et al. (2011). With regard to the H2. a hypothesis, we run an independent-samples t-test for determining if there were differences in self-reported values for Shared Mental Models between the BAC and the EAC. The self-reported values for Shared

Mental Models were found to be higher in the EAC groups (M = 2.42, SD = 0.70, n=15) than in BAC (M = 2.17, SD = 0.72, n=15), a statistically non-significant difference, M =2.17, SD = 0.72, 95% CI [-0.78, 0.28], t(28) = -0.971, p = .340,d= .35. The mean difference was not statistically significantly different from zero. Therefore, we cannot reject the null hypothesis and cannot accept the alternative hypothesis that students who received personal additional reminders will experience higher "Shared mental models" than the ones who didn't receive any additional awareness reminders.

Another independent-samples t-test was run for determining if there were differences in self-reported values for Mutual Performance Monitoring between the BAC and the EAC (H2.b). The self-reported values for Mutual Performance Monitoring were found to be higher in the EAC groups (M = 2.68, SD = 0.73, n=15) than in BAC (M = 2.60, SD = 0.53, n=15),a statistically non-significant difference, M =, 95% CI [-0.55, 0.39], t(28) = -0.342, p = .735, d= .12. The mean difference was not statistically significantly different from zero. Therefore, we cannot reject the null hypothesis and cannot accept the alternative hypothesis that the Role-based Awareness Visualization leads to higher Mutual Performance Monitoring.

An independent-samples t-test was run for determining if there were differences in self-reported values for "Team Effectiveness" between the BAC and the EAC. The self-reported values for "Team Effectiveness" were found to be higher in the EAC groups (M = 2.69, SD = 0.92, n=15) than in BAC (M = 1.92, SD = 0.83, n=15), a statistically significant difference, M =, 95% CI [-1.44, -0.09], t(27) = -2.318, p = .028, d=.87 The mean difference was statistically significantly different from zero. Therefore, we can reject the null hypothesis and accept the alternative hypothesis that the combination of the role-based awareness visualization and role-based awareness reminders leads to higher perceived Team Effectiveness.

RQ3: Next, we investigated the impact of different awareness scaffolding elements (role-based awareness visualization vs role-based awareness visualization and role-based awareness reminders) on group performance in both conditions? We hypothesized that group performance both in terms of Formal Completeness (H3.1.) and of Evidence Sufficiency (H3.2) in EAC will be higher thanks to the additional help for performing in the role from the Awareness Visualization and Awareness Reminders.

To measure the quality of group performance based on the argument maps of the group of both conditions, we looked into two aspects of arguing with an argument mapping tool that was explained and trained in the training session prior to the sessions for collaborative

argumentation. The first aspect was about the Formal Correctness (FC) of ontology elements with respect to the conventions of argument mapping with Rationale. The second aspect examined the sufficiency of the evidence used for supporting reasons and counter-arguments in the maps based on their connection to the theory and/or relevant scientific sources or personal experiences. We used a previously validated coding scheme that was informed from the model solution to the particular problem case used in this study.

Two independent-samples t-tests were run to determine if there were differences in group performance (argument maps) between the BAC and the EAC both in terms of Formal Correctness (FC) and in Evidence Sufficiency (ES). Regarding the Formal Correctness of arguments, there was no statistically significant difference between the BAC (M = 52.4, SD = 15.4, n=5) a EAC (M = 48.4, SD = 8.79 ,n=5), M =, 95% CI [-14.35, 22.35], t(8) = 0.503, p = .629, d=.32. Therefore, we cannot reject the null hypothesis and cannot accept the alternative hypothesis H3a. Regarding the Evidence Sufficiency of arguments, no significant difference was found between the BAC (M = 7.8, SD = 1.30, n=5) and the EAC (M = 6.2, SD = 2.77, n=5), , M =, 95% CI [-1.56, 4.76], t(8) = 1.167, p = .277, d=.14. Therefore, we cannot reject the null hypothesis and cannot accept the alternative hypothesis H3b.

RQ4: For understanding how the different awareness scaffolding elements for monitoring and guiding collaborative argumentation (BAC vs. SAC) influence the active participation in collaborative argumentation, we defined two aspects of active participation relevant to collaborative argumentation i.e., engagement in role-specific behaviors (RSB) and engagement in meaningful argumentative discussion (ARG) pro role. Two different coding schemes were developed for RSB and ARG instances in each role. Instances of RSB were identified based on the same criteria as the ones set for identifying and attributing points for RSB in the Role-based awareness visualization during the session (table 2). However, in this case of coding for RSB we used the complete and meaningful segments of verbal indicators of role-specific behavior pro role (without time restrictions) as well as non-verbal indicators (i.e., writing on computer) during the argument phase of the instructional design (40 min). Given the discursive nature of argumentative contributions in the videos, we identified the argument contributions pro role (ARG) based roughly on the categories of the coding scheme for the "Social modes of co-construction" dimension by Weinberger and Fischer (2006). Thereby, we recognized every new argument-related contribution (externalization), elaboration on previous arguments (elicitation) and integration or conflict-oriented contribution during the discourse in

the argument phase of the instructional design (40 min) as argument-related contribution pro role (ARG).

For comprehending better, the influence of these two components of active participation on the group performance, we discerned four extreme cases of interest i.e., the most and least successful groups in terms of group performance on their group performance scores from the BAC and the EAC. The groups G4 and G5 from the Basic Awareness Conditions were found to be the most and least successful groups respectively (henceforth BG4+ and BG5-), while groups G8 and G9 were the most and least successful groups of EAC respectively (henceforth EG8+ and EG9-).

We analyzed the videos of the four groups with quantitative content analysis and counted the instances of engagement in role i.e., RSB and ARG pro role (figure 9 and figure 10) to better understand the interplay of the components of active participation. In the next step, we looked into our field notes (observation diary) from the study (Kawulich, 2005) and into the memos which from the quantitative content analysis of the videos (Miles, Huberman & Saldana, 2014) for remarks about the collaboration processes (i.e., plan making, group dynamics) and the interaction with the different awareness scaffolds. In the case of interaction with awareness scaffolds, we focused on the remarks about the Role-based Awareness Visualization and the Role-based Awareness reminders because of their technical nature (i.e., supported by different screens and media). These remarks could help us interpret the results of the quantitative content analysis and shed light on the questions 4a and 4b respectively. We summarized the results with the help of two case-ordered matrixes (table 4.5. and table 4.6.). This display allows for systematic comparisons across roles, across conditions with respect to the performance of each group (Miles, Huberman & Saldana, 2014).

With respect to the interplay of active participation elements (i.e., role-specific behaviors and argument contributions) in each group, we see that RSB are more than ARG in the most successful cases compared to the least successful ones. We also observe that in the most successful cases the RSB and ARG ratios are more balanced than in the least successful ones (figure 4.9.). The role-based analysis pro group revealed that RSB and ARG rations pro role are more balanced in the successful groups (figure 4.10.). When combined with the remarks on collaboration processes, we realize that in the least successful groups students ignored their RSB duties because of confusion (i.e., DA in EG9-) or preferred to focus on parallel activities (i.e., Writer in BG5- and EG9-). Moreover, there seems to be a connection between ignoring the plan or applying a non-elaborated plan for collaboration and the group

performance (table 4.5.). Finally, based on the remarks on the interaction with the awareness scaffolds (table 4.6.) there were no explicit references to the role-based awareness visualization. Moreover, the awareness reminders in the EAC were only partly effective (i.e., not perceived on time, triggered short-term behavioral adaptation)

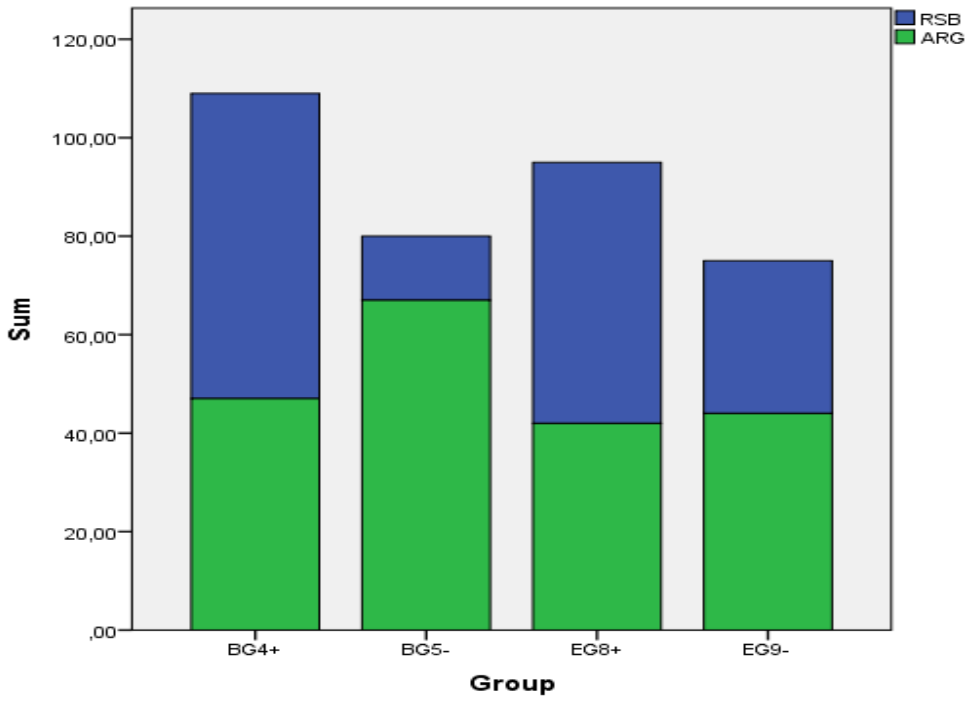


Figure 4.9. Sum of role-specific behaviors and argument contributions (i.e., active participation) of all roles pro group.

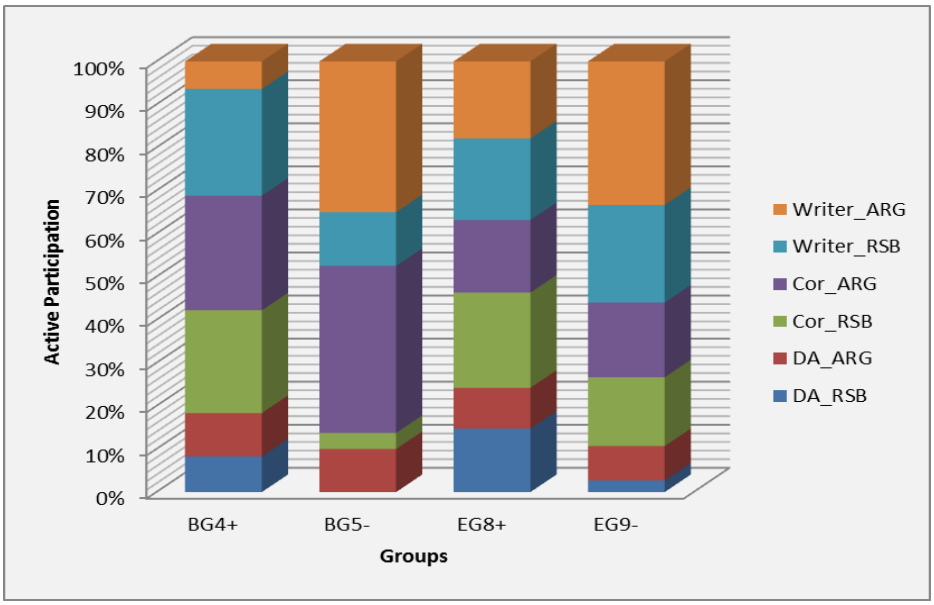


Figure 4.10. Percentages of role-specific behaviors and argument contributions (i.e., active participation) of each role pro group.

Table 4.5.

Remarks on Collaboration Processes of All Roles pro Group

	Collaboration Processes	
Extreme Cases	Prompt for Plan Making	Group Dynamics
BG4+	Ignored	W: complains about monotone role duties Equal coordination efforts
BG5-	Ignored	W: dominates discussion and coordination C: insecure about role duties DA: mostly silent
EG8+	Applied	C: complains about importance of role Equal coordination efforts Mutual control and exchange of role duties
EG9-	Applied "First create only pro arguments and then contra arguments"	C: confused about the role duties W: dominates discussion and coordination DA: mostly silent

Note. W: Writer, C: Corrector, DA: Devil`s Advocate

Table 4.6.

Remarks on Interaction with Awareness Scaffolds of All Roles pro Group

	Interaction with Awareness Scaffolds	
Extreme Cases	Role-based Awareness Visualization	Role-based Awareness reminders
BG4+	N/R	N/A
BG5-	N/R	N/A
EG8+	N/R	DA: 3 reminders to "keep in role", only one perceived→ short-term activity in role
EG9-	N/R	W & C: 1 reminder "Your balloon is not growing" each→ short-term RSB DA: 4 "keep in role" and 1 "Your balloon is not growing" reminders→ "I would like to add a counter argument"

Note. N/A: Not Applied, N/R: No references, →: Reaction

W: Writer C: Corrector, DA: Devil`s Advocate

RQ5: Finally, we analyzed the questionnaire data on students' experience with the various parts of the Argue(a)ware instructional setting. The questionnaire consisted of seven Likert scale questions (5 point-1: Exceptionally bad; 5: Exceptionally good) on the experience with the awareness scaffolds and the script elements and on multiple choice question on the influence by the ISA measurement. Furthermore, it included four short answer questions inquiring about what they liked the most and the least, the overall perceived usefulness of technology in the system, and the intention for using the system again. Students in the basic awareness condition reported higher satisfaction with the use of role-based awareness visualization than the students in the enhanced awareness condition where the awareness reminders for being more active in the participation and keeping in the role were issued via text reminders on the smartwatches (figure 4.11.).

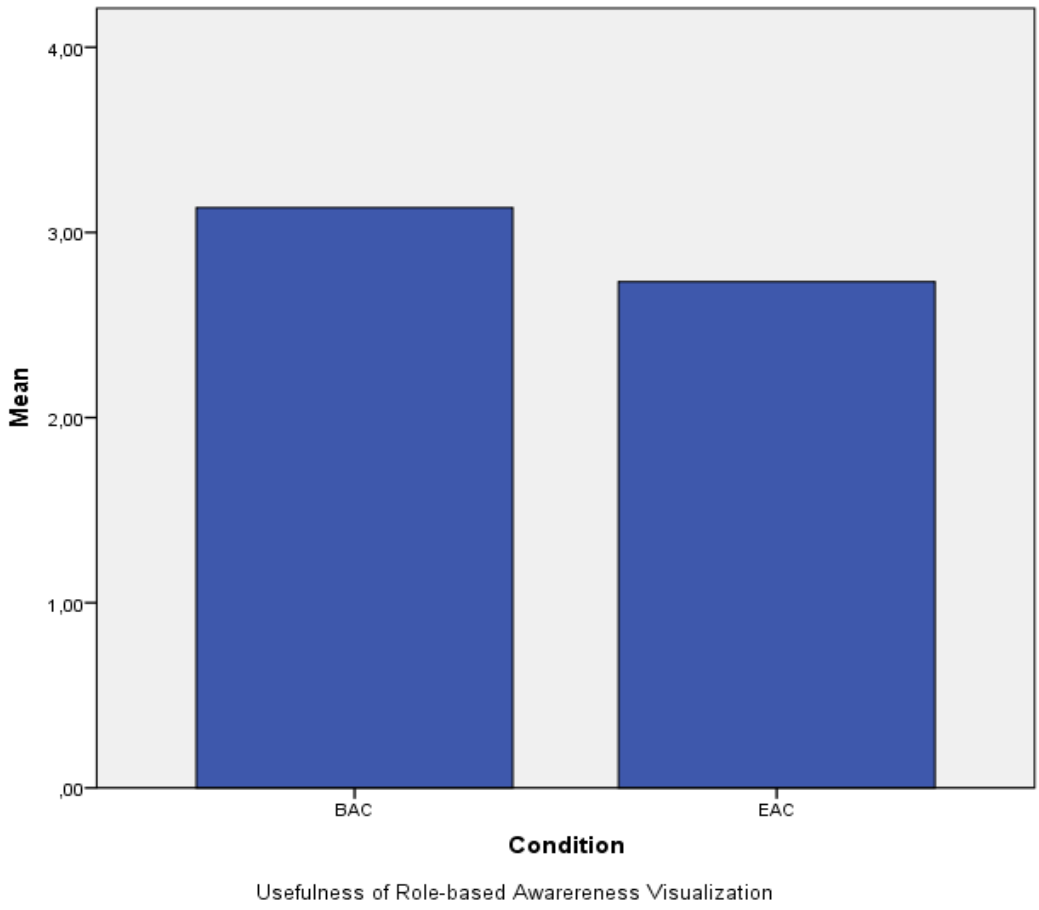


Figure 4.11. Usefulness of role-based awareness visualization in both conditions. Note. (1: Exceptionally bad; 5: Exceptionally good)

Students in the EAC also rated the use of awareness reminders as "good" with a mean of 2.7 points. However, the diary data revealed that students in the EAC condition often did not realize that they had received a notification or had ignored the notification in spite of the repeated issuing of the reminders from the experimenters. Upon reading the notification they, sometimes, looked at their balloon visualization for confirming their status, but most of the times they returned to their role or increased their participation only for a brief time. Most of awareness reminders for not behaving according to their role or participating actively in the discussion was issued to the "Devil's advocates" (total: 12), whereas the "Writers" (total: 2) and the "Controllers" (total: 3) were notified fewer times. Regarding the perceived influence of the Intermediate Self-assessment questionnaire (ISA) on awareness of role, we see that students in BAC (M= 3) perceived higher influence than the students in EAC (M= 2.8). With respect to the multiple-choice question on the perceived influence of ISA measurement on the

performance in the role, slightly more students in the EAC (n=5) experienced improvement after the ISA measurement than in the BAC (n=4), most students declared no influence of ISA on their performance and no students experienced deterioration in their performance in the role.

With respect to what they liked the most and the least about the parts of the group awareness tool, students liked the awareness break for role assignment more in the BAC (M=3) than in the EAC (M=2.5). Similarly, students appreciated the awareness break for plan making better in the BAC (M=3.2) than in the EAC (M= 2.7). The count-down timer on the big display, was equally appreciated by students in BAC (M=3.9) and EAC (M=3.8). Regarding the answers to the short-answer questions, students often referred to the role-based awareness visualization positively i.e.," through the gamification of my role, I wanted to "win" more and have a significant influence on the quality of the group outcome". One student reported that "the balloons did not reflect the performance correctly. Maybe a person talked less but the quality of his/her arguments was good". The students in the EAC condition complained about the additional input from smartwatches; "Too much input (two displays, smartwatch, group mirror, and questionnaire) to process." Furthermore, some students commented that "the role of smartwatches was incomprehensible". However, some students in the same condition found the interaction with several media including smartwatches for communicating implicit feedback to be "an interesting idea".

Particularly interesting is the case of a student, who had taken up the role of "Devil's advocate" but did not behave according to it and was inactive at parts of the discussion. She had therefore received six awareness reminders for balancing her participation (based on the observation diary data) and had gained only two points in her balloon (based on the role-based awareness visualization log files). The students, however, reported high satisfaction with the awareness notifications in the questionnaire and mentioned that she was "motivated through the smartwatches to participate more".

4.4. Discussion and Limitations

In this section, we discuss the main results of the different analyses that were conducted for addressing the five research questions and the matching hypotheses of this study.

With respect to the first research question on the impact of different degrees of role-based awareness scaffolding (basic vs. enhanced) on the awareness of performance in the role and the awareness of collaboration and coordination efforts in both conditions, we

hypothesized that the groups in the EAC where additional guidance support via personal awareness reminders was provided will exhibit higher the self-reported awareness values as measured at two different time points (intermediate self-assessment-ISA and final Self-assessment-FSA) when compared to the BAC groups, where the basic mirroring (role-based awareness visualization) and monitoring (intermediate self-assessment) where provided. This hypothesis was not warranted by the results of the multiple independent t-tests, although the means of the ISA and FSA were higher in the EAC condition. On the contrary, the second hypothesis that students' self-reported awareness values will increase between the two-time measurements within the EAC more than within the BAC was warranted by the multiple paired samples t-test. When examining the last result, we are led to believe that enhanced awareness support in the form of additional guidance through awareness reminders can boost the awareness of students' performance in the role as well as the awareness of their coordination and collaboration efforts over time by directing them back to the mirroring and monitoring tools.

However, due to the small effect size of the significant difference result and due to the contradicting nature of the results from the comparison between conditions with respect to the measurements at the two different points we need to proceed with caution in interpreting and generalizing the importance of the influence of the awareness reminders on awareness of performance in the role. Moreover, one limitation of the study that probably weakens the importance of the influence of awareness reminders on perceived awareness of performance in role and of coordination and collaboration efforts, is that Intermediate self-assessment (ISA) was used both as the monitoring tool for influencing the awareness and as measurement of the performance in role and of coordination and collaboration efforts. Further studies are needed on how the awareness reminders as guiding systems can enhance the awareness of students' performance in their role based on the information provided by the mirroring tools such as awareness visualizations. Additionally, the connection between the explicit feedback from the self-assessment tool and the implicit feedback from the monitoring tools could be strengthened by feeding this information to the awareness notification tool. The tool could then produce prompts for guiding collaboration based on this information, thereby acting as a double agent i.e., awareness information tool with guiding mechanisms.

Regarding the impact of different degrees of role-based awareness scaffolding (basic vs. enhanced) on self- perceived team effectiveness, we hypothesized that self-reported values for **a)** "Shared mental models" (SMM), **b)** "Mutual Performance Monitoring" (MPM) and **c)**

"Team Effectiveness" (TE) will be higher in EAC condition as a side effect of the awareness reminders for behavioral adaptation, which were issued to students based on their progress in the role as visualized by the role-based awareness visualization. The underlying assumption was that the reminders will direct the focus on monitoring their own performance with respect to the group performance ("Mutual Performance Monitoring") and keeping up with working plan ("Shared mental models") for achieving the best possible result ("Team Effectiveness"). However, the results of the independent t-tests on SMM and the MMP showed no significant different between groups although the mean values of the self-reported values were higher in EAC than in BAC, thereby not allowing us to warrant our hypotheses. In contrast, the independent t-test on TE between conditions confirmed our hypothesis that awareness reminders in EAC will lead to higher perceived team effectiveness.

These results could be attributed to the affordances of guiding tools (i.e., awareness reminders here) to build upon awareness information from mirroring or monitoring systems in order to assist the comparison of current shared mental models to ideal ones. (Soller, Martinez, Jermann, & Muehlenbrock, 2005). The results could mean that the basic awareness support with the role-based awareness visualization (mirroring tool) and the intermediate self-assessment (monitoring tool) had positive effects on building the shared mental models and monitoring one`s own performance. The higher mean values in the EAC with respect to SMM and MMP, could mean that basic awareness support revealed gaps or problems in building the shared mental models and performing mutual monitoring in the group and the awareness reminders in the EAC managed to address these problems by issuing prompts with direct advice for increasing self-perceived effectiveness. Further research on the effects of awareness reminders on team effectiveness with a bigger sample size is needed.

The group performance of students in BAC and EAC, which was measured based on their group outcomes, was expected to be higher in EAC both with respect to the criteria of Formal Completeness and Evidence Sufficiency of arguments in the maps. The additional awareness reminders would make sure students would keep in their role and thereby take care more actively of the format, the contents (corrector) and the validity of arguments (Devil's Advocate) and their prompt transfer into the argument map (writer). Our hypotheses were not warranted though, based on the two independent-samples t-tests which were run to determine differences in group performance (argument maps) between the BAC and the EAC both in terms of Formal Correctness (FC) and in Evidence Sufficiency (ES). These results indicate that there was no influence of awareness reminders on practicing the role-duties that would in turn

affect the group performance. However, the results could be also influenced by a number of unaccounted factors which could influence the performance of the students in each the group i.e., prior knowledge on topic, prior experience with collaborative argumentation. A further study, with more systemic control over these factors is required in the next phase of development of Argue(a)ware system.

The findings of the quantitative content analysis of the most and least successful cases (defined based on their group performance) helped us shed more light on the impact of different degrees of awareness scaffold (basic vs. advanced) on active participation elements i.e., role-specific behaviors (RSB) and argument contributions (ARG) pro role with respect to the group performance (figures 4.9 and 4.10.). Moreover, the field notes and the analysis memos helped us interpret the active participation levels with respect to collaboration processes (i.e., plan making and group dynamics) and the interaction with the technology-based awareness scaffolding elements (i.e., role-based awareness visualization and role-based awareness reminders) pro group (tables 4.5. and table 4.6.). The findings on the interplay of active participation elements in each group indicate that the awareness scaffolding elements were successful in prompting the RSB but this may have come at the cost of the ARG in the least successful groups. This indicates the need for expanding the awareness support with capabilities for diagnosing difficulties in the argument discourse that go beyond the diagnosis of difficulties in acting in the role. Addressing these difficulties in argumentative discourse may then be facilitated with the awareness reminders i.e., by sending motivational prompts for promoting participation of students in discussion or with the mirroring tool by rewarding their argument contributions in the discussion with points in separate balloons for argumentation or with the use of graphical bars on the same display.

Finally, regarding the reaction to the awareness reminders in the EAC, we observed some problems i.e., reminders were not perceived on time. Also, when perceived on time they triggered only short-term behavioral adaptation. The problems with the perception of the notification could be explained by the technical problems with the use of smartwatches i.e., reported and observed “week” vibration modus. The results could also indicate the need to study text messages and the contents of the prompts sent to students for their ability to influence the behavior of the students by adding some authority to an otherwise well-established medium for day-to-day communication purposes such as the text messages on smartphones or smartwatches.

The results on students' experience with the role-based awareness visualization and the awareness reminders (from the questionnaire, log files, and the diary) can be also linked to the empirical issues for displaying and monitoring awareness by Buder (2011). The rather high satisfaction with the use of the role-based awareness visualization and the positive comments on the motivating aspects of monitoring how the personal success contributes to the group performance, indicate that the group mirror succeeded in making group norms visible to group members in a non-obtrusive way. The high interpersonal comparability of performances without moderating the group 's interaction directly in the basic awareness condition was proven to be the favored design approach compared to the combination of group mirror and awareness reminders in the enhance awareness condition.

The awareness reminders were designed for increasing the directivity of the system via reminding students to keep in their role, as well as for triggering adaptive behaviors via motivating them to make their balloons bigger (i.e., participate more). The relatively low satisfaction with the awareness reminders can be explained by the reported and observed technical problems with the use of smartwatches of the smartwatches as part of the CSCL environment for argumentation. Students reported to vibration and sound configurations of the notifications on the smartwatch were "too weak". This may have led to lower satisfaction with the smartwatches as a medium for displaying the awareness reminders. Finally, the mixed feedback on smartwatches and the use of many screens (overwhelm vs. enthusiasm) calls for further investigation on the type of display or the combination of displays for displaying awareness information in CSCL environments in the best possible way.

Finally, the lack of any references to the role-based awareness visualization may indicate that the system was well assimilated in the system and therefor triggered no immediate reactions. However, a study on the interaction with the role-based awareness visualization as part of a bigger setting for collaborative argumentation could benefit from direct measurements of attention on the visualization (i.e., eye-trackers for gaze inspection).

5. Towards a Role-based Awareness Notification System

In this chapter we explain how the results of the second study have informed the design of "Argue(a)ware" in the third phase of development. Moreover, we explore how related work on the Interruption-Reaction-Comprehension framework (McCrickard & Chewar, 2006) for notification systems and the use of ubiquitous media for notification systems has shaped the

new version of role-based awareness notification prototype. Following, we present a study on "Ubiquitous Media for a Role-based Awareness Notification System" and discuss potential implications of this study for the design of "Argue(a)ware" in the next phase of development.

In the second study, we compared a basic "Argue(a)ware" prototype which included the role-based awareness visualization and the self-assessment questionnaires for monitoring performance to an enhanced "Argue(a)ware" prototype with which included an awareness notification tool. The latter was used for issuing awareness reminders to guide students' collaboration and trigger active participation. The awareness notification system was used as a lightweight display (i.e., smartwatch as a small peripheral display) of information in "Argue(a)ware" (Sirisaengtaksin & Olfman, 2014). The display of information on the smartwatches of the participants was triggered by the low levels of role-specific behaviors as depicted by the role-based awareness visualization for issuing notifications. It aimed at promoting behavioral adaptation i.e., more role-specific behaviors in an interactive way, as it required the user to act on them (Hornsby et al., 2010). Text-based messages such us "Keep in your Role." or "Your balloon is not growing bigger." were sent to the users' smartwatches based on predefined rules in an attempt to mock-up the functions of push notification technologies (Latif, Hassan & Hasan, 2008). Push technology is known for raising high awareness of updates and its ability to trigger prompter responds to them (Sirisaengtaksin & Olfman, 2014).

We hypothesized that the additional guidance via the awareness reminders will result in higher self-perceived awareness, higher group performance and higher self-perceived team effectiveness through more active participation in the role (role-specific behaviors) and in the argumentative discourse. The hypotheses were partly confirmed. The mixed methods analysis revealed that the awareness reminders, when perceived on time, they succeeded in guiding collaboration (i.e., resulted in more role-specific behaviors). Repeated issuing of the notifications increased the chances of students' perceiving the notification and acting on it. However, the notifications did not manage to direct students' attention to role-based awareness visualization. Moreover, technical difficulties with the smartphones used as delivery devices for the awareness reminders (i.e., low vibration modus) hindered the timely perception of the reminders and thus their effect on participation. These results indicated the need for investigating and developing further the media involved in facilitating the awareness reminders in the "Argue(a)ware" instructional system.

In the next phase of the development of "Argue(a)ware", we would like to address these problems by designing and testing different notification modes on different devices for facilitating the role-based awareness reminders. Thereby, our aim is still to guide students' active participation in collaborative argumentation. More specifically, we would like to focus on raising students' attention to the reminders and triggering a prompter reaction to the contents of the reminders whilst avoiding a high interruption cost for the primary task of arguing for solving the problem at hand in the group. This is considered as a first step towards developing further the media involved in facilitating the awareness reminders in the enhanced awareness prototype of "Argue(a)ware" from the second study. Thereby, the ultimate goal is to address the loose connection between the awareness reminders and the role-based awareness visualization as indicated in the results of the second study. In that respect, the awareness notification system should gradually transform into a double information agent i.e., offering awareness information on progress in the role and guiding role-based active participation. The role-based awareness notification tool should draw the information from the role-based awareness visualization and the self-assessment tool and build on them to offer customized advice to students for increasing the effectiveness of the collaboration.

As a first step towards designing a role-based awareness notification tool, we took into account the theories on defining user goals in notification systems as described by the Interruption, Reaction and Comprehension (IRC) Framework of McCrickard and Chewar (2003). This framework examines critical parameters of interface design such as the attention-utility tradeoff which describes efforts to maintain the equilibrium of benefits from awareness notifications and interruption costs in CSCW learning setting (McCrickard & Chewar, 2003; 2006). Following, an assessment of the Interruption- Reaction- Comprehension parameters of the awareness notification system from the second study (i.e. text-based awareness notification on smartwatches) was performed (Chewar, McCrickard & Sutcliffe, 2004). The assessment aimed at defining the user notification goals for the next phase of the development of the awareness notification system. The assessment of the awareness notification system from the second phase of system development categorized the system as an „ambient medium" with

respect to the action models of IRC framework (Hinfner, 2017)[3]. More specifically, the values of the Interruption- Reaction- Comprehension parameters were calculated as Low - Middle – High (0-0-1) respectively. "Ambient media" fall into the wider category of ambient information systems which are also known as ambient displays or peripheral displays (Pousman & Stasko, 2006)

According to literature on ambient displays, the goal of ambient displays is "to generally support monitoring of non-critical information" as "a parallel, multitasking approach, extraneous or supplemental to a user's attention priority". Thereby, the goal is to present information "without distracting or burdening the user" (Mankoff et al., 2003; McCrickard et al., 2003 in Pousman & Stasko, 2006, p.2). As such, ambient tools do not focus on attracting students' attention and require no immediate reaction to the given stimulus (Pousman & Stanko 2006). The low reaction affordances of the "ambient" displays do not match the aim of the awareness notification tool to act as guiding tool in collaborative argumentation setting. Offering guidance to students requires that students perceive the information on time, value it as important and feel compelled to act on it immediately (Jermann, Soller, & Muehlenbrock, 2001).

For this purpose, we redefined the user notification goals based on the IRC framework to match this aim (McCrickard et al., 2003). These goals were translated into design challenges for the design of the role-based awareness notification system. The latter is meant to work hand by hand with the role-based awareness visualization for supporting the relational space of collaboration. However, the awareness breaks for regulating and evaluating collaboration (i.e., self-assessment) were not included in the support for the relational space of collaboration in this phase. It was decided, that the focus in this phase of development of "Argue(a)ware" should be on developing further and studying the technical media involved (i.e. group mirror and awareness notification prototypes). No other changes were made with respect to the instructional support and the content space support (figure 5.1.).

[3] The IRC values were calculated with the help of the IRC analytical measurements by Chewar, McCrickard & Sutcliffe, 2004 and can be found in Hinfner, (2017).

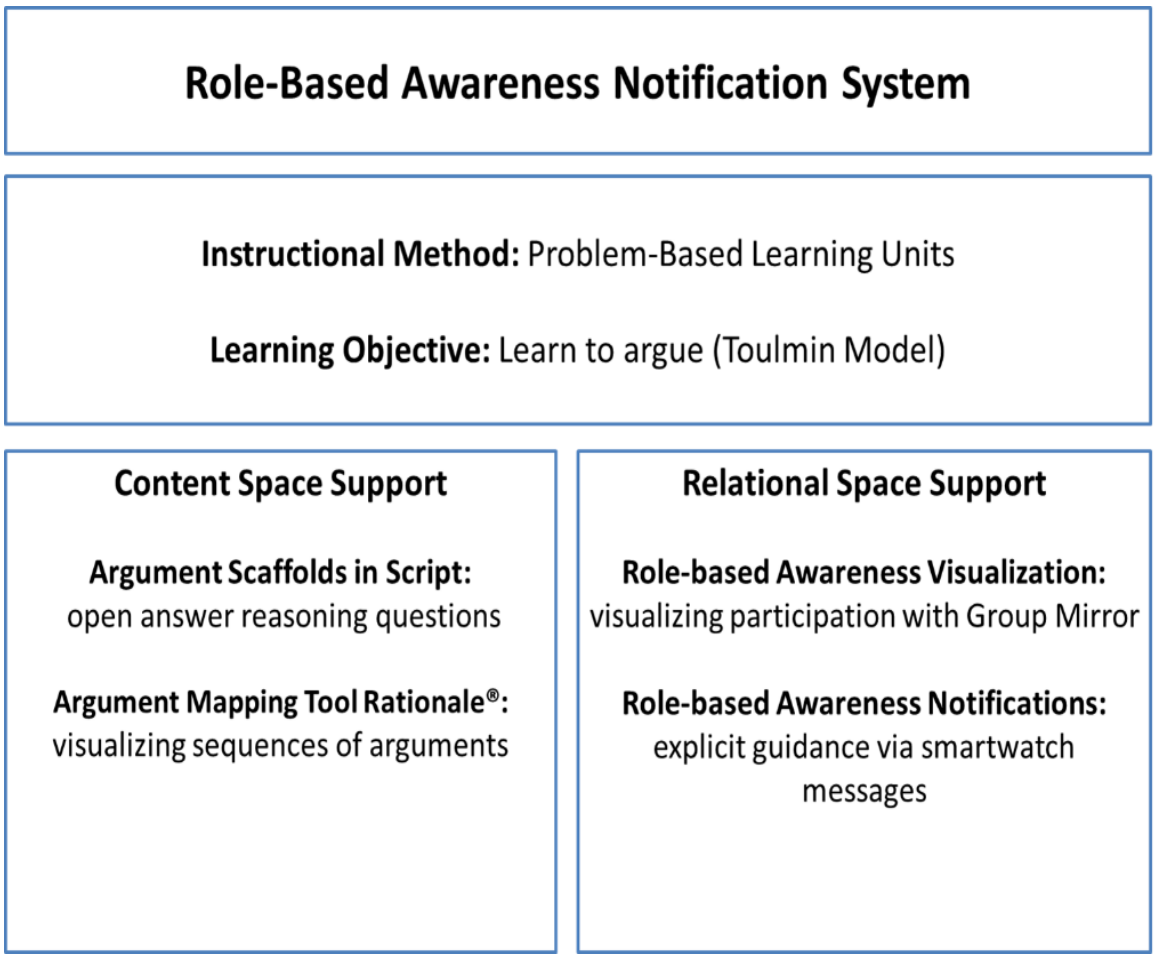


Figure 5.1. Support for role-based collaborative argumentation in the third phase of development of "Argue(a)ware".

5.1. The Design of a Role-based Awareness Notification System

The first design challenge for the next draft of the role-based awareness notification system is to assist timely perception of the notifications without increasing the cost of interruption on the main task. This goal is line with the theory of the "Attention-Utility Tradeoff" (McCrickard & Chewar, 2003). The theory supports that users of notification systems are often willing to sacrifice some primary task attention to gain benefits such as important information about task processes. However, untimely interruptions or overactive alarms insensitive to user priorities may result in unwanted distractions, the loss of critical content, and ultimately in low satisfaction with the system (Arroyo & Selker 2003). "Interruption" is typically measured by calculating the cost of interruption to the main task i.e.,

disruptiveness to main task and the primary task sustainment i.e., how much was the primary task affected by the notification (Chewar, McCrickard & Sutcliffe, 2004).

The next design challenge is to provoke a more immediate reaction to the notifications. Reaction is defined as “the rapid response to a given stimulus” (Pousman & Stanko 2006, p. 2). For responding to a notification stimulus, a quick shift of attention between collaboration tasks is required. Students need to pause their participation in argumentative processes (if they are participating) to acknowledge their own status in the role and compare it to status of the status of the group and other members. The comparison is assisted by the role-based awareness visualization which utilizes a balloon metaphor as a progress meter for active participation in the distinct roles (subchapter 4.1.2.). In the next step, students need to react to the information from the role-based awareness visualization by adjusting their behaviors to the standards of role-based collaboration (i.e., increase their role-specific behaviors in the discussion).

At the same time, we want to sustain a high level of understanding of the notification message. This information presented in the awareness notifications is important for pacing on or adjusting to role-specific behaviors, as well as for achieving an overall understanding of team contributions. Therefore, it is important to design the content of the awareness notifications to be easily comprehensible (i.e. clear content), easy to remember for longer time (i.e., short, standardized messages). In that way students can make better sense of it with the help of the role-based awareness visualization on the large screen (McCrickard et al., 2003). In sum, we set the user notifications goals for the awareness systems to low user interruption, near-term reaction, and long-term comprehension through access to additional information. These goals translate to low Interruption, high Reaction, and high Comprehension parameter values (0-1-1) respectively. Notification systems with this particular configuration of IRC values are known as "secondary display" systems (McCrickard et al., 2003b).

These displays refer to visual implementations that are usually facilitated on small screens but are used to convey a fairly large amount of information. This information is intended to be perceived and interpreted in a quick glance rather than over longer period of a user’s attention. Examples of secondary displays are clocks and email alert tools on computers. The design of this system is based on the premise that users may be willing to tolerate an interruption if this adding utility through appropriate, timely reaction or long-term comprehension (McCrickard et al., 2003). In terms of Argue(a)ware, a secondary display system should afford timely interruptions on the main task to introduce additional information which is clearly indicating the importance for shifting attention main task of collaboration i.e.,

editing the argumentation map or correcting an argument on the personal screen to the role-based awareness visualization on the large screen display which shows the progress in the role.

Moreover, the reaction to the notification needs to be prompt i.e., student needs to perceive the notification and read the information it conveys when the latter is still relevant to the context of information presented on the role-based awareness visualization. The combination of the two pieces of information (i.e., the reminder to Keep in Role and the visualization of few points in the balloon) could lead to participation adjustment. Moreover, it could assist an overall understanding of participation contributions. Technical problems with the smartwatch as medium for alerting users and displaying the awareness information in the previous study (i.e., low vibration modus) hindered the timely perception of the reminders and thus their effect on participation.

In designing the role-based awareness notification system with a secondary display system configuration, we want to examine how technological media with different affordances can assist the achievements of our user notification goals. For this reason, we examined different ubiquitous peripheral displays such as smartphones or wearables (i.e., smartphones and smart-rings) for presenting awareness information in our secondary display system (Röcker, 2009). These ubiquitous media could display awareness information in a way that it moves from the periphery to the focus of user's attention and back again for causing less distraction on the primary task (Markopoulos, 2009). The use of mobile smart devices such as smartphones and wearable technologies (e.g., smartwatches and smart-rings) for facilitating notification systems is are gaining popularity over traditional graphical user interfaces lately (López & Guerrero, 2016).

Furthermore, we investigated literature on the information representation types and notification modalities of awareness notification systems. Awareness notification systems employ different notification channels with auditory (e.g., short sounds); visual (e.g., flashing light); tactile (e.g., vibration) or olfactory cues (e.g., aroma) to attract users' attention. In addition, awareness notification systems afford displaying awareness information with different visual representations such as graphical representations with various patterns, pictograms, shapes, and colors or textual representations of awareness information (Tang & Lee, 2016).

In the next chapter we present a user study on the influence of three medium-fidelity notification prototypes for the role-based awareness notification system on the perceived interruption, reaction, comprehension parameters in the setting for collaborative

argumentation. Moreover, the user experience with the different prototypes was measured. The prototypes run on three different ubiquitous devices (smartwatch, smartphone, smart-ring) afford diverse types of visual representations of awareness information (textual vs. abstract visual) and multimodal notification channels (light and vibration).

5.2. Study on Ubiquitous Media for a Role-based Awareness Notification System

Mobile and wearable ubiquitous devices for facilitating notification systems such as light displays, smart devices i.e., smartwatches, smartphones and wearable technologies i.e., smart rings are gaining popularity over traditional graphical user interfaces (López & Guerrero, 2016). These media represent the wide range of physical and screen-based ubiquitous computing systems for assisting ambient notification systems (Pousman & Stanko 2006; McCrickard et al, 2003). Typically, ambient information systems are not placed at the center of user's main attention priority and they are used to maintain awareness of low-priority information in conjunction with large displays (Tang & Lee, 2016).

Ambient or peripheral notification systems afford displaying awareness information with different visual representations such as graphical representations with various patterns, pictograms, shapes, and colors or textual representations of awareness information (Tang & Lee, 2016). These visual representations can be abstract or concrete. With respect to the comprehension of abstract visual representations i.e., distinct color LEDs display on desktop screens or a wall-mounted display we see that they are resulting in high recognition accuracy from users (Tarasewich et al., 2003). A study on "Irwin", a small, omnipresent tool for maintaining awareness of internet resources during an internet browsing task with the help of embedded text-based animations, indicated that text-based awareness representation result in high long-term comprehension and no immediate reaction (McRickard, 1999).

Furthermore, awareness notification systems employ different notification channels with auditory (i.e., short sounds); visual (i.e., flashing light); tactile (i.e., vibration) or olfactory cues (i.e., aroma) to attract users' attention. Studies examine multiple notification modalities of awareness notification devices (Warnock, McGee-Lennon, & Brewster, 2011; Roumen et al., 2015). These are tested with respect to different objective measurements i.e., and the error rates in the main task and subjective measurements i.e., perceived disruptiveness to the main task. Objective measurements often show no relationship between notification modalities and

error rates in the main task (Arroyo, Selkers & Stouffs, 2002; Warnock, McGee-Lennon, & Brewster, 2011). Subjective measurements of disruptiveness are influenced by the importance and the perceived urgency of the awareness information. For example, users prefer vibration and sound-based notifications for urgent and moderately urgent notifications (Roumen et al., 2015). Disruptiveness of systems depends also on users' familiarity with the type of notification channels i.e., auditory and the visual notifications are considered less disruptive because they are more common (Arroyo, Selkers & Stouffs, 2002).

A reaction to multimodal awareness notifications is often defined as the delay between receiving and viewing notifications, and it is measured objectively (i.e., in seconds) (Warnock, McGee-Lennon, & Brewster, 2011; Pielot, Church, & deOliveira, 2013). Moreover, the objective measurements are often paired with subjective measurements of students' perceptivity of notification i.e., user's reaction to an interruption and their subjective experience of it (Mehrotra et al., 2016). In a study by Warnock, McGee-Lennon, and Brewster (2011) on different notification modalities for delivering target and distractor notifications to older users, the reaction time (seconds) was measured. Notification functions and modalities affected the reaction time, with pictograms and abstract visuals resulting in the lowest reaction times followed by and text-, speech- and vibration-based notifications. The study of Pielot and colleagues (2013) on the nature and effect of mobile phone notifications on the daily lives of users shows that users attend faster to their notification when notified with a vibration cue. With respect to reaction to notification from various notification channels of ubiquitous devices, we see that vibration and sound stand out as reliable and fast channels to convey notification on mobile phones (Saket, Prasojo, Huang, & Zhao, 2013) and wearable devices such as smart-rings (Roumen et al., 2015) and smart-watches (Hernández-Leo, Balestrini, Nieves & Blat, 2012).

Research on the interruption, reaction, and comprehension aspects of different media, with diverse notification modalities and information representation types in ambient awareness notification systems is rich. However, we are not aware of any study that compares different ubiquitous media with their different notification affordances (i.e. information representation types and notification modalities) for facilitating a secondary display system in a CSCL environment. Therefore, we argue for a systematic comparison of ubiquitous media (smartphone, smartwatch, smart-ring) with different notification affordances with respect to the perceived interruption, reaction and comprehension parameters as defined by the IRC framework within our setting for collaborative argumentation (McCrickard & Chewar 2003).

To investigate these issues, we have designed three low-fidelity prototypes of a role-based notification system for delivering awareness reminders on a) a smartwatch (wearable device, text-based notification with vibration and light), b) a smartphone (mobile device, text-based notification with vibration and light) and c) a smart-ring (wearable, graphical- based notification with light and vibration affordances, on small screen) of the collaborators in the "Argue(a)ware" instructional system for collaborative argumentation. All prototypes were drafted with the secondary display IRC value configuration in mind i.e. low interruption, high interruption, and high comprehension of notifications.

Following, we conducted a within-subjects user study where three university students (n= 3, Mage=28, mixed educational background) argued for solving three different problem cases and producing an argument map in each of the three consecutive meetings (max 90min) in the "Argue(a)ware" instructional system. Students were assigned the roles of writer, corrector and devil`s advocate and were instructed to maintain the same role across the three meetings. In each meeting students worked with a different role-based awareness notification prototype, where they received a notification indicating their balloon is not growing bigger after five minutes of not exhibiting any role-specific behaviors. The role-based awareness notification prototypes aimed at introducing timely interventions which would prompt students to check on their own progress in the role and the group progress as visualized by the role-based awareness visualization on the large display. Ultimately, this should prompt them to reflect on the awareness information from the visualization and adapt their behaviors to the desired behavior standards over time.

In this study, we compared users' perceived interruption, reaction and comprehension parameter values from the different role-based awareness notification prototypes with respect to their notification modalities and information representation types by means of mixed methods analysis. Additionally, we examined the user experience with the different prototypes as part of the "Argue(a)ware" setting for collaborative argumentation. These values are used to make inferences about the suitability of each medium for representing the desired secondary display system configuration of the IRC values (0-1-1). In the next sections, we describe the design characteristics of the three low-fidelity prototypes and the changes in the Argue(a)ware instructional design. Following, we present the methods and the results of the within-subjects user study. We conclude with the implications of the study for the design of "Argue(a)ware" in the next phase of development.

5.2.1. Role-based awareness notification prototypes.

The design of the three prototypes was informed by related work on the use of the different media as awareness information media with different notification modalities. Moreover, their design was adjusted for reflecting the desired secondary display configuration of IRC values (low-high-high) in a CSCL setting for collaborative argumentation. For the implementation of the smartphone and smartwatch prototype we used commercially available devices (an LG Nexus 5 smartphone and Motorola 360 smartwatch respectively). The smart-ring prototype was conceptualized and implemented by Mrs. Hinfner, a Media Informatics Student at LMU Munich, in terms of her bachelor thesis (Hinfner, 2017). The description of the design process and the technical requirements of the smart-ring prototype are beyond the scope of this dissertation. All prototypes differ with respect to the notification modalities for alerting users and the types of information representation (textual vs. abstract light) employed for displaying the issued awareness reminders (table 5.1.). Both notification modalities and information representation types define the notification affordances of each role-based awareness notification prototype.

5.2.1.1. The smartphone prototype.

For our smartphone prototype we used the LG Nexus 5 smartphone with an Android 4.4. operating system, where only the instant messaging app- WhatsApp was preinstalled. The awareness reminder with a text-based notification („Your balloon is not getting any bigger“) appeared briefly in the notification bar at the top of the smartphone screen where normally other notifications are listed. The screen lighted up for two seconds (2 sec) upon arrival of the text while users were also notified by a short vibration cue which was felt indirectly by the users since the smartphone was placed next to the personal computer of the user on the desk in front of him/her. Vibration configurations on the smartphone prototype draw on previous research on vibration-based notifications no additional hardware modifications on smartphones (i.e., extra vibrators) are made (Saket et al., 2013).

Finally, a blinking red LED light with a low frequency blink (non-configurable) at the top left corner of the smartphone screen alerted users for missed WhatsApp notifications. Flashing lights have been used to catch the user’s attention in peripheral displays for interrupting users in less obtrusive way and for demanding action (Matthews et al., 2004). The blinking red light served as an omnipresent reminder of the awareness notification which aimed

at attracting focused attention of user at a later more opportune moment (Smith et al., 2014). . The user needs to attend to the notification by touching on the screen to unlock the screen, tapping on the text of the notification for opening the WhatsApp application to read the reminder, or can read the short text as appearing in the lock-screen and then swipe right to delete it.

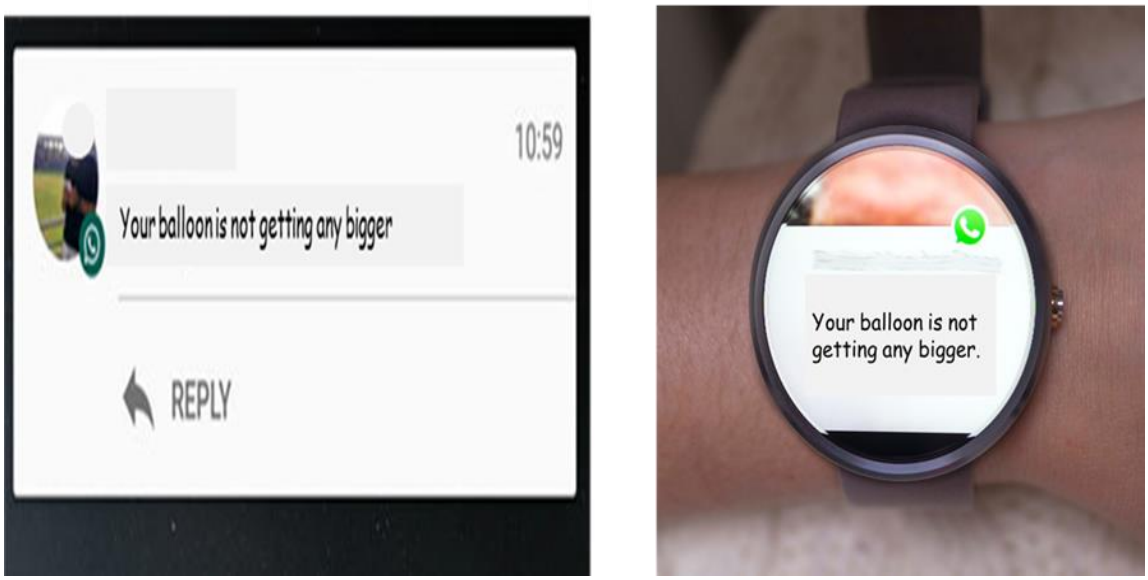


Figure 5.2. Mock-up examples of text-based notifications with the awareness reminder "Your balloon is not getting any bigger." The text is presented on the notification bar at the top of the smartphone prototype screen (left) and on the screen of the smartwatch prototype (right).

5.2.2. The smartwatch prototype.

Our smartwatch prototype was implemented on the Moto 360 smartwatch (first generation) which was paired with the help of the Android Wear to the cloud service and with Bluetooth connection to a smartphone device (not visible to the user). The awareness reminder with a text-based notification („Your balloon is not getting any bigger") was first sent to the smartphone and then was instantly presented as a short message from the instant messaging app- WhatsApp (table x) on the screen of the smartwatch. Upon arrival of the text, the user is notified with a short light-up of the screen and a slight vibration (vibration intensity was non-configurable) on their wrist. Users can have a quick glance of the text but for interacting with the notifications users need to swipe right to dismiss the notification from their watch and phone or swipe up to see more notifications. Interaction with wrist gestures (left and right flick

of the wrist), was deactivated for avoiding unintentional action taking i.e., minimizing or erasing notifications.

5.2.2.1. The smart-ring prototype.

In terms of this study, we decided to employ a customized medium-fidelity prototype of a smart-ring as designed by Mrs. Hinfner (2017) (figure 5.2.). The decision not to use any commercially available smart-rings was taken due to criticism on their high prices, unstable functioning and extremely low battery life (Wang, Millet & Smith, 2016). The inspiration for the prototype came from a popular smart-ring used as a notification system - Ringly ™, which features mobile alerts with vibrotactile feedback on your finger (4 vibration settings) and light feedback (5 different colors on the LED screen at the sight of the ring surface) when you receive notifications by connecting to your smartphone via Bluetooth. Like Ringly ™, our smart-ring prototype affords combinations of various vibrations settings for alerting users and various colors for blinking light-based notifications, which attract attention and convey messages (Hifner, 2017).

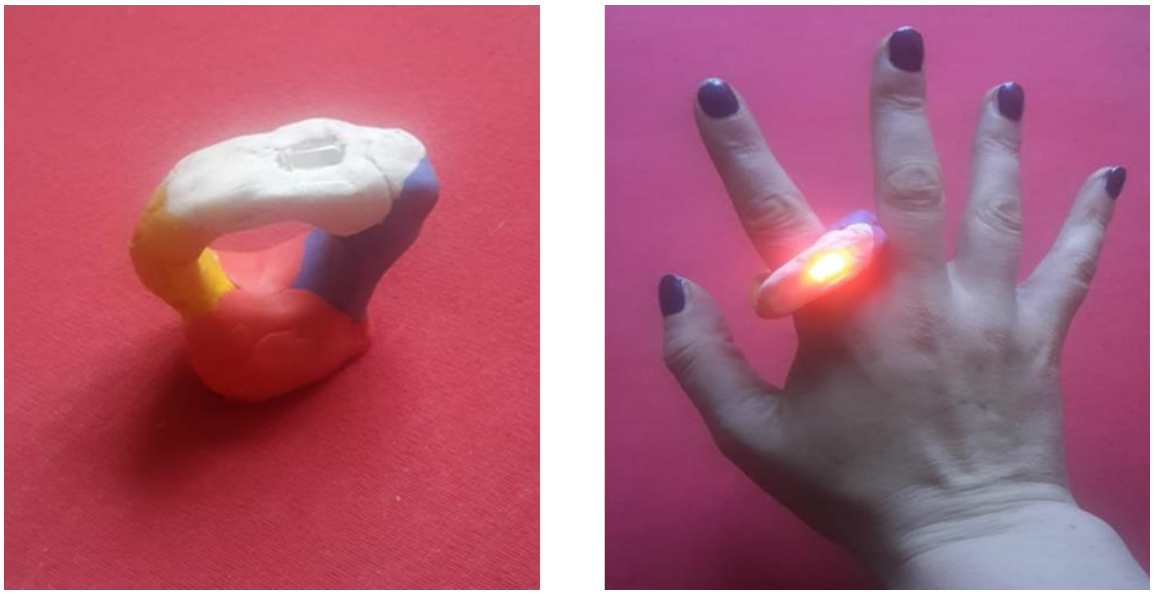


Figure 5.3. The smart-ring prototype (left) with the abstract light visualization for representing awareness reminder (right), i.e., an equivalent to the text-message "Your balloon is not getting any bigger".

We used a combination of red-purple alternating blinking light as an abstract visualization of the awareness reminders for checking on the progress in the role-specific duties

in the role-based awareness visualization. This abstract visualization served as an equivalent to the text-based awareness reminder “Your balloon is not getting any bigger.” which was delivered on the smartphone and smartwatch prototypes. Moreover, the alternating flashing served as an attention catch, similar to how flashing lights have been used to catch the user’s attention in peripheral displays and for interrupting users in less obtrusive way and for demanding action (Matthews et al., 2004). Finally, a short vibration alerted the user of the need to react to the message to increase the perceived urgency of the notification (Roumen et al., 2015). The ring was activated and de-activated by the experiment facilitator. Since the rings did not afford any text-based notification, students were informed about the meaning of the abstract visualization and were instructed to keep their hands at sight, so they can perceive the light and stretch their hand in front of them to acknowledge the notification (figure 5.3., right).

Table 5.1.

Notification Affordances of Role-Based Awareness Prototypes

Notification Affordances	Smartphone	Smartwatch	Smart-ring
Device is on	dark screen	dark screen	white light
Awareness Information Representation	textual representation: „Your balloon is not getting any bigger. “	textual representation: „Your balloon is not getting any bigger. “	abstract visual: rot-purple alternating flashing light
Notification Modalities	vibration cue on desk short screen light-up omnipresent blinking red LED light	vibration cue on wrist short screen light-up	vibration cue on finger rot-purple alternating flashing light
Device is off	dark screen	dark screen	no light

5.2.3. Methods.

In this section we present information about the participants, the processes and the study setting. Moreover, we present the data collection processes and our approach to analyzing the data for answering the research questions of the study.

5.2.3.1. Participants.

In this user study three students (Mage=28), one male bachelor's architecture student and two female bachelor's media informatics students volunteered to take part in the three study sessions for collaborative argumentation in the "Argue(a)ware" setting. Students could choose between 10 Euro in cash or nine (9) study points for their studies as a refund for their participation in each session.

5.2.3.2. Processes.

The main task of students was to argue for and agree on the best solution to a learning problem in the group and then transfer their arguments into a joint argument map using the online argumentation mapping tool Rationale®. Next to that, students should monitor their progress in their role with the role-based awareness visualization. In each session they received a different problem case related to learning and technology issues in modern day society. The collaborative argumentation processes were coordinated with the help of a revised "Role-based Awareness-Oriented Argumentation Script" (subchapter 4.1.1.), which now included the following parts (figure 2). In the first session, students were introduced to the "Argue(a)ware" setting for collaborative argumentation (figure 5.4.). The functions of the argument mapping tool Rationale®, as well as of the role-based awareness visualization and the use of different role-based awareness notification prototypes were explained via an explanatory video. At this point, students were informed about the duties of each role and were introduced to the role-based awareness visualization as tool for monitoring their own progress and their contribution to the group (subchapter 4.1.2.) with the help of the growing balloon metaphor (figure 4.7.). This introduction phase was omitted in the next two sessions, but students were encouraged to ask questions about the system at any point.

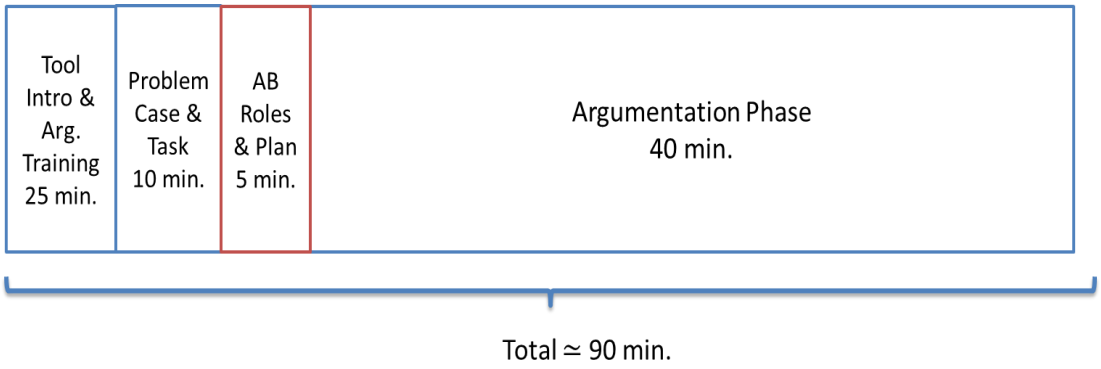


Figure 5.4. The revised instructional design of "Role-based Awareness-Oriented Argumentation Script".

Next, they were given 10 minutes time for reading up on the problem case and the theory text (on paper) and the actual task for argumentation from (on argument tool card). Following, during a short awareness break for role assignment and plan making (subchapter 4.1.1.), students choose among the roles of writer, corrector and devil's advocate, which they maintained in all three meetings and plan their next steps for collaboration. The writer was responsible for writing down the arguments, while the corrector role was responsible for formatting of arguments and for pointing out logical inconsistences and mistakes in the application of rules in argument mapping tool. The main duty of role of devil's advocate was to question emerging arguments and thereby contribute to the creation of counter-argument and more substantiated reasons. Consequently, a 40-minute long argumentation phase was launched for working on the problem case. Prior to launching the argumentation phase, students were assigned to one role-based awareness notification prototype for the meeting and were instructed to place them next them (smartphone) or wear them (smartwatch, smart-ring). Participants were assigned a different prototype in each session for collaborative argumentation (table 5.2.).

Table 5.2.

Assignment of Role-Based Awareness Notification Prototypes to Each Role pro Study Session

Session	Writer	Corrector	Devil's Advocate
1st	Smartphone	Smart-ring	Smartwatch
2nd	Smart-ring	Smartwatch	Smartphone
3rd	Smartwatch	Smartphone	Smart-ring

During the argumentation phase, students were rewarded with one point for every 30 seconds of exhibiting role-specific behaviors (for criteria of direct attribution of points for role-specific behaviors (table 4.2.) which was displayed inside their balloon (blue balloon: writer, yellow balloon: corrector, pink balloon: devil's advocate, light blue balloon: group performance) in the role-based awareness visualization (figure 4.7.). However, if a student did not get any points for more than two minutes, he/she was reminded of his role-specific duties with a notification from his/her role-based awareness notification system that indirectly asked him/her to take notice of their role- specific behaviors in the balloon metaphor and adjust his/her behaviors accordingly i.e. "Your balloon is not getting any bigger" (originally, in German).

5.2.3.3. Study setting.

The "Argue(a)ware" study setting is depicted in the figure 5.5. It includes a large TV display [11] on the wall, which is divided into four windows. The problem case tool cards and the argumentation tool cards with task description were displayed at the left part of the wall display, while the role-based awareness visualization was displayed at the upper right part of the display and a countdown timer for each task was displayed at the lower right part of the display. In every session, participants worked together for arguing to solve the problem case but only the writer had access to a personal computer [1] for editing the argument map with the argument mapping tool Rationale®. The contents of the argument map were also displayed with the help of the free online desktop sharing software TeamViewer® on the screen of the experimenter's computer [4] for better control of the argumentation processes.

During the study, one experimenter was responsible for observing the discussion and attributing points for role-specific behaviors on the role-based visualization and sending out messages to participants' smartphone and smartwatch or activating the smart-ring, while the other experimenter was taking notes and making sure the system was running smoothly. The different notification devices were networked with three different smartphone devices that were controlled by the first experimenter. The smartphone [7] was notified directly via WhatsApp™ application using one of the experimenters' smartphones [8], while the smartwatch prototype [6] was connected via Bluetooth® connection to a receiver's smartphone [9] and through that it received the WhatsApp messages from the sender smartphone [8], as push notifications. The smart-ring [5] was connected via Bluetooth® to another smartphone [10], which was used for activating the notifications. One video camera was positioned at the side of the table were students collaborated [12], for recording their interactions with the role-based notification devices, while the voices and the personal screen were recorded with help of the Camtasia® Recorder software.

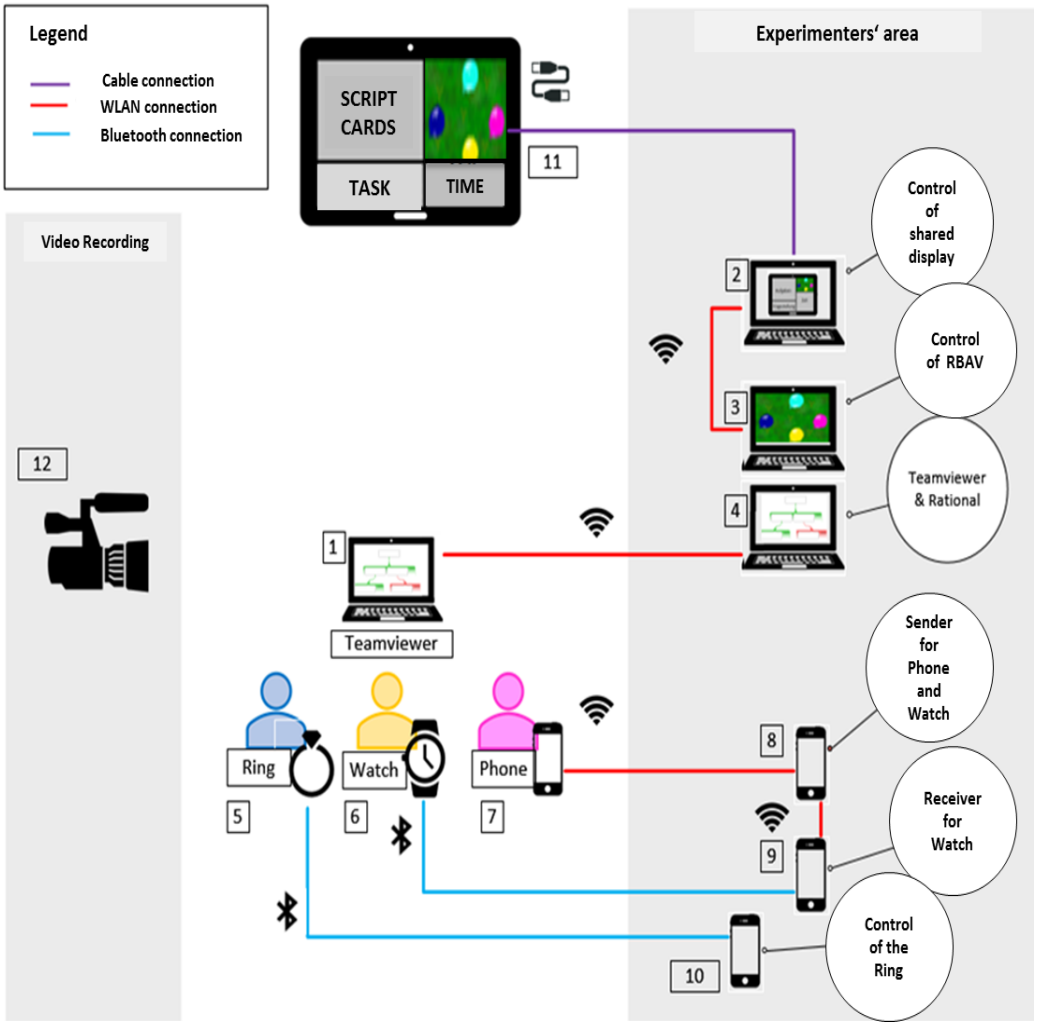


Figure 5.5. "Argue(a)ware" study setting with the use and connection of the role-based awareness notification prototypes and the multiple displays for facilitating the display of tool and awareness-related information.

5.2.3.4. Data collection.

At the end of each session, participants were asked to fill out a questionnaire (Appendix J, in German) for evaluating their experience with the different role-based awareness notification prototypes with respect to interruption, comprehension and reaction related issues. Each questionnaire included closed format items (multi-option variable questions, dichotomous contingency questions and 6-point Likert scale evaluation questions) and two short answer items. While perceived notifications from the intended receiver are examined with respect to the different notification modalities and the information representation types, the

perceived notifications intended to other members are examined with respect to the notification medium used for facilitating the notification prototype.

The first section included personal questions related to the study (i.e., previous experience with the ubiquitous media) while the second section inquired the user experience with the notification medium. In the third session, students had to declare if they had received any notifications. Then, students were asked to define the type of notifications they had perceived i.e., alterations of vibration and light notification or text-based notification. Multiple answers to this question were possible. Depending on their answers, students were redirected to the subsections on "Vibration", "Light" and "Text". Each of these subsections comprised of three items on the comprehensiveness, reaction time, disruptiveness of the received notifications on the main task from the perspective of the receiver. The last section of the questionnaire included the two short answer items on what perceived as exceptionally good or bad when using the different role-based awareness notification prototypes as well on as their overall experience with the study.

5.2.3.5. Analytical approach.

The study followed a mixed methods research design with a triangulation model for validating quantitative data (Creswell et al., 2003). In line with this design, we collected quantitative and qualitative data on the perceived interruption, reaction, comprehension of the different notification prototypes and the user experience with them concurrently. The intent was to use the analysis of qualitative data of the questionnaire for validating and refining the interpretation of the quantitative data analysis.

The small-scale user study examines the answers to the following questions:

RQ1. What was the perceived **cost of interruption** of different notification modalities (vibration and light) from the different role-based awareness notification prototypes across roles?

RQ2. What was the perceived **reaction** to different notification modalities (vibration and light) from the different role-based awareness notification prototypes across roles?

RQ3. What was the perceived **comprehension** of notifications from the different role-based awareness notification prototypes across roles?

RQ4. What was the **user experience** with the different role-based awareness notification prototypes across roles?

The cost of interruption of notifications was defined here as the perceived disruption to the main task by the notification received by the intended user and by the other users. Moreover, reaction was conceptualized as the subjective speed of perceiving the notification and attending to it i.e., reading the text, or acknowledging that the message was perceived in the case of the ring). Also, comprehension was conceptualized here as the ease of understanding the intended meaning of the notification i.e. the instruction to monitor the progress in the role on the role-based awareness visualization. Finally, user experience was defined as the intuitiveness of use and enjoyment with the use of the different media for the awareness notification prototypes.

5.2.4. Results.

In this section, we present the results of the analysis of the quantitative and qualitative questionnaire data. Every student worked with a different medium in each session, resulting in three data sets per role-based awareness notification prototype (n=3). Descriptive statistics such as frequencies, measures of central tendency, and measures of variability were used to describe a large set of quantitative data from the three participants with respect to the research questions in a sensible way. The descriptive statistics were combined with the results of the qualitative analysis of student's comments in the short answer items to gain deeper understanding of the phenomena explored in the study. All statistical tests were run with the help of the statistical software package "SPSS 24.0".

5.2.4.1. Questionnaire - quantitative data.

In the first step, we analyzed the familiarity of students with the three notification devices i.e., smartphone, smartwatch, smart-ring. All students declared no previous experience with a smart-ring device; only the corrector had used a smart-watch before, while the corrector declared having limited experience with a smartphone. Students declared that they had perceived the notifications on smartwatches only based on the vibration cues (n=3), while vibration was the main notification channel for users of smartphones (n=2) and smart-rings (n=2) as well.

The perceived **cost of interruption** from notifications (RQ1) was calculated based on the means of answers of the intended receivers of notifications to the questions on how disruptive the different notification modalities were (i.e. vibration and light) of the notification prototypes for the intended receiver with respect to the main task (1: not disruptive at all, 6:

extremely disruptive, reversed item). For calculating the perceived disruptiveness of notification to the receivers we examined the notification affordances (i.e., modalities and information representation types) of each medium separately. Results showed that vibration cue on the wrist from the smartwatch (M= 1.33) was perceived as less disruptive to the main task when compared to the vibration cue on finger from the smart-ring (M= 1.66) and the vibration cue on the desk from the smartphone (M=3.5). Due to missing data, no meaningful comparison of the disruptiveness of light-based notifications could be made for any of the notification prototypes (table 5.3.).

Table 5.3.

Mean Values of Cost of Interruption of Notifications to Intended Receiver with Respect to Notification Modalities pro Notification Prototype

Notification Prototype	Notification Modalities	Cost of Interruption from notifications to receiver		
		M	SD	n
Smart-ring (SR)	SR_light	1.0	-	1
	SR_vibration	1.66	1.54	3
Smartwatch (SW)	SW_light	-	-	-
	SW_vibration	1.33	.577	3
Smartphone (SP)	SP_light	4.0	-	1
	SP_vibration	3.5	2.08	2

The **perceived reaction** to the notifications (RQ2) was measured based on the mean values of participants' answers to the question on how fast they reacted to the notifications i.e., interacted with the medium upon noticing the notification (1: not fast at all, 6: immediate). For measuring the perceived reaction to notifications, we examined the notification affordances (notification modalities of each medium separately. Results showed that students interacted faster with their smartwatch upon noticing the vibration cue on their wrist (M= 5.67), then they interacted with their smart-ring upon noticing the vibration cue on their finger (M= 5.33), or with their smartphone upon noticing the vibration cue on the desk (M=3.5). Due to missing

data, no meaningful comparison of reaction to light-based notifications could be made for any of the notification prototypes (table 5.4.).

Table 5.4.

Mean Values of Reaction to The Notification Affordances pro Notification Prototype

Notification Prototype	Notification Modalities	Reaction to notifications		
		M	SD	n
Smart-ring	SR_light	2.0	-	1
(SR)	SR_vibration	5.33	1.15	3
Smartwatch	SW_light	-	-	-
(SW)	SW_vibration	5.67	.705	3
Smartphone	SP_light	1.0	-	1
(SP)	SP_vibration	3.5	3.53	2

The **perceived comprehension** of the notifications was calculated based on the mean values of the answers to question on how easy it was to understand the intended meaning of the notifications i.e. the need to monitor the progress in the role in the role-based awareness visualization on the large display (1: not at all, 6: very easily understandable). For calculating the perceived comprehension of the notifications, we examined the information representation types (text-based vs. abstract visual) of each medium separately. When comparing the ease of comprehension of text-based notifications, we see that text on smartwatch (M= 4.5) was perceived as equally easy to comprehend as the text on smartphone (M= 2). Due to missing data, no meaningful comparison of the ease of comprehending light-based notifications could be made for any of the notification prototypes (table 5.5.)

Table 5.5.

Mean Values of Comprehension of The Notification Affordances pro Notification Prototype

Notification Prototype	Notification Affordances	Comprehension of notifications		
		M	SD	n
Smart-ring (SR)	SR_light	3.0	-	1
Smartwatch (SW)	SW_text	5.0	1.41	2
Smartphone (SP)	SP_text	5.0	3.53	3

The **user experience** with the different notification prototypes (RQ4) was measured based on the mean values of answers to questions on how a) intuitive and b) enjoyable was the experience with each of the notification prototypes (1: not at all, 6: a lot). Results showed that using the smart-ring was the most intuitive (Mint=5.5, SD=1.15) and most enjoyable experience (Menj= 4.7, SD=.55). The use of smartphone was more intuitive (Mint=5, SD=1.73) than the use of smartwatch (Mint=4.5, SD=.57). Finally, the use of smartwatch was found to be more enjoyable (Menj=4.5, SD=1.15) than the use of the smartphone (Menj=3, SD=). A mean score of the answers to the answers to the three questions was calculated pro medium to define the user experience in total. We see, also that the user experience with the smart-ring was the highest (Mexp=4.5, SD=.50) followed by the experience with the smartwatch (Mexp=4.5, SD=.76) and then with the smartphone (Mexp=4, SD=1.0) (figure 5.6.).

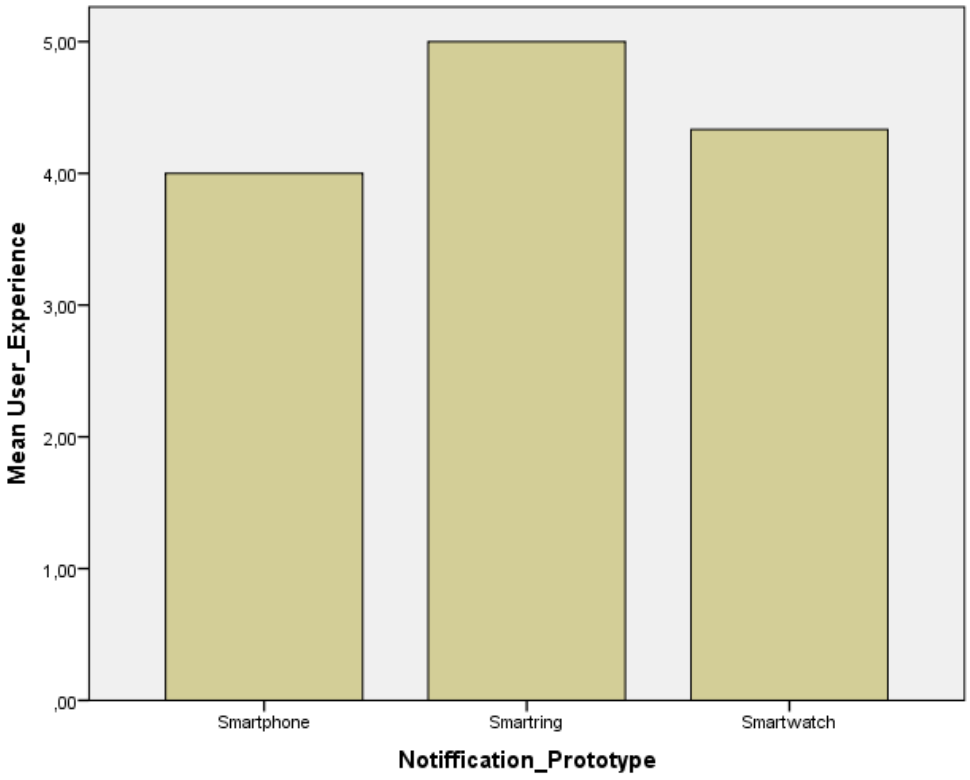


Figure 5.6. User experience (mean of intuitiveness and enjoyment of use) for each notification prototype.

5.2.4.2. Questionnaire-qualitative data.

Students' remarks from the from the short open-ended questions on the parts they perceived as exceptionally good or bad when using the different role-based awareness notification prototypes as well on as their general experience with the study were collected. The relevant comments on the positive (+) and negative experiences (-) with the notification prototypes of the users were analyzed pro medium and across roles (table x.).

With respect to the general experience the study setting; only the Devil's advocate offered comments. He noted that "Instructions for compliance with my role were very disturbing or I felt almost personally attacked...I also felt that I performed well in my role well and then received the (subjective) notification that it was very unpleasant and has negatively affected me for the rest of the discussion." (table 5.6.)

Table 5.6.

Positive (+) and Negative (-) Experiences with the Awareness Notification Prototypes

Roles	Smartwatch	Smart-ring	Smartphone
Corrector	+ not disturbing the discussion + (I felt like) it promoted the compliance with my role in the group	+ clear use thanks to the strong vibration	No data
Writer	+ felt quite good + did not interfere with my work + vibration alarm was minimal + others are unlikely to notice it (cc vibration)	+ vibration helpful - constant and repeated vibration rather disturbing	+ least distracting medium - did not notice it
Devil's Advocate	+was the best + it can deliver the most subtle notifications + looking at it was very natural.	+ advantageous + the vibration was less obtrusive (cc than smartwatch) - light notification felt obtrusive; I kept the ring away and relied on the vibration alone	+ enjoyable because it was unobtrusive

5.2.5. Discussion and Limitations

In this section, we discuss the results from the analysis of quantitative and qualitative questionnaire data with respect to the five research questions of this study. In parallel, we

address any limitations of the measurements or the study setting that may have an influence on the discussion of the data. Finally, we make inferences about the suitability of the different ubiquitous media to act as a secondary display awareness notification medium.

With respect to the perceived cost of interruption (disruption to main task) from the different notification modalities, vibration cues on the wrist (smartwatch) were considered the least disruptive to the main task compared the vibration cues on desk (smartwatch) or on the finger (smart-ring). With respect to perceived reaction to vibration-based notifications, students indicated that the vibration cues on the wrist caused them to attend faster to the notification i.e. read the text on their smart-watch. These results are in line with the research on the perceived urgency of vibration-based notifications and the high reaction times to vibration on wearable devices (e.g., Pielot and colleagues, 2013; Hernández-Leo, Balestrini, Nieves & Blat, 2012). The results of the comparison of different vibration cues i.e., on the wrist (smartwatch), the finger (smart-ring) and on the desk (smartphone) are a small contribution to the study corpus that requires further investigation.

Unfortunately, due to very sparse data, no inferences could be made about the cost of interruption or the reaction to light as notification modality. Some partial inferences about light as a notification modality can be made based on the qualitative data. There, light-based notifications (i.e. rot-purple alternating flashing light) was perceived as very disruptive and forced the user to hide his hand despite the instructions to keep that hand with finger on always at sight. This participant mentioned also that he relied on the vibration for perceiving his notifications instead. Finally, the limited data on light as notification modality type hindered the comparison of different notification channels (vibration and light) with respect to their disruptiveness and the reaction speed.

Regarding the comprehensiveness (i.e. ease to understand the intended meaning of the notification) of the different information representation types only partial inferences can be made. The text on the smartwatch screen was perceived as equally easy to comprehend on both the smartwatch and smartphone. This result could mean that both smartphones and smartwatches could be equally good at establishing the connection between the role-based awareness visualization and the role-based awareness notification system. In that sense, this result is in line with research on text-based notification systems on smartphones, which act as middleware for establishing the connection to shared displays in a pervasive classroom environment in collaborative writing environments (Brenes, Lopez & Guerrero, 2017; Manathunga et al., 2015). Due to lack of data on light as information representation type, no

inferences could be made about its comprehensiveness. Moreover, the comparison of different information representation types (textual and visual) with respect to their comprehensiveness could be not facilitated either due to sparse data on light as information representation type.

With respect to the user experience (i.e., intuitiveness and enjoyment of use) with the different ubiquitous media, we see that the use of the smart-ring was perceived as the most intuitive and enjoyable experience. Interestingly enough, in the qualitative data students declared that the use of the smartwatch was very intuitive (i.e., "looking at it was very natural) and enjoyable ("felt quite good") but no similar remarks were made for the use of the smart-ring. Finally, the use of the smartphone was perceived as enjoyable because it created less distraction and was perceived as the least distracting medium by the writer. The displease of devil's advocate with the notifications for keeping in his role, indicate that the there is a need for making the criteria for attributing points for role-specific behaviors on the role-based awareness visualization more clear. This could also mean that the design of the role-based awareness tool could profit from insights of the research on shared visualization-systems with automated visual analytics affordances in collocated environments for collaboration (Yusoff & Salim, 2015).

Major limitations of the study design have lowered the quality of inferences in this study. First, the study design accounted for multiple aspects at the same time i.e. use of different ubiquitous media (smartwatch, smartphone, smart-ring) which afforded different notification modalities (vibration and light-based) and different information representation types (textual and graphical). Although the decision for attempting multiple comparisons at the same time was founded on the lack of similar research in the CSCL field, this was a rather ambitious endeavor. Assessing the systems at so many levels and based only on one group of participants did not allow for any generalizable inferences or for in-depth analysis of the phenomena discussed. The problems of the study design were corroborated by the lack of data on light-based notification modalities. The lack of data can be explained by the fact that students perceived the notifications almost exclusively based on the vibration cues. This means that students did not fill in any data on the "Light" section of the questionnaire.

Finally, if we were to oversee these limitations and make a preliminary inference about the most suitable medium for acting as awareness notification medium with a secondary display configuration (0-1-1) based on the results of this study, the smartwatch would stand out as the best candidate. However, this result calls for further investigation in follow-up studies. These studies should focus on comparing notification modalities of one medium based on a larger set

of participants and with the use of objective measurements for the IRC parameter values (Chewar, McCrickard & Sutcliffe, 2004).

6. Conclusions and Future Work

In this chapter, we present an overview of the findings and the discussion points from each study and draw conclusions with respect to the influence of different awareness mechanisms on raising awareness for supporting collaboration processes in the relational space of collaboration. Moreover, we draw conclusions on the influence of these collaborative processes on the process and group outcomes of collaboration in the content space of collaboration. Following, we provide replicable and generalizable design principles based on these conclusions. These principles are formed as heuristic statements and are subject to refinement in further research. Moreover, we address the limitations of the research on Argue(a)ware and conclude with suggestions for future work on Argue(a)ware.

6.1. Summary of Findings

In this section we present summaries of study processes and findings with respect to the of design approaches and research questions from each of the studies conducted in the three phases of development of Argue(a)ware.

6.1.1. Findings on awareness-oriented argumentation scripts.

In the first phase of development of Argue(a)ware tool, we built support of the content space of collaborative argumentation with argument scaffold elements in a pedagogical face-to-face macro-script and an argument mapping tool. Furthermore, we extended the use of the script for supporting the relational space of collaboration by embedding awareness prompts for reflecting on collaboration during regular breaks in the script. We designed two variations of the same of script which differ with respect to the type of group awareness prompts they used for supporting the relational space of collaboration i.e. behavioral and social. These will be referred to as awareness-oriented argumentation Scripts (AOAS) henceforth. The Behavioral Awareness Script (BAS) variation included prompts for regulating, reflecting on and evaluating the behavioral aspects of social interaction i.e., performing participation check, performance comparisons and coordination checks. The Social Awareness Script (SAS) variation included prompts for regulating, reflecting on and evaluating inter-relational aspects

of social interaction i.e., taking-up a role, evaluating performance in the role, encouraging active participation.

Upon designing the two script variations, we conducted a longitudinal, multiple-case study with in ten groups of Media Informatics master students (n = 28, in groups of three or two, group=case, 4 sessions x70 min, BAS= 5, SAS=5.) where each group was conceptualized as a case. Students collaborated every time for arguing to solve one different ill-structured problem and for transferring their arguments in the argument mapping tool Rationale. Thereby, we wanted to investigate the effects of different awareness prompts on (a) collaborative metacognitive processes i.e., regulation, reflection, and evaluation (b) the relation between collaborative metacognitive processes and the quality of collaborative argumentation as well as (c) the impact of the two script variations on perceived team effectiveness and (d) what was experience with the different parts of the script variations in the two groups and how this fits into the design framework by Buder (2011).

The quantitative analysis of argument outcomes from the groups, yield no significant difference between the groups that worked with the BAS and the SAS variations. No significant difference between the script variations with respect to the results from the team effectiveness questionnaires was found either. Quantitative content analysis of the arguments outcomes (i.e., argument maps) over time helped us define the four extreme cases of the most and least successful cases from both script variations

Video data from the sessions for collaborative argumentation of the most and least successful groups who worked with the BAS and the SAS variations were further analysed using qualitative content analysis. Prompts for regulating collaboration processes were found to be the most successfully and consistently applied ones, especially in the most successful cases from both script variations, based on the time spent on regulating the collaboration during the assigned awareness break and during the argumentation phases. Regarding the influence of the collaboration processes on the argumentation outcomes, in all four cases, we observed a synergy between the regulating processes of creating a plan and discussing the topic. These processes were prompted only in BAS variation but appeared as natural by-products of collaboration in SAS, for promoting and structuring argumentation. In the most successful case of the SAS variation the regulating processes of plan making and discussing the topic were assisted by the regulative processes of role assignment, as well as by the reflective one for making remarks for improving the collaboration next time in SAS (both prompted). These findings suggest that a combination of regulating prompts from both script variations could

lead to increased awareness of regulatory collaboration processes, and in turn, result in higher argumentation outcomes.

When examining these results with respect to the guidelines for designing awareness tools by Buder (2011), we see that the discussion-based format of the prompts (i.e. open display format) of the awareness prompts assisted the plan-making processes and role-assignment among the students (i.e. regulative processes). This discussion-based format was associated to successful application of prompts i.e., students engaged in elaborated talk on plan and role-assignment and performed the regulatory processes promptly during the awareness. It also resulted in students discussing their plan and performing in the role as a response to the prompt in the time following the awareness breaks. This reaction was consistent throughout the four sessions of collaboration in both the most and the least successful groups.

The awareness prompts afforded an explicit feedback display format (e.g. assessment of participation levels of self- and others) through discussion (Buder, 2011). The prompted explicit feedback display format (i.e., ratings of one's self and of others) was criticized for running only on subjective awareness information on participation, contribution efforts and performance in the role. In the case of awareness prompts for reflecting and evaluating collaboration, the combination of the open display format (i.e. discussion in the group) and explicit feedback display format (i.e., ratings of one's self and of other) was associated with wrong application or partial application of the prompts within the awareness breaks (i.e., students rated themselves when they had to rate others, or simply mentioned the prompt but did not act on it).This resulted in evaluation apprehension phenomena (Cottrell, 1972) and evaluation bias (i.e., users may have not assessed themselves or others frankly) (Ghadirian et al., 2016). The awareness prompts for reflection and evaluation did reveal frictions in the plan making process (i.e., dropping out of the plan for collaboration) in the least successful groups. Problems with group dynamics i.e., free-loading and presence of dominance were not powerful enough to trigger the desired changes in the behaviors of the students. The prompts for evaluating the collaboration in both script variations had no apparent connection to argumentation outcomes. The results indicated that dominant presence phenomena inhibited substantive argumentation in the least successful groups. They also indicated that the role-assignment influenced the group dynamics by helping student's making clear the labour division in the group.

The scripted awareness breaks were designed based on literature on "reflection breaks" in CSCL (Verpoorten & Vestera, 2014; Bachhel & Thaman, 2014). Awareness breaks

promoted explicit, repeated and enforced processes of feedback display (Buder, 2011). The findings of the first study showed that the imposed timing of the awareness breaks felt rather disruptive to the main task. Moreover, the five-minute time frame was perceived as sufficient for regulatory discussion, but "more than enough" for reflecting and evaluating each other's performance in collaboration. Results on the application of awareness prompts for performing Metacognitive process of collaboration during awareness breaks showed that students often utilized the breaks for off-task discussion (i.e., socializing with their group members). This type of off-topic discussion could be beneficial for establishing the socio-emotional processes in the group (Kirschner et., 2015).

Finally, the application of the prompts and the breaks "faded-out" over time. This fading-out phenomenon could be the result of demotivation from the repeated character of the task in line with "over-scripting" phenomenon as described by Dillenbourg (2002). This means that awareness prompts for reflection and evaluation may have increased the perceived complexity of the script which resulted in demotivation. It could also be an indication that students have internalised the script and do not need the prompts for engaging in the respected typed of discussion within the awareness breaks.

Finally, in terms of post-study feedback survey students reported high satisfaction with prompts for regulating collaboration in terms of planning the tasks ahead and assigning

roles amongst them. However, students did not like the prompts for evaluating their performance as writers, revisers or controllers or their coordination openly in the group. With respect to feedback on awareness breaks, students wished for shorter awareness breaks.

6.1.2. Findings on awareness scaffolds for role-based collaborative argumentation.

In the second phase of development of Argue(a)ware the focus is on structuring and regulating social interactions in the relational space of collaborative argumentation by means of scripted roles and role-based awareness scaffolds. We designed support for mirroring participation in the role (i.e., a role-based awareness visualization) and support for monitoring participation, coordination and collaboration efforts in the role (i.e., self-assessment questionnaire). Moreover, we designed additional support for guiding participation in the role i.e., role-based reminders as notifications on smartwatches.

Regarding the monitoring procedures, the group mirror aimed at making group norms of participation visible to the group members in a non-obtrusive way, thus enabling the interpersonal comparability of performances to be measured by the self-assessment questionnaire (Buder, 2011). The role-based awareness visualization and the self-assessment questionnaire are interdependent and offer the basic awareness support for awareness by combining mirroring and monitoring functions. Finally, a mock-up system (low-fidelity prototype) for delivering text-based awareness notifications via smartwatches was employed here. The awareness notification included messages which reminded students of their role duties and of the need to monitor their performance in the role-based awareness visualization. These messages aimed at guiding students directly to adhere to their role-specific behaviors in the collaborative argumentation setting and were tested here as part of the enhanced awareness version of Argue(a)ware.

In a between subjects study, ten groups of three university students each (n = 30, *Mage* =22y, mixed educational backgrounds, 1x90min) worked with two variants of the Argue(a)ware for arguing to solve one ill-structured problem and transferring their arguments in the argument mapping tool Rationale. Next, to that, students should monitor their progress in their role with the role-based awareness visualization and the self-assessment questionnaire with the basic awareness support (role-based awareness visualization with the intermediate self-assessment) and the enhanced awareness support (additional role-based awareness reminders). Half of the groups worked only with the role based awareness visualization and the self-assessment questionnaire (Basic Awareness Condition-BAC) while the other half groups received additional text-based awareness notifications via smartwatches that were sent to students privately (Enhanced Awareness Condition- EAC).

Thereby, we tested the use of different degrees of awareness support in the two conditions with respect to their impact on a) self-perceived awareness of performance in role and of collaboration and coordination efforts (measured with the same questionnaire at two time points), b) on perceive team effectiveness, c) group performance. We hypothesized that students in EAC will perform better thanks to the additional awareness reminders that increased the directivity and influenced their awareness in the role. The mixed methods analysis revealed that the awareness reminders, when perceived on time, succeeded in guiding collaboration (i.e., resulted in more role-specific behaviors). Students in the EAC condition improved their awareness over time (between the two measurements). These results indicated that enhanced awareness support in the form of additional guidance through awareness reminders can boost

the awareness of students' performance in the role as well as the awareness of their coordination and collaboration efforts over time by directing them back to the mirroring and monitoring tools.

Moreover, students in EAC exhibited higher perceived team effectiveness than the students in BAC. However, no significant differences in building of shared mental models or performing in mutual performance monitoring were found between the groups. Moreover, students in BAC and EAC did not differ significantly with respect to the formal correctness or evidence sufficiency of their group argumentation outcomes.

These results from the analysis of group performance outcomes (i.e., argumentation maps) indicate that there was no influence of awareness reminders on practicing the role-duties that would in turn affect the group performance. However, the results could be also influenced by a number of unaccounted factors which could influence the performance of the students in each the group i.e., prior knowledge on topic, prior experience with collaborative argumentation. A further study, with more systemic control over these factors is required in the next phase of development of Argue(a)ware system. The qualitative content analysis of active participation elements (i.e., argumentative contributions and role-based behaviors) in the cases of the most and least successful groups of the two conditions showed that the awareness scaffolding elements were successful in prompting the RSB but this may have come at the cost of the ARG in the least successful groups. This indicates the need for expanding the awareness support with capabilities for diagnosing difficulties in the argument discourse that go beyond the diagnosis of difficulties in acting in the role.

In the next step, we performed a quantitative content analysis for looking into the "black-box" of collaboration in terms of active participation (role-specific behaviors and argument contributions) based on the most and least successful groups. The case-ordered analysis together with the remarks from our field notes and analysis of memos indicated that repeated issuing of the notifications increased the chances of students' perceiving the notification and acting on it. However, the notifications did not manage to direct attention to role-based awareness visualization and the results of the self-assessment. These results indicated the need for expanding the awareness support for mirroring, monitoring and guiding collaboration to address active participation not only in terms of the role-specific behaviors but to motivate the argument contributions as well.

Moreover, technical difficulties with the smartphones used as delivery devices for the awareness reminders (i.e., low vibration modus) hindered the timely perception of the reminders and thus their effect on participation.

Finally, the questionnaire on the experience with the different parts of Argue(a)ware system indicated the need for exploring further media for supporting the awareness reminders in order to avoid the overwhelming effects of the multiple displays of the system and enhancing higher perceptiveness of the reminders with low interruption costs for other group members. The rather high satisfaction with the use of the role-based awareness visualization and the positive comments on the motivating aspects of monitoring how the personal success contributes to the group performance, indicate that the group mirror succeeded in making group norms visible to group members in a non-obtrusive way. The high interpersonal comparability of performances without moderating the group interactions directly in the basic awareness condition was proven to be the favored design approach compared to the combination of group mirror and awareness reminders in the enhance awareness condition.

Finally, the role-based awareness notification tool should draw the information from the role-based awareness visualization and the self-assessment tool and build on them to offer customized advice to students for increasing the effectiveness of the collaboration.

6.1.3. Findings on ubiquitous media for a role-based awareness notification system.

In the third phase of the development of Argue(a)ware, we focused on designing and testing different notification modes on different ubiquitous mobile devices for facilitating the next prototype of a notification system for role-based awareness reminders. Thereby, the aim of the system was again to guide students' active participation in collaborative argumentation. More specifically, we focused on raising students' attention to the reminders and triggering a prompter reaction to the contents of the reminders whilst avoiding a high interruption cost for the primary task (i.e., arguing for solving the problem at hand) in the group. These goals were translated into design challenges for the design of the role-based awareness notification system. The system should afford low interruptions, high reaction and high comprehension of notifications. Notification systems with this configuration of IRC values are known as "secondary display" systems (McCrickard et al., 2003).

Next, we designed three low-fidelity prototypes for a role-based notification system for delivering awareness reminders: The first run on a smartwatch and afforded text-based information with vibration and light notification modalities. The second run on smartphone and afforded text-based information with vibro-tactile and light-based notification modalities. Finally, the third prototype run on a smart-ring which afforded graphical- based (i.e. abstract light) information with and light and vibration notification modalities.

To test the suitability of these prototypes for acting as "secondary display" systems, we conducted a within-subjects user study where three university students (n= 3, Mage=28, mixed educational background) argued for solving three different problem cases and producing an argument map in each of the three consecutive meetings (max 90min) in the Argue(a)ware instructional system. Students were assigned the roles of writer, corrector and devil`s advocate and were instructed to maintain the same role across the three meetings. In each meeting students worked with a different role-based awareness notification prototype, where they received a notification indicating their balloon is not growing bigger after five minutes of not exhibiting any role-specific behaviors. The role-based awareness notification prototypes aimed at introducing timely interventions which would prompt students to check on their own progress in the role and the group progress as visualized by the role-based awareness visualization on the large display. Ultimately, this should prompt them to reflect on the awareness information from the visualization and adapt their behaviors to the desired behavior standards over time.

In this study, we compared users' perceived cost of interruption to the main task, perceived reaction time (i.e., time needed for attending to notification upon noticing it) and comprehension (i.e., ease of understanding the intended message of the notification for looking at the group mirror). Thereby, the IRC parameter values of notifications the different role-based awareness notification prototypes were calculated with respect to their notification modalities (vibration and light) and information representation types (textual vs. graphical) by means of mixed methods analysis. Additionally, we examined the user experience with the different prototypes as part of the "Argue(a)ware" setting for collaborative argumentation. Students' evaluations of the different role-based awareness notification prototypes aimed at helping us shape the design final product (formative evaluation) by defining the perceived influence on the IRC related phenomena (summative evaluation).

Results showed that students perceived the notifications from all media mostly based on vibration cues. Thereby, the vibration cues on the wrist (smartwatch) were considered the

least disruptive to the main task compared to the vibration cues on finger (smart-watch) and the vibration cues on the desk (smartphone). Students also declared that vibration cues on wrist prompted the fastest reaction i.e., attending to notification by interacting with the smartwatch. These results indicate that vibration cues on the wrist can be a suitable notification mechanism for increasing the perceived urgency of the message and prompting the reaction on it without causing great distraction to the main task, as studies previous studies showed before (Pielot and colleagues, 2013; Hernández-Leo, Balestrini, Nieves & Blat, 2012).

Based on very limited qualitative data on light as notification modality and awareness representation type no inferences could be made about its influence on the cost of interruption, reaction and comprehension parameters comprehensiveness. That said, we could make inferences only about the comprehensiveness of textual information representation types on the smartwatch and the smartphone. There the intended instruction of the text-notification to monitor the collaboration was perceived as equally easy to understand. This result is in with line the research on text-based notification systems on smartphones and smartwatches, which act as middleware for establishing the connection to shared displays in a pervasive classroom environment in collaborative writing environments (Brenes, Lopez & Guerrero, 2017; Manathunga et al., 2015).

The qualitative and quantitative data on the experience with different media as awareness notification systems, favor different prototypes. Qualitative data on the experience with the media indicate that the smartwatch was a very intuitive and enjoyable experience, while quantitative data on user experience (mean of intuitiveness and enjoyment of use) indicate that the smart-ring offered the best experience. A combination of quantitative results on disruptiveness of vibration cues on the wrist and the qualitative results on the user experience, indicate that smartwatches may be the most suitable medium for acting as awareness notification medium with a “secondary display” IRC configuration (low-high-high). However, this inference needs to be tested in terms of follow up study. In the next study, the great limitations of study (limited data due to low power and mal-structured measurement instruments) need to be repaired. Finally, the focus should be on comparing notification modalities of one medium (e.g., smartphone) based on a larger set of participants and with the use of objective measurements for the IRC parameter values (Chewar, McCrickard & Sutcliffe, 2004).

6.2. Conclusions

Design principles are considered as the scientific outcomes of design-based research while the design artifacts are considered as the practical outcomes of it. Design principles are defined as "evidence-based heuristics that can inform future development and implementation decisions" (Herrington et. al., 2013, p.8). They contain procedural knowledge with emphasis on the comprehensive presentation of the procedures, results and context in order to allow the readers to determine which insights may be relevant to their own specific needs. Finally, generalization of research findings from design-based research study is rather limited; instead, design principles are used for the purposes of analytical generalization. Thereby, we will attempt to keep the mechanisms that caused learning (i.e., learning of argumentation) separate from the context and form expectations for how these mechanisms could perform in other or similar contexts (Ercikan & Roth, 2014)

Van den Akker (1999) suggests a heuristic format of statements for conveying the knowledge encompassed in design principles, such as, "If you want to design intervention X [for purpose/function Y in context Z]; then you are best advised to give that intervention the characteristics C1, C2, …, Cm [substantive emphasis]; and do that via procedures P1, P2, …, Pn [procedural emphasis]; because of arguments…" (in Herrington et. al., 2013 p. 9). Here, we will adopt this format to produce the design principles as a scientific outcome of our work:

1. If you want to design support for raising students' awareness of behavioral and social aspects of collaborative argumentation by engaging them in metacognitive regulatory processes, (i.e., plan making, role-assignment); then you are best advised to use process prompts with an open display format of information (i.e., discussion based format), with question asking affordances (i.e., "Is the problem clear to all of you?") and concrete instructions for discussion (i.e. "Discuss any ambiguities in the group") to elicit explanations on topic and processes. These prompts are better presented during a short-dedicated break from collaboration at the beginning of each session for collaborative learning. These prompts allow students to exchange information on who does not understand what or who feels more competent to take up a certain task, so they can engage in help for each other and increase positive interdependence. Moreover, these breaks have an influence on the regulatory processes of collaboration (i.e., discussing the topic) also outside the break for collaboration. There is no

need for "fading-out" this prompt but adopting flexible time frames for engaging in these processes is suggested.

2. If you want to design support for raising students' awareness of behavioral aspects (i.e., participation level and contributions in their role) of collaborative argumentation by assisting their reflection and evaluation processes, you are best advised to use a combination of monitoring tools with explicit feedback (i.e., ratings of participation and contributions with the self-assessment questionnaire) and mirroring tools (i.e., implicit feedback on participation with a visualization tool). This combination of tools can increase the interpersonal comparability and promote individual accountability by making group norms visible to group members in a non-obtrusive way. It can also motivate the active participation in the role duties.

3. If you want to design support for guiding participation in collaborative argumentation, you are best advised to use an awareness notification system as personal secondary display of information; where the students receive prompting messages for monitoring their collaboration. This tool should afford low interruption cost to the main task (i.e. perceiving the notification with a glance or by interacting quickly with the medium), high reaction (i.e. fast response time) to the content of the display and the high comprehension of the notification (i.e. understanding of the context and long-term memorization of information). This text-based information representation format is advised due to its clarity for conveying the message and associating the message to the intended; monitoring collaboration with the help of the visualization tool. Vibro-tactile notification modalities are preferred notification modes because the result in higher reaction. Smartphones could be considered for the potential to act as secondary display in collaborative argumentation.

6.3. Limitations

One big limitation of this thesis is the lack of pre-and post-measurements with respect to the argumentation outcomes from the first two studies. The use of argumentation scaffolds and the argument mapping tool for learning and practicing the structural argumentation elements (Toulmin, 1958; 2003) was assessed only means of feedback survey on the user experience with them. The learning gains in group performance were assessed only by comparing the first session to the fourth session for collaboration in the first study, while in the second study the learning of structural argumentation elements was assessed in one session for collaboration. Moreover, the study did not include any measurements for assessing prior

knowledge in the domain or any post-test for controlling domain-learning gains from the process of arguing to solve ill-structured problems. These are all limitations compared with experimental studies. However, in our complex and ecologically valid setting we had the chance to look into the mechanisms that connect the awareness mechanisms to the collaboration processes and how the latter influence the argument quality.

Another limitation of this study, when compared to experimental studies, is the lack of a control condition. The rationale behind this absence of a control group is that the study design aimed at gaining procedural and design knowledge for informing the development of a tool. Therefore, the comparison between a collaborative argumentation setting without group awareness support vs. a collaborative argumentation with the Argu(a)ware would be feasible after the development of the tool has reached a mature stage.

Finally, we know due small sample size and multiple confounding factors in our study, our results are not generalizable. In this respect, we argue that the procedural knowledge from the interventions implemented in this study is of value for designers, researchers and practitioners who may want to design, research and employ similar tools for raising collaborative argumentation.

6.4. Directions for Future Work

In the next phase of development of Argue(a)ware, we would like to explore the potential of allowing students to customize the system through tailoring activities by themselves, i.e. create an adaptable system (Oppermann, 2005). In that way, we can increase the match between the user needs and the behaviors of the system and keep the system flexible. However, this a rather long-term goal, as it requires a higher fidelity prototype of the Argue(a)ware group awareness tool for collaborative argumentation.

For achieving this goal, we can take small steps by designing more flexible macro and micro scripts for collaborative argumentation and considering more flexibility in the use of the systems of guidance and regulation i.e., by allowing students to send reminders to fellow group members for activating their participation.

Moreover, we would like to shift from the user-centered design approach to a design approach that involve more stakeholder i.e., teachers and students should co-designers in the next phases of development of the tool. The idea that stakeholders could become co-designers not only at design time, but throughout the whole existence of the system in line with the Meta-Design

theory (Fischer, 2003). During our studies, we collected user experience data from Media Informatics students at LMU. Their feedback on the design features of the different prototypes of the tool was quite valuable to us and inspired the idea that students should have some control over the design of the systems and the chance to create and contribute their own visions and objectives. Their design background could be making them the ideal users to engage in informed participation for co-creating innovative computational environments for supporting awareness in collaborative argumentation settings.

7. References

Alavi H.S & Dillenbourg, P. (2012). An Ambient Awareness Tool for Supporting Supervised Collaborative Problem Solving. IEEE Transactions on Learning Technologies, 5(3) 264-274.

Andriessen J., Baker M., Suthers D. (2003). Argumentation, Computer Support, and the Educational Context of Confronting Cognitions. In: Andriessen J., Baker M., Suthers D. (Eds) *Arguing to Learn. Computer-Supported Collaborative Learning*, vol 1. Springer, Dordrecht.

Andriessen, J. (2005). Arguing to Learn. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 443–460). Cambridge: Cambridge University Press. Retrieved from http://ebooks.cambridge.org/ref/id/CBO9780511816833A037

Arroyo, E., & Selker, T. (2003). Arbitrating multimodal outputs: Using ambient displays as interruptions. *Human-Computer Interaction: Theory and Practice (Part II)-Proceedings of HCI International*, *2*, 591-595.

Bachhel, R. & Thaman, R. G. (2014). Effective use of pause procedure to enhance student engagement and learning. *Journal of Clinical & Diagnostic Research*, *8*(8), 1-3. doi:10.7860/JCDR/2014/8260.4691

Baker, M. (2003). Computer-Mediated Argumentative Interactions for the Co-Elaboration of Scientific Notions. In J. Andriessen, M. Baker, & D. Suthers (Eds.), *Arguing to Learn* (pp. 47–78). Dordrecht: Springer Netherlands. Retrieved from http://link.springer.com/10.1007/978-94-017-0781-7_3

Bakker A., van Eerde D. (2015). An Introduction to Design-Based Research with an Example From Statistics Education. In: Bikner-Ahsbahs A., Knipping C., Presmeg N. (Eds) *Approaches to Qualitative Research in Mathematics Education. Advances in Mathematics Education.* Springer, Dordrecht

Barron, B. (2003). When smart groups fail. Journal of the Learning Sciences, 12(3), 307-309. Routledge

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning*, *1996*(68), 3–12. https://doi.org/10.1002/tl.37219966804

Beers, P. J., Kirschner, P. A., Boshuizen, H. P., & Gijselaers, W. H. (2007). ICT-support for grounding in the classroom. Instructional Science, 35(6), 535-556.

Belkadi, F., Bonjour, E., Camargo, M., Troussier, N., & Eynard, B. (2013). A situation model to support awareness in collaborative design. *International Journal of Human-Computer Studies*, *71*(1), 110–129. https://doi.org/10.1016/j.ijhcs.2012.03.002

Bell, P., Hoadley, C., M., and Linn, M., C.(2004). Design-based research in education. *Internet environments for science education*, 73-85.

Belland, B. R., Glazewski, K. D., & Richardson, J. C. (2011). Problem-based learning and argumentation: Testing a scaffolding framework to support middle school students' creation of evidence-based arguments. Instructional Science, 39(5), 667-694.

Bodemer, D., & Dehler, J. (2011). Group awareness in CSCL environments. *Computers in Human Behavior*, *27*(3), 1043–1045. https://doi.org/10.1016/j.chb.2010.07.014

Buckingham Shum, S. (2003). The Roots of Computer Supported Argument Visualization. In P. A. Kirschner, S. J. Buckingham Shum, & C. S. Carr (Eds.), *Visualizing Argumentation* (pp. 3–24). London: Springer London. Retrieved from http://link.springer.com/10.1007/978-1-4471-0037-9_1

Buder, J. & Bodemer, D. (2008). Supporting controversial CSCL discussions with augmented group awareness tools. I*nternational Journal of Computer-Supported Collaborative Learning*, *3*(2), 123-139.

Buder, J. (2011). Group awareness tools for learning: Current and future directions. *Computers in Human Behavior*, *27*(3), 1114–1117. https://doi.org/10.1016/j.chb.2010.07.012

Buder, J., & Bodemer, D. (2008). Supporting controversial CSCL discussions with augmented group awareness tools. *International Journal of Computer-Supported Collaborative Learning*, *3*(2), 123–139. https://doi.org/10.1007/s11412-008-9037-5

Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: synchronizing task-oriented collaborative activity. *International Journal of Human-Computer Studies*, *58*(5), 605–632. https://doi.org/10.1016/S1071-5819(03)00024-7

Cavagnetto, A., Hand, B. M., & Norton-Meier, L. (2010). The nature of elementary student science discourse in the context of the science writing heuristic approach. *International Journal of Science Education*, *32*(4), 427-449.

Chavez, J., & Romero, M. (2012). Group Awareness, Learning, and Participation in Computer Supported Collaborative Learning (CSCL). *Procedia - Social and Behavioral Sciences*, *46*, 3068–3073. https://doi.org/10.1016/j.sbspro.2012.06.012

Chewar, C. M., McCrickard, D. S., & Sutcliffe, A. G. (2004, August). Unpacking critical parameters for interface design: evaluating notification systems with the irc framework. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques* (pp. 279-288). ACM.

Chinn, C. A. (2006). Learning to argue. *Collaborative learning, reasoning, and technology*, 355-383.

Chinn, C., & Clark, D. B. (2013). Learning through collaborative argumentation. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. M. O'Donnell (Eds.), International handbook of collaborative learning (pp. 314-332). New York: Routledge.

Clark, D. B., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *45*(3), 293-321.

Clark, D. B., D'Angelo, C. M., & Menekse, M. (2009). Initial structuring of online discussions to improve learning and argumentation: Incorporating students' own explanations as seed comments versus an augmented-preset approach to seeding discussions. *Journal of Science Education and Technology*, *18*(4), 321-333.

Cottrell, N. B. Social facilitation. In C. G. McClintock (Ed.),*Experimental social psychology*. New York: Holt, Rinehart & Winston, 1972.

Creswell, J. W. (2003). Research design.

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: what are the differences and do they matter?. Higher education, 62(3), 279-301.

Davies, W. M. (2009). Computer-assisted argument mapping: a rationale approach. Higher Education, 58(6), 799-820.

de Jong, F., Kollöffel, B., van der Meijden, H., Staarman, J. K., & Janssen, J. (2005). Regulative processes in individual, 3D and computer supported cooperative learning contexts. Computers in Human Behavior, 21(4), 645-670.

De Wever, B., Van Keer, H., Schellens, T., & Valcke, M. (2010). Roles as a structuring tool in online discussion groups: The differential impact of different roles on social knowledge construction. Computers in Human Behavior, 26(4), 516-523.

Di Micco, J, M., Hollenbach, K, Pandolfo A. and Bender W,. 2007. The impact of increased awareness while face-to-face. Human-Computer Interaction, 22, (1), 47-96.

Di Vesta, F. J., & Smith, D. A. (1979). The pausing principle: Increasing the efficiency of memory for ongoing events. Contemporary Educational Psychology, 4(3), 288-296.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design.

Dillenbourg, P., & Jermann, P. (2007). Designing integrative scripts. In *Scripting computer-supported collaborative learning*(pp. 275-301). Springer US.

Dillenbourg, P., & Hong, F. (2008). The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, *3*(1), 5-23.

Dourish, P., & Bellotti, V. (1992, December). Awareness and coordination in shared workspaces. In *Proceedings of the 1992 ACM conference on Computer-supported cooperative work* (pp. 107-114). ACM.

Fischer, F., Bruhn, J., Gräsel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. Learning and Instruction, 12(2), 213-232.

Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., ... & Strijbos, J. W. (2014). Scientific reasoning and argumentation: Advancing an interdisciplinary research agenda in education. *Frontline Learning Research*, *2*(3), 28-45.

Fischer, G. (2003, June). Meta-design: Beyond user-centered and participatory design. In *Proceedings of HCI international* (Vol. 4, pp. 88-92).

Fransen, J., Kirschner, P. A., & Erkens, G. (2011). Mediating team effectiveness in the context of collaborative learning: The importance of team and task awareness. *Computers in Human Behavior*, *27*(3), 1103–1113. https://doi.org/10.1016/j.chb.2010.05.017

Fysaraki, M., & Hussmann, H. (2016). Towards Tool Support for Team Awareness in Collaborative Argumentation: (pp. 507–512). SCITEPRESS - Science and Technology Publications. https://doi.org/10.5220/0005905605070512

Fysaraki, M., Fischer, F., Hußmann, H., & Stegmann, K. (2016). Team Awareness Support for Collaborative Argumentation in Higher Education: A Qualitative Multiple-Case Study. In C. K. Looi, J. L. Polman, U. Cress, & P. Reimann (Eds.), Transforming learning, empowering learners: The International Conference of the Learning Sciences (ICLS)

2016, Volume 2 (pp. 1227-1228). Singapore: International Society of the Learning Sciences.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). Educational research: An introduction. Longman Publishing.

Gijlers, H., Weinberger, A., van Dijk, A. M., Bollen, L., & van Joolingen, W. (2013). Collaborative drawing on a shared digital canvas in elementary science education: The effects of script and task awareness support. *International Journal of Computer-Supported Collaborative Learning*, *8*(4), 427–453. https://doi.org/10.1007/s11412-013-9180-5

Goodyear, P., Jones, C., & Thompson, K. (2014). Computer-supported collaborative learning: Instructional approaches, group processes and educational designs. In Handbook of research on educational communications and technology (pp. 439-451). Springer New York.

Gu, X., Shao, Y., Guo, X., & Lim, C. P. (2015). Designing a role structure to engage students in computer-supported collaborative learning. The Internet and Higher Education, 24, 13-20.& Morris, R., Hadwin, A. F., Gress, C. L., Miller, M., Fior, M., Church, H., & Winne, P. H. (2010). Designing roles, scripts, and prompts to support CSCL in gStudy. Computers in Human Behavior, 26(5), 815-824.

Gutwin, C., Penner, R., & Schneider, K. (2004, November). Group awareness in distributed software development. In Proceedings of the 2004 ACM conference on Computer supported cooperative work (pp. 72-81). ACM.

Haller, M., Leitner, J., Seifried, T., Wallace, J. R., Scott, S. D., Richter, C., ... & Hunter, S. (2010, April). The nice discussion room: Integrating paper and digital media to support co-located group meetings. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 609-618). ACM.

Harrell, M., & Wetzel, D. (2015). Using Argument Diagramming to Teach Critical Thinking in a First-Year Writing Course. In The Palgrave Handbook of Critical Thinking in Higher Education (pp. 213-232). Palgrave Macmillan US.

Herrington, J., McKenney, S., Reeves, T., & Oliver, R. (2007, June). Design-based research and doctoral students: Guidelines for preparing a dissertation proposal. In *EdMedia: World Conference on Educational Media and Technology* (pp. 4089-4097). Association for the Advancement of Computing in Education (AACE).

Hernández-Leo, D., Balestrini, M., Nieves, R., & Blat, J. (2012). Exploiting awareness to facilitate the orchestration of collaborative activities in physical spaces. In *2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning, EC-TEL2012. CEUR WS* (Vol. 931, pp. 55-56).

Hinfner, T. (2017). Evaluation von mobilen Geräten als Awareness - Benachrichtugungssysteme in CSCL. Ludwig Maximilian University, Munich.

Hmelo, C. E., & Lin, X. (2000). Becoming self-directed learners: Strategy development in problem-based learning. Problem-based learning: A research perspective on learning interactions, 227-250.

Huberman, A. M., & Miles, M. B. (1984). *Innovation up Close*. Boston, MA: Springer US. Retrieved from http://link.springer.com/10.1007/978-1-4899-0390-7

Janssen, J., & Bodemer, D. (2013). Coordinated Computer-Supported Collaborative Learning: Awareness and Awareness Tools. *Educational Psychologist*, *48*(1), 40–55. https://doi.org/10.1080/00461520.2012.749153

Janssen, J., Erkens, G., & Kanselaar, G. (2007). Visualization of agreement and discussion processes during computer-supported collaborative learning. Computers in Human Behavior, 23(3), 1105-1125.

Janssen, J., Erkens, G., & Kirschner, P. A. (2011). Group awareness tools: It's what you do with it that matters. *Computers in Human Behavior*, *27*(3), 1046–1058. https://doi.org/10.1016/j.chb.2010.06.002

Järvelä, S., & Hadwin, A. F. (2013). New frontiers: Regulating learning in CSCL. Educational Psychologist, 48(1), 25-39.

Jermann, P., & Dillenbourg, P. (2008). Group mirrors to support interaction regulation in collaborative problem solving. Computers & Education, 51(1), 279-296.

Jermann, P., Soller, A., & Muehlenbrock, M. (2001). From mirroring to guiding: A review of the state of art technology for supporting collaborative learning. In European Conference on Computer-Supported Collaborative Learning EuroCSCL-2001(pp. 324-331).

Johnson, D. W., & Johnson, R. T. (1999). *Learning together and alone: cooperative, competitive, and individualistic learning (5th ed.).* Boston, MA: Allyn & Bacon.

Johnson, D. W., & Johnson, R. T. (2004). Cooperation and the use of technology. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology (pp. 785–811).* Mahwah, NJ: Lawrence Erlbaum Associates.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, *1*(2), 112–133. https://doi.org/10.1177/1558689806298224

Judele, R., Tsovaltzi, D., Puhl, T., & Weinberger, A. (2014, January). Collaborative learning in Facebook: Adverse effects of individual preparation. In system sciences (HICSS), 2014 47th Hawaii international conference on (pp. 1616-1624). IEEE.

Kanselaar, G., Andriessen, J., Erkens, G., Jaspers, J., Prangsma, M. E., & Veerman, A. L. (2002). Co-construction of knowledge in computer supported collaborative argumentation (CSCA). Three Worlds of CSCL: Can we support CSCL?, 93-130.

Karacapilidis, N., Papadias, D. (2001). Computer supported argumentation and collaborative decision making: the HERMES system, In *Information Systems*, *26*(4), 259-277.

Karousos, N., Papaloukas, S., Kostaras, N., Xenos, M., Tzagarakis, M., & Karacapilidis, N. (2010). Usability Evaluation of Web-Based Collaboration Support Systems: The Case of CoPe_it!. Knowledge Management, Information Systems, E-Learning, and Sustainability Research, 248-258.

Kim, K, Grabowski, B, & Sharma, P. (2004). Designing a Classroom as a Learner-Centered Learning Environment Prompting Students' Reflective Thinking in K-12. *Association for Educational Communications and Technology*, *3*(3), 123-130.

Kimmerle, J., Cress, U., & Hesse, F. W. (2007). An interactional perspective on group awareness: Alleviating the information-exchange dilemma (for everybody?). *International Journal of Human-Computer Studies*, *65*(11), 899–910. https://doi.org/10.1016/j.ijhcs.2007.06.002

Kirschner, P. A., Jochems, W., Dillenbourg, P., & Kanselaar, G. (2002). Three worlds of CSCL: Can we support CSCL? Heerlen: Open University of the Netherlands.

Kirschner, P. A., Kreijns, K., Phielix, C., & Fransen, J. (2014). Awareness of cognitive and social behaviour in a CSCL environment: Self- and group awareness in CSCL. *Journal of Computer Assisted Learning*, *31*(1), 59–77. https://doi.org/10.1111/jcal.12084

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in human behavior*, *19*(3), 335-353.

Kreijns, K., Kirschner, P.A. & Vermeulen, M. (2013). Social Aspects of CSCL Environments: A Research Framework. *Educational Psychologist*, *48*(4), 229-242.

Krippendorff, K. (1989). Content analysis. In E. Barnouw, G. Gerbner, W. Schramm, T. L. Worth, & L. Gross (Eds.), International encyclopedia of communication (Vol. 1, pp. 403-407). New York, NY: Oxford University Press. Retrieved from http://repository.upenn.edu/asc_papers/226

Krippendorff, K. (2004). Reliability in content analysis. Human communication research, 30(3), 411-433.

Lazonder, A. W., Wilhelm, P., & Ootes, S. A. (2003). Using sentence openers to foster student interaction in computer-mediated learning environments. Computers & Education, 41(3), 291-308.

Lee, H., & Kim, D. (2013). Designing Sentence Templates in Computer-Supported Collaborative Learning. *International Journal of Information and Education Technology*, 222–225. https://doi.org/10.7763/IJIET.2013.V3.268

Lin, X., Hmelo, C., Kinzer, C. K., & Secules, T. J. (1999). Designing technology to support reflection. *Educational Technology Research and Development*, *47*(3), 43–62. https://doi.org/10.1007/BF02299633

Liu, C. C., & Tsai, C. C. (2008). An analysis of peer interaction patterns as discoursed by on-line small group problem-solving activity. Computers & Education, 50(3), 627-639.

Lopez, G & Guerrero, L,A. (2017). Awareness Supporting Technologies used in Collaborative Systems: A Systematic Literature Review. In Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17), 808-820.

Lund, K., Molinari, G., Séjourné, A., & Baker, M. (2007). How do argumentation diagrams compare when student pairs use them as a means for debate or as a tool for representing debate?. International Journal of Computer-Supported Collaborative Learning, 2(2), 273-295.

Martinez-Maldonado, R., Clayphan, A., Yacef, K., & Kay, J. (2014). Towards providing notifications to enhance teacher's awareness in the classroom. In International Conference on Intelligent Tutoring Systems (pp. 510-515). Springer International Publishing.

McCrickard, D. S., Chewar, C, M., & Somervell, J. (2004). Design, science, and engineering topics?: teaching HCI with a unified method. In Proceedings of the 35th SIGCSE technical symposium on Computer science education (SIGCSE '04). ACM, New York, NY, USA, 31-35.

McCrickard, D. S., Czerwinski, M., & Bartram, L. (2003). Introduction: design and evaluation of notification user interfaces. *International Journal of Human-Computer Studies*, *58*(5), 509-514.

Meier, C. (2017). *Konzeptionierung eines Group Awareness Tools zur Unterstützung der Social und Behavioral Group Awareness*. Ludwig Maximilians University, Munich.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: a methods sourcebook* (Third edition). Thousand Oaks, Califorinia: SAGE Publications, Inc.

Miller, M., & Hadwin, A. (2015). Scripting and awareness tools for regulating collaborative learning: Changing the landscape of support in CSCL. Computers in Human Behavior, 52, 573-588.

Mohammed, S., & Dumville, B. C. (2001). Team mental models in a team knowledge framework: Expanding theory and measurement across disciplinary boundaries. Journal of organizational Behavior, 22(2), 89-106.

Monteserin, A., Schiaffino, S., & Amandi, A. (2010). Assisting students with argumentation plans when solving problems in CSCL. Computers & Education, 54(2), 416-426.

Morris, R., Hadwin, A. F., Gress, C. L. Z., Miller, M., Fior, M., Church, H., & Winne, P. H. (2010). Designing roles, scripts, and prompts to support CSCL in gStudy. *Computers in Human Behavior*, *26*(5), 815–824. https://doi.org/10.1016/j.chb.2008.12.001

Nelson, K. M., & Cooprider, J. G. (1996). The contribution of shared knowledge to IS group performance. *MIS quarterly*, 409-432.

Noroozi, O., Weinberger, A., Biemans, H. J., Mulder, M., & Chizari, M. (2012). Argumentation-based computer supported collaborative learning (ABCSCL): A synthesis of 15 years of research. Educational Research Review, 7(2), 79-106.

Ogata, H., Matsuura, K., & Yano, Y. (1996). Knowledge awareness: Bridging between shared knowledge and collaboration in sharlok. Proceedings of Educational Telecommunications, 232-237.

Phielix, C., Prins, F. J., Kirschner, P. A., Erkens, G., & Jaspers, J. (2011). Group awareness of social and cognitive performance in a CSCL environment: Effects of a peer feedback and reflection tool. *Computers in Human Behavior*, *27*(3), 1087–1102. https://doi.org/10.1016/j.chb.2010.06.024

Pielot, M., Church, K., & De Oliveira, R. (2014, September). An in-situ study of mobile phone notifications. In *Proceedings of the 16th international conference on Human-computer interaction with mobile devices & services* (pp. 233-242). ACM.

Pifarré, M., Cobos, R., & Argelagós, E. (2014). Incidence of group awareness information on students' collaborative learning processes: Incidence of group awareness information. *Journal of Computer Assisted Learning*, *30*(4), 300–317. https://doi.org/10.1111/jcal.12043

Piskurich, G. M. (2015). *Rapid instructional design: Learning ID fast and right*. John Wiley & Sons.

Pousman, Z., & Stasko, J. (2006, May). A taxonomy of ambient information systems: four patterns of design. In Proceedings of the working conference on Advanced visual interfaces (pp. 67-74). ACM.

Rahwan, I., & Sakeer, P. V. (2006). Towards representing and querying arguments on the semantic web. *Frontiers In Artificial Intelligence And Applications*, *144*, (3).

Reeves, T. (2006). Design research from a technology perspective. In *Educational design research* (pp. 64-78). Routledge.

Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education*, *16*(2), 96.

Reid, C. E. (2011). Rationale argument mapping software. Journal of Technology in Human Services, 29(2), 147-154.

Rick, J., & Horn, M. (2013). Human--Computer Interaction and the Learning Sciences. International Society of the Learning Sciences.

Röcker, C. (2009). Perceived Usefulness and Perceived Ease-of-Use of Ambient Intelligence Applications in Office Environments. In M. Kurosu (Ed.), *Human Centered Design* (Vol. 5619, pp. 1052–1061). Berlin, Heidelberg: Springer Berlin Heidelberg. Retrieved from http://link.springer.com/10.1007/978-3-642-02806-9_120

Ruhl, K. L., Hughes, C. A., & Schloss, P. J. (1987). Using the pause procedure to enhance lecture recall. Teacher education and special education, 10(1), 14-18.

Ryu, S., & Sandoval, W. A. (2015). The Influence of Group Dynamics on Collaborative Scientific Argumentation. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(3), 335–351. https://doi.org/10.12973/eurasia.2015.1338a

Sandoval, W. A., & Bell, P. (2004). Design-based research methods for studying learning in context: Introduction. *Educational psychologist*, *39*(4), 199-201.

Salim, S. S. (2015). A systematic review of shared visualisation to achieve common ground. Journal of Visual Languages & Computing, 28, 83-99.

Sangin, M., Molinari, G., Nüssli, M.-A., & Dillenbourg, P. (2011). Facilitating peer knowledge modeling: Effects of a knowledge awareness tool on collaborative learning outcomes and processes. *Computers in Human Behavior*, *27*(3), 1059–1067. https://doi.org/10.1016/j.chb.2010.05.032

Scheuer, O., & McLaren, B. M. (2013). CASE: A configurable argumentation support engine. IEEE Transactions on Learning Technologies, 6(2), 144-157.
2 Scheuer, O., McLaren, B. M., Weinberger, A., & Niebuhr, S. (2014). Promoting critical, elaborative discussions through a collaboration script and argument diagrams. Instructional Science, 42(2), 127-157.

Scheuer, O., McLaren, B. M., Weinberger, A., & Niebuhr, S. (2014). Promoting critical, elaborative discussions through a collaboration script and argument diagrams. Instructional Science, 42(2), 127-157.

Slof, B., Erkens, G., Kirschner, P. A., Jaspers, J. G., & Janssen, J. (2010). Guiding students' online complex learning-task behavior through representational scripting. *Computers in Human Behavior*, *26*(5), 927-939.

Shum, S. B. (2003). The roots of computer supported argument visualization. In Visualizing argumentation (pp. 3-24). Springer London.

Soller, A., Martinez, A., Jermann, P. & Muehlenbrock, P. (2005). From Mirroring to Guiding: A Review of State of the Art Technology for Supporting Collaborative Learning. *International Journal of Artificial Intelligence in Education (IJAIED), 15*, 261-290

Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*, *2*(4), 421–447. https://doi.org/10.1007/s11412-007-9028-y

Soller, A., Martinez, A., Jermann, P. & Muehlenbrock, P. (2005). From Mirroring to Guiding: A Review of State of the Art Technology for Supporting Collaborative Learning. *International Journal of Artificial Intelligence in Education (IJAIED), 15*, 261-290

Strijbos, J. W., Martens, R. L., Jochems, W. M., & Broers, N. J. (2004). The effect of functional roles on group efficiency: Using multilevel modeling and content analysis to investigate computer-supported collaboration in small groups. Small Group Research, 35(2), 195-229.

Suthers, D. D., Vatrapu, R., Medina, R., Joseph, S., & Dwyer, N. (2008). Beyond threaded discussion: Representational guidance in asynchronous collaborative learning environments. Computers & Education, 50(4), 1103-1127.

Tang, K. H., & Lee, Y. H. (2016). Evaluation of detection and discrimination ability of peripheral vision on notification information based on large displays. *Displays*, *41*, 50-60.

Tausch, S., Ta, S., & Hussmann, H. (2016). A Comparison of Cooperative and Competitive Visualizations for Co-located Collaboration. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (pp. 5034-5039). ACM.

Tarasewich, P., Campbell, C. S., Xia, T., & Dideles, M. (2003, October). Evaluation of visual notification cues for ubiquitous computing. In *International Conference on Ubiquitous Computing* (pp. 349-366). Springer, Berlin, Heidelberg.

Teasley, S. D. (1997). Talking about reasoning: How important is the peer in peer collaboration?. In Discourse, tools and reasoning (pp. 361-384). Springer Berlin Heidelberg. Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. Computers & education, 46(1), 71-95.

Toulmin, S. E. (2003). *The Uses of Argument: Updated Edition* (2nd ed.). Cambridge: Cambridge University Press. Retrieved from http://ebooks.cambridge.org/ref/id/CBO9780511840005

Toulmin, Stephen (1958). The Uses of Argument. Cambridge: Cambridge University Press.

Tsovaltzi, D., Puhl, T., Judele, R., & Weinberger, A. (2014). Group awareness support and argumentation scripts for individual preparation of arguments in Facebook. *Computers & Education*, *76*, 108–118. https://doi.org/10.1016/j.compedu.2014.03.012

Twardy, C. (2004). Argument maps improve critical thinking. *Teaching Philosophy*, *27*(2), 95-116.

Van den Akker, J. (1999). Principles and methods of development research. In *Design approaches and tools in education and training* (pp. 1-14). Springer Netherlands.

Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.). (2006). *Educational design research*. Routledge.

Van Amelsvoort, M., Andriessen, J., & Kanselaar, G. (2007). Representational tools in computer-supported collaborative argumentation-based learning: How dyads work

with constructed and inspected argumentative diagrams. The Journal of the Learning Sciences, 16(4), 485-521.

van Bruggen, J. M., Boshuizen, H. P. A., & Kirschner, P. A. (2003). A Cognitive Framework for Cooperative Problem Solving with Argument Visualization. In P. A. Kirschner, S. J. Buckingham Shum, & C. S. Carr (Eds.), *Visualizing Argumentation* (pp. 25–47). London: Springer London. Retrieved from http://link.springer.com/10.1007/978-1-4471-0037-9_2

van Echtelt, F. E. A., Wynstra, F., van Weele, A. J., & Duysters, G. (2008). Managing Supplier Involvement in New Product Development: A Multiple-Case Study. *Journal of Product Innovation Management*, *25*(2), 180–201. https://doi.org/10.1111/j.1540-5885.2008.00293.x

van Gelder, T. (2013). Argument Mapping. In H. Pashler, *Encyclopedia of the Mind*. 2455 Teller Road, Thousand Oaks California 91320 United States: SAGE Publications, Inc. Retrieved from http://sk.sagepub.com/reference/encyclopedia-of-the-mind/n19.xml

Veerman, A., Andriessen, J., & Kanselaar, G. (2002). Collaborative argumentation in academic education. Instructional Science, 30(3), 155-186. https://doi.org/10.1023/A:1015100631027

Verpoorten, D., & Westera, W. (2014). Structured reflection breaks embedded in an online course – effects on learning experience, time on task and performance. *Interactive Learning Environments*, *24*(3), 606–624. doi:10.1080/10494820.2014.910531

von Aufschnaiter, C., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. Journal of Research in Science Teaching, 45(1), 101-131.

Wallace, J. R., Scott, S. D., Lai, E., & Jajalla, D. (2011). Investigating the role of a large, shared display in multi-display environments. Computer Supported Cooperative Work (CSCW), 20(6), 529.

Warnock, D., McGee-Lennon, M., & Brewster, S. (2011, September). The role of modality in notification performance. In *IFIP Conference on Human-Computer Interaction* (pp. 572-588). Springer, Berlin, Heidelberg.

Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. Computers & education, 46(1), 71-95.

Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer–supported collaborative learning. Instructional Science, 33(1), 1-30.

Weinberger, A., Stegmann, K., & Fischer, F. (2007). Knowledge convergence in collaborative learning: Concepts and assessment. Learning and Instruction, 17(4), 416-426.

Weinberger, A., Stegmann, K., Fischer, F., & Mandl, H. (2007). Scripting argumentative knowledge construction in computer-supported learning environments. Scripting computer-supported collaborative learning, 191-211

Xun, G., & Land, S. M. (2004). A conceptual framework for scaffolding III-structured problem-solving processes using question prompts and peer interactions. *Educational Technology Research and Development*, *52*(2), 5–22. https://doi.org/10.1007/BF02504836

Yin, R. K. (2009). How to do better case studies. The SAGE handbook of applied social research methods, 2, 254-282.

Yin, R. K. (2013). Case study research: Design and methods. Sage publications.

Yiong-Hwee, T., & Churchill, D. (2007). Using sentence openers to support students' argumentation in an online learning environment. Educational Media International, 44(3), 207-218.

8. Appendix

Appendix A

Session 1: Behaviourism and Law of Effect for dealing with Cynthia?

The following scenario of a problematic situation in classroom was presented to students at the beginning of the first session for collaborative argumentation:

"Cynthia is a problem student. She doesn't do her homework, and when she does, it's only half-finished. She acts out in class, refusing to follow the rules and cracking jokes at the teacher's expense. Her teacher, Mr. Greene, is at his wit's end. How can he deal with Cynthia?"

The problem case asked students to think like teachers, and we assisted their problem-solving processes with a text about the behaviourist theory and Law of Effect (Appendix x). The text was a two-page collection of basic information on the respected theories, the areas of application and criticism on them from research papers and related content from webpages.

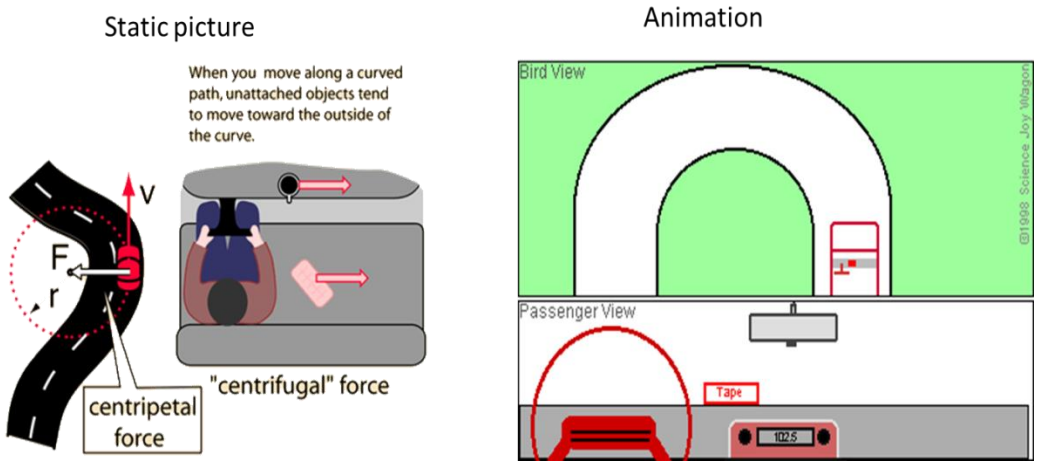
Session 2: Constructivism and Technology: How does technology complement constructivism?

After a small introductory text on the connection of constructivist theory and technologies for learning, we provided students with an example of a constructivist- technology enhanced scenario. In this scenario we prompted students to take the place of a teacher for English composition who wants to teach his students about short story composition with collaborative e-learning system for asynchronous, e-mail-based communication. The introduction to constructivist learning environments and the constructivist- technology enhanced scenario aimed at helping students prepare their arguments for solving the problem at hand.

Session 3: Static pictures or Animations for explaining "centrifugal force"?

The following scenario in the context of physics teaching with multimedia was presented to students at the beginning of the third session for collaborative argumentation:

"You are riding in a car going around a curve. Sitting on your dashboard is an object. As you go around the curve, the object moves to outside edge of the car. Because you don't want to blame it on ghosts, you say "centrifugal force pushed the object across the dashboard. Here are some illustrated examples of how centrifugal force works:"



Accompanying material from problem case script card on the topic of "animations and cognitive load" from the 3rd session for collaborative argumentation.

The examples of a static picture and an animation for explaining the physics concept of centrifugal force in classroom, served as a reference point for answering the question from the first argumentation task on whether animations or static pictures are more effective for understanding „centrifugal force" transfer their arguments into the map. In the second argumentation task, students were asked to connect these pictures and the problem case to the theory of cognitive load and expand their maps with arguments for answering the question of which of both would result in less cognitive load when studying the concept of centrifugal force. A text on animations and static graphic for learning with references to cognitive load theory was attached to the problem case for supporting the understanding of the

Session 4: Gamification in LMSs for enhancing the motivation of employees?

The following scenario about the failures of Learning Management Systems in motivating learning among the employees of a fictional company was presented to students at the beginning of the fourth session for collaborative argumentation.

"The human resources department at "Rubi GmbH" is interested in rolling out eLearning in order to secure long-term learner engagement for their trainees. They have tried out many different Learning and Management systems (LMS) in the market but the employees showed fleeting interest in the learning process that dissipated all too quickly, leaving a bunch of disinterested, disengaged and unmotivated learners in its wake. In their last attempt they used the Growth Engineering LMS:"

The picture of „Dashboard - view of Growth Engineering LMS" used in the problem case scenario of the fourth session for collaboration.

The picture of „ Admin-area- view of Growth Engineering LMS" used in the problem case scenario of the fourth session for collaboration.

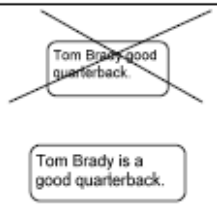
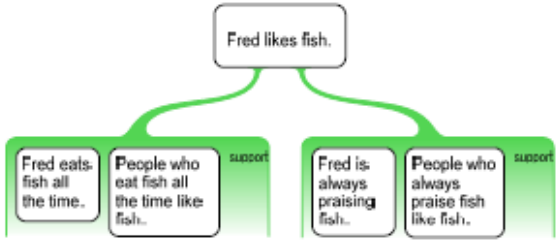
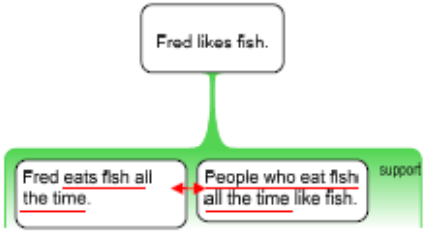
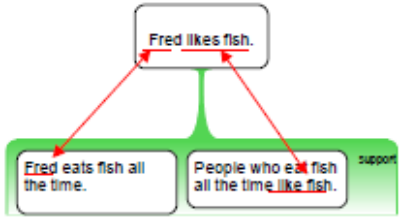
Based on the problem case and the escorting text on gamification and motivation in Learning Management systems (LMS), where the concepts of intrinsic and extrinsic motivation and gamification were explained, students had to first argue on whether the gamification elements in LMSs are appealing more to the extrinsic or the intrinsic motivation of employees (Arg. Task 1) and then transfer the argument back to the context of this problem case by arguing on

whether the Growth Engineering LMS succeed at getting employees engaged in the training programmes.

Rationale

THE RULES OF ARGUMENT MAPPING

You already know the basic rules of logic, and use argumentation in your daily life all the time.
The following rules are intended only to assist you in applying them consistently so you can clearly distinguish the parts of an argument.

Within each box		Within each simple argument	
Declarative Sentence: Each box should have a full sentence (not a phrase) and should be declaring something, taking a position (whether it is true or false). You need to be clear as to what exactly you mean: *was* Brady a good quarterback or is he *still* a good quarterback?		Assertibility Question: All reasons for claims must answer the question: "How do we know that [insert specific claim here] is true/warranted?" You are asking what evidence allows one to assert that the claim is true. Every claim box should have a reason box below it that answers this question.	
No Reasoning: No box should have reasoning going on *inside* it, only single claims. The reasoning is represented by the arrows and locations in the map. Look for words that indicate reasoning (e.g. *because*) and translate the reasoning into the map.		Holding Hands: Applied horizontally within each simple argument. Within each reason, a term stated in one co-premise must be mentioned in one of the other co-premises *in that same reason* (*if it is not in the claim above it* – see the Rabbit Rule below). The terms must 'hold hands' within a single reason *if they are not already accounted for by the Rabbit Rule.*	
Two Terms: Each box can only have two main terms, so that each box is either true or false, not both. If you have more than two terms in a single box, separate them into multiple boxes.		Rabbit Rule: Applied vertically, between a claim and each of its reasons, and is combined with the Holding Hands rule. "You can't pull a rabbit out of a hat." Using these two rules for each simple argument, you make sure that every term mentioned in each box is found in one of the others.	

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Rationale

ARGUMENT MAPPING – THE RULES

These sheets are based on the heuristics and Rationale application of Critical Thinking Skills BV. See: www.ReasoningLab.com .

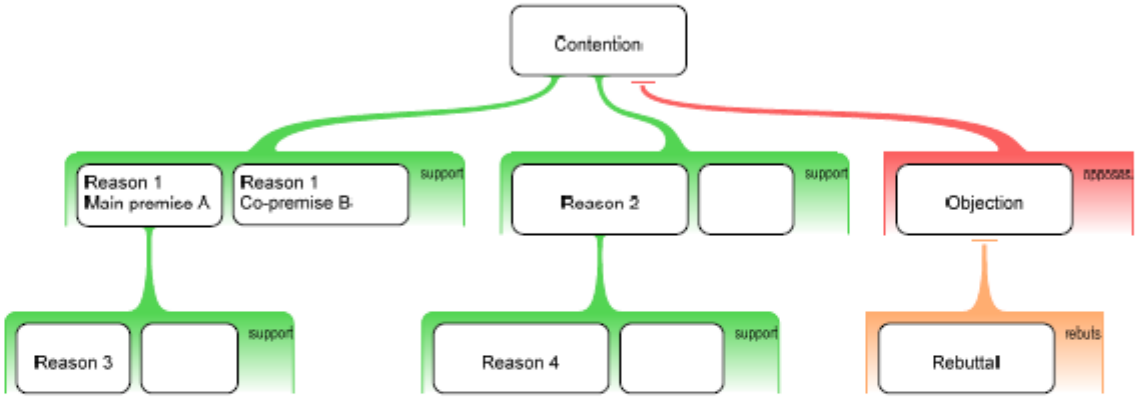
Introduction

Argument mapping is a way to visually show the logical structure of arguments. You break up an argument into its constituent claims, and use lines, boxes, colors and location to indicate the relationships between the various parts. The resulting map allows us to see exactly how each part of an argument is related to every other part.

Definitions

- Argument: a claim and reason(s) to believe that that claim is true.
- Contention: the main point an argument is trying to prove, usually a belief. Also called the conclusion, position, the main claim, the issue at hand.
- Reason: evidence given to support the contention.
- Co-premise: the subset of a reason. Every reason has at least two co-premises, and each of these co-premises must be true for the reason to support the claim.
- Objection: a 'reason' that a claim is *false*; evidence against a claim
- Rebuttal: an objection to an objection.

The Syntax of an Argument Map (In Advanced Reasoning mode)



Things To Note

- Arguments can have many claims, many reasons, many objections and rebuttals, but only **one** contention.
- Distinguish a claim with a single reason (made up of two co-premises) from a claim with two independent reasons.
- Every argument is made up of one or more simple arguments. A simple argument is the building block of all arguments, consisting of one claim and one reason (with two or more co-premises). A complex argument, like the one above, has several simple arguments linked together. In the example above, there are four simple arguments, one objection, and one rebuttal. Together, they form a debate.
- The exact structure of an argument is very important. For example, if side A has two good reasons to conclude something, and their opponent (side B) thinks one of those reasons is bad, then A's contention may still be true/warranted *if* the remaining, unobjected-to reason is convincing.
- An argument map can represent a debate by showing exactly where two sides disagree on the issue. In the above example, side B disagrees with side A's contention, even though it accepts the reasons (1 and 2) that A gives. It disagrees with A's contention because of a separate objection to the contention. Side A rebuts the objection of side B, thus (it hopes) invalidating the objection and saving its contention.
- Remember that an argument map shows the structure of the argument/debate – every box is not necessarily true, but the first step is to understand the structure of the argument. Only then can you critique it.

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Appendix C

Awareness Breaks	Behavioural Awareness Script Cards	Social Awareness Script Cards
1st Awareness Break **After reading the problem case and before entering the AP1.** **5 min. for B1** **1 min. for S1** **+** **4 min. for S2**	**B1** Is the problem case clear to all? Discuss any ambiguities in the group. Create a plan for the next steps for solving the problem (e.g. time plan and task delegation). Remember: Achieving a common understanding and following your plan will benefit your collaboration.	**S1** Pick a role: **Writer**: mainly responsible for writing down the arguments in the argument map. **Controller**: mainly responsible for reading the arguments and controlling for grammar and syntax mistakes, as well as for misuses of the argument mapping rules. **Reviser**: mainly responsible for reading through the arguments and controlling for arguments for logical inconsistencies and meaning ambiguities.

		S2 Please, listen to your group mates carefully and respectfully when talking. Feel free to encourage them to engage actively in talk if needed. How do you define successful group collaboration? Please, discuss it in the group. Remember: Sustaining a friendly atmosphere in the group, as well as keeping an open mind to the opinions of your group mates will benefit your collaboration.
2nd Awareness Break **Immediately after AP1 and before entering AP2.** **5 min. in both scripts**	**B2** Are you participating actively in the discussion so far? Take a moment to consider your participation rate. Please, discuss this in the group.	**S3** How do you feel with the role assignment? How would you evaluate your performance as writer, reviser or controller? Discuss these questions in the group and reassign the roles amongst you, if needed.

3rd Awareness Break **Immediately after AP2.** **5 min. in both scripts**	**B3** How would you evaluate your coordination efforts compared to your group mates? How would you evaluate your contribution in the collaboration compared to your groupmates? Discuss these questions with your groupmates. Make remarks for improving the group collaboration processes next time.	**S4** How well you did you do in creating a friendly atmosphere in the group? Did you keep an open mind to the opinions of your groupmates? Discuss these questions with your groupmates. Make remarks for improving the group collaboration processes next time.

Appendix D

Formal correctness of arguments:

Assign one point to the segment if you see the following within each simple argument:

- A single reason (made up of two or more co-premises): 1 point for each premise
- Independent reasons (no explanations to reasons)
- Holding Hands: a term stated in at least **two** co-premises in that same reason (examine them pair wise).
- Rabbit Rule: a term is stated in the claim and in **each** of its reasons.

Assign one point to each segment if you see the following

- Two Terms: Each box can only have two main terms, so that each box is either true or false, not both. (One verb, up to 2 subjects if they belong together)
- Declarative Sentence: a full sentence declaring something with no ambiguities (Verb must be incluced)
- No Reasoning: No box should have reasoning going on inside it, only single claims. Look for words that indicate reasoning (e.g. because)

Evidence sufficiency:

Assign one point to the segment if it contains the following:

- correct relevant evidence from theory text
- examples from personal experience or based on problem case
- correct relevant evidence from other scientific sources

You should cross check with the theory text and the problem case

APPENDIX E

Coding Scheme III

Conditions	Codes for Awareness prompts	Sub codes with examples	Type of reaction expected
BAS	**Coordination Prep-CP**	• **Discussing the task_DTa: talking about the task (Aufgabe) before/ while / after formulating arguments** ○ **asking questions about the task** i.e. "what is it we need to do?" "Is it clear to all of us?" ○ **expressing thoughts on the task** i.e. "I think the task is hard/ easy/ unclear…" ○ **discussing the ambiguities i.e.** " i don't understand this part of the task" • **Discussing the topic_DTo: talking about the theory related topics (from text) before/ while / after formulating arguments** ○ **asking questions about the topic** i.e. "what does Behaviorism mean?",	**Reg** **Reg** **Reg**

		○ **expressing thoughts on the topic** i.e. "I think it means …", "I understand it this way…" ○ **discussing the ambiguities with/without examples** (content based) ○ ***But NO formulation/dictation while typing into the map.*** ○ • **Creating a plan_CaP: talking about/ deciding on the next steps** ○ **delegating tasks** i.e."let's all prepare some arguments by ourselves", ○ **talking up tasks/ roles (in BAS)** i.e. "I will be typing" ○ **setting time frame,** "x minutes for finding reasons", "first, we need to find a contention and then find the reasons" ○ **Writing down** the rules for collaboration on a paper (s) ○ **Writing down** the arguments on a paper (s)	**Ref**

		○ Reading the text for collecting arguments ○ Mentally formating the map: "we start with this and go on with this…" • **Referring to the (value of the) plan_RvP** ○ *similar expressions: "we need a plan", "a plan is helpful/ useful"*	
BAS	**Participation Check- PC**	• **Discussing own participation_DoP** ○ *similar expressions: "I (didn't) join(ed), contributed …"* • ***Reflecting on plan_RoP*** ○ *similar expressions: "According to our plan",* ○ *We did this,* ○ *"We said we will do this…"* • **Revising collaboration plan_RCP** ○ *Discussing the need for changes to the plan in the immediate future* ○ ***AND followingly** making changes to the plan either by writing them down or making them directly in the map* • **Referring to the value of checking participation_ RvCP**	**Ev** **Ref** **Reg** **Ref**

		○ *similar expressions: "I (do not) like the talking/referring to my participation…", "This is (not) useful")*	
BAS	**Evaluation of Coordination and Collaboration- ECC**	• **Comparing own collaboration efforts to others_CCol** ○ *similar expressions: "I did contribute/talk less/more than…"* • **Comparing own coordination efforts to others_CCor** ○ *similar expressions: "I did plan/took care of the plan less/more than…"* • **Making remarks for next time_MReB** ○ *similar expressions:"We need to change …",* ○ *" We should(n't) change..."*	**Ev** **Ev** **Ref**
SAS	**Role check - RC**	• **Assigning roles _AS** ○ *Expressing interest/ arguing for becoming "Writer, Reviser, Controller",* ○ *Inquiring as to who wants to be "Writer, Reviser, Controller",* ○ *Delegating the role of "Writer, Reviser, Controller", to a colleauge*	**A** **E** **A**

		○ *Agreeing to becoming "Writer, Reviser, Controller"* • **Evaluating performance in role_ER** ○ *similar expressions: "I did good/bad as a…"* • **Reassigning roles_RAS** ○ *Asking to take up another role,* ○ *Taking up another role (changing place or actively acting in the other role)*	
SAS	**Proper Collaboration- PrC**	• **Encouraging participation/opinion expression of other (silent) members_EnP** ○ *Asking or challenging one person or both other members to be more active and express their minds* • **Defining successful group collaboration_ DSgC** ○ *defining / expressing what do they think about how a good / successful collaboration should be* ○ *similar expressions: " I think a good collaboration consists of…"*	**A** **A** **R** **R**

		• **Referring to the value of friendly atmosphere in the group_RvFA**
		  ○ *similar expressions: " I think friendliness in the group is important /overrated etc"*
		• **Referring to values of keeping an open mind to other opinions._RvOM**
		  ○ *similar expressions: " I think* open mindedness *in the group is important /overrated etc"*	

	Evaluation of Friendliness and Open mindedness_EFOM	• **Evaluating friendliness levels in the group_EvFA**
		  ○ *similar expressions: "I think that I was / we/you were (not so) friendly"*
		  ○ *" I/ We could be more friendly"*
		• **Evaluating open mindedness levels in the group_EvOM**
		  ○ *similar expressions: "I think that I was , we/you were (not so) open minded ",*
		  ○ *" I/ We could be more open minded ".*
		• **Making remarks for next time_MReS**
		  ○ *similar expressions: "We need to change …",*
		  ○ *" We should(n't) …")*
			E
			E
			R

R: Explicit & proactive/ retroactive reflection on collaboration through discussion

A: Regulatory actions /behaviors

M: metacognitive reflective remarks on the collaboration & learning processes

E: Evaluation

Appendix F

Collaborative Processes	Awareness Script Card	Prompt for	Collaborative Processes	Awareness Script Card	Prompt for	Collaborative Processes	Awareness Script Card	Prompt for
Regulation	B1	Discussing the topic	Reflection	B2	Reflecting on the plan	Evaluation	B2	Discussing own participation
	B1	Discussing the task		B2	Referring to the value of the plan		B3	Comparing own coordination efforts to others
	B1	Creating a plan		B3/S4	Making remarks for next time		B3	Comparing own collaboration efforts to others
	B2	Revising collaboration plan		S4	Referring to the value of friendly atmosphere in the group		S3	Evaluating performance in role
	S1	Assigning roles					S4	Evaluating friendliness levels in the group
	S3	Reassigning roles		S4	Referring to values of keeping an open mind to other opinions		S4	Evaluating open mindedness levels in the group
	S2	Encouraging participation/opinion expression of other (silent) members						
	S2	Defining successful group collaboration						

Appendix G

Please complete the following questionnaire with specific regard to the group collaboration processes in today's session.

		strongly agree	agree	uncertain /	disagree	strongly disagree
1.	It was clear from the beginning what this team had to accomplish	☐	☐	☐	☐	☐
2.	This team spent time making sure every team member understands the team objectives	☐	☐	☐	☐	☐
3.	Group members understand what is expected of them in their respective roles	☐	☐	☐	☐	☐
4.	Shortly after the start this team had a common understanding of the task we had to handle	☐	☐	☐	☐	☐
5.	Shortly after the start this team had a common understanding of how to deal with the task	☐	☐	☐	☐	☐
6.	In our team we can rely on each other to get the job done	☐	☐	☐	☐	☐
7.	Members of this team are able to bring up problems and tough issues	☐	☐	☐	☐	☐
8.	People in this team sometimes reject others being different	☐	☐	☐	☐	☐
9.	Working with members of this team, my unique skills and talents are valued and utilized	☐	☐	☐	☐	☐

10.	It is difficult to ask other members of this team for help	☐ ☐ ☐ ☐ ☐
11.	Group members keep information to themselves that should be shared with others	☐ ☐ ☐ ☐ ☐
12.	No one in this team would deliberately act in a way that undermines my efforts	☐ ☐ ☐ ☐ ☐
13.	We regularly take time to figure out ways to improve our team's work processes	☐ ☐ ☐ ☐ ☐
14.	In this team, someone always makes sure that we stop to reflect on the team's work process	☐ ☐ ☐ ☐ ☐
15.	My team members depend on me for information and advice	☐ ☐ ☐ ☐ ☐
16.	I depend on my team members' information and advice	☐ ☐ ☐ ☐ ☐
17.	When my team members succeed in their jobs, it works out positively for me	☐ ☐ ☐ ☐ ☐
18.	I am satisfied with the performance of my team	☐ ☐ ☐ ☐ ☐
19.	We have completed the task in a way we all agreed upon	☐ ☐ ☐ ☐ ☐
20.	I would want to work with this team in the future	☐ ☐ ☐ ☐ ☐

Please write any further comments overleaf

Appendix H

Your name:

Date:

Intermediate Evaluation

* Required

1. **Compared to your group members, how much have you contributed to the coordination efforts of the group so far?** *
   Mark only one oval.

	1	2	3	4	5	
Very little	◯	◯	◯	◯	◯	Very much

2. **How well have you performed in your role (as writer, corrector, Devil's advocate) so far?** *
   Mark only one oval.

	1	2	3	4	5	
Very bad	◯	◯	◯	◯	◯	Excellent

3. **How active were you in the discussion so far?** *
   Mark only one oval.

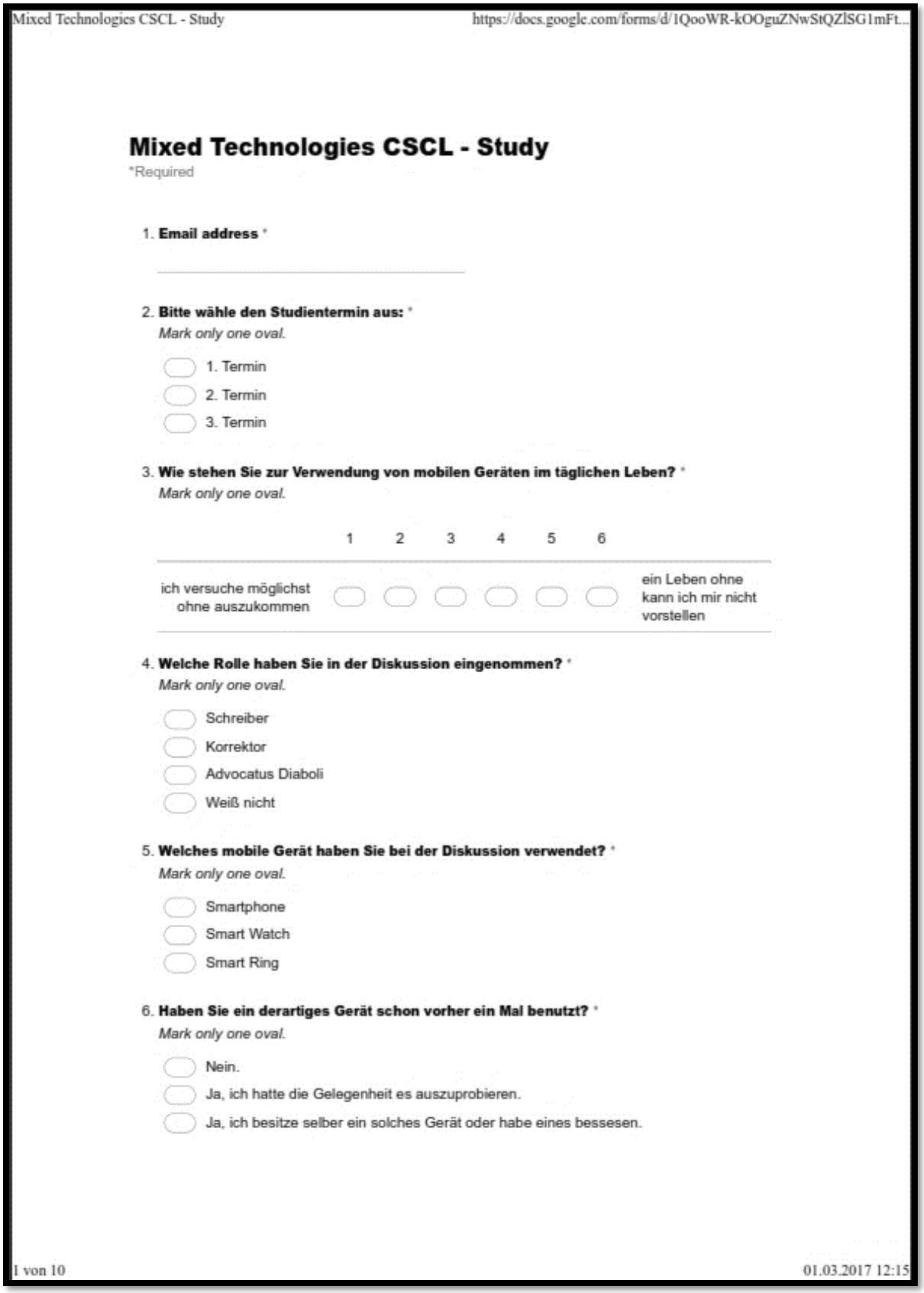
	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	A lot

4. **Compared to your group members, how much have you contributed to the collaboration efforts of the group so far?** *
   Mark only one oval.

	1	2	3	4	5	
Very little	◯	◯	◯	◯	◯	Very much

Appendix I

Appendix J



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Mixed Technologies CSCL - Study

*Required

1. **Email address** *

2. **Bitte wähle den Studientermin aus:** *
Mark only one oval.
- 1. Termin
- 2. Termin
- 3. Termin

3. **Wie stehen Sie zur Verwendung von mobilen Geräten im täglichen Leben?** *
Mark only one oval.

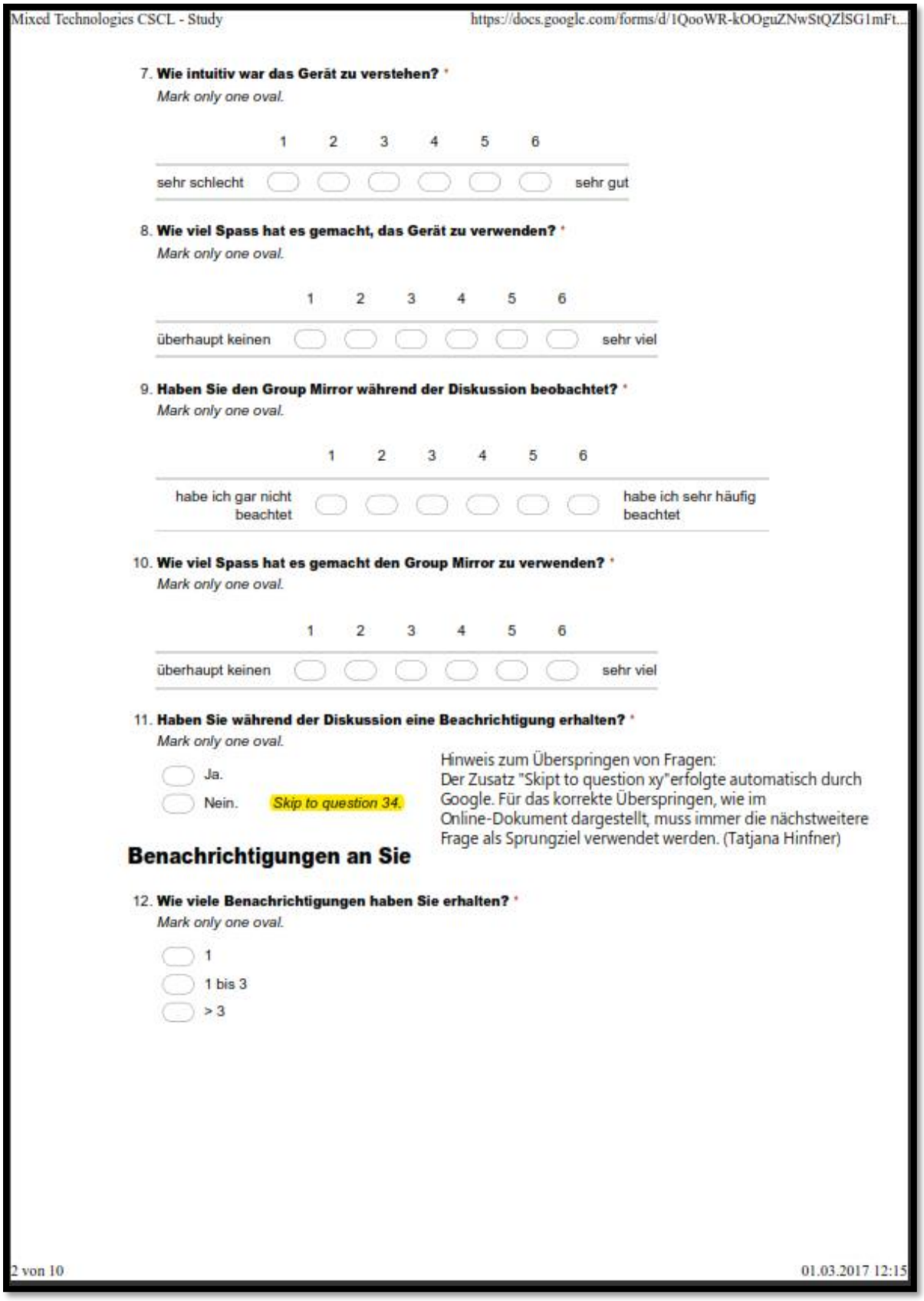
	1	2	3	4	5	6	
ich versuche möglichst ohne auszukommen							ein Leben ohne kann ich mir nicht vorstellen

4. **Welche Rolle haben Sie in der Diskussion eingenommen?** *
Mark only one oval.
- Schreiber
- Korrektor
- Advocatus Diaboli
- Weiß nicht

5. **Welches mobile Gerät haben Sie bei der Diskussion verwendet?** *
Mark only one oval.
- Smartphone
- Smart Watch
- Smart Ring

6. **Haben Sie ein derartiges Gerät schon vorher ein Mal benutzt?** *
Mark only one oval.
- Nein.
- Ja, ich hatte die Gelegenheit es auszuprobieren.
- Ja, ich besitze selber ein solches Gerät oder habe eines bessesen.

1 von 10 01.03.2017 12:15



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7. **Wie intuitiv war das Gerät zu verstehen?** *
Mark only one oval.

	1	2	3	4	5	6	
sehr schlecht	◯	◯	◯	◯	◯	◯	sehr gut

8. **Wie viel Spass hat es gemacht, das Gerät zu verwenden?** *
Mark only one oval.

	1	2	3	4	5	6	
überhaupt keinen	◯	◯	◯	◯	◯	◯	sehr viel

9. **Haben Sie den Group Mirror während der Diskussion beobachtet?** *
Mark only one oval.

	1	2	3	4	5	6	
habe ich gar nicht beachtet	◯	◯	◯	◯	◯	◯	habe ich sehr häufig beachtet

10. **Wie viel Spass hat es gemacht den Group Mirror zu verwenden?** *
Mark only one oval.

	1	2	3	4	5	6	
überhaupt keinen	◯	◯	◯	◯	◯	◯	sehr viel

11. **Haben Sie während der Diskussion eine Beachrichtigung erhalten?** *
Mark only one oval.

◯ Ja.
◯ Nein. *Skip to question 34.*

Hinweis zum Überspringen von Fragen:
Der Zusatz "Skipt to question xy"erfolgte automatisch durch Google. Für das korrekte Überspringen, wie im Online-Dokument dargestellt, muss immer die nächstweitere Frage als Sprungziel verwendet werden. (Tatjana Hinfner)

Benachrichtigungen an Sie

12. **Wie viele Benachrichtigungen haben Sie erhalten?** *
Mark only one oval.

◯ 1
◯ 1 bis 3
◯ > 3

2 von 10 01.03.2017 12:15

13. **Welche Art von Benachrichtigung haben Sie erhalten? (Mehrfachantworten möglich)** *

Tick all that apply.

- [ ] Andere Leuchten/-Displayfarbe
- [ ] Blinkende Leuchte innerhab des Displays oder am Gerät selbst
- [ ] Vibration (kurz)
- [ ] Vibration (lang)
- [ ] Vibration (wiederholt in kurzen Abständen)
- [ ] Textbenachrichtigung
- [ ] Ich bin mir nicht sicher.
- [ ] Other: _____

14. **Sie haben in der letzten Frage auch die Benachrichtigung "Textnachricht" ausgewählt?** *

Mark only one oval.

- ◯ Ja *Skip to question 22.*
- ◯ Nein

Zum Typ Licht gehören "Andere Leuchten/-Displayfarbe" und "Blinkende Leuchte innerhab des Displays oder am Gerät selbst".

15. **Sie haben in der vorherigen Frage, welche Benachrichtigung Sie bemerkt haben. auch eine Benachrichtigung vom Typ Licht ausgewählt?** *

Mark only one oval.

- ◯ Ja *Skip to question 16.*
- ◯ Nein

Zum Typ Vibration gehören "Vibration (kurz)", "Vibration (kurz)" und "Vibration (wiederholt in kurzen Abständen)".

16. **Sie haben in der vorherigen Frage, welche Benachrichtigung Sie bemerkt haben, auch eine Benachrichtigung vom Typ Vibration ausgewählt?** *

Mark only one oval.

- ◯ Ja *Skip to question 28.*
- ◯ Nein *Skip to question 34.*

Licht - Benachrichtigung

17. **Wie verständlich war die Licht - Benachrichtigung für Sie?** *

Mark only one oval.

	1	2	3	4	5	6	
komplett unverständlich	◯	◯	◯	◯	◯	◯	sehr leicht verständlich

18. **Wie schnell haben Sie auf die Licht - Benachrichtigung reagiert?** *
Mark only one oval.

	1	2	3	4	5	6	
Gar nicht	◯	◯	◯	◯	◯	◯	Fast zeitgleich

19. **Wie störend oder angenehm war die Licht - Benachrichtigung für Sie in Bezug auf Ihre Hauptaufgabe?** *
Mark only one oval.

	1	2	3	4	5	6	
hat mich komplett unterbrochen	◯	◯	◯	◯	◯	◯	hat die Hauptaufgabe nicht gestört

20. **Haben Sie das Gefühl, auch andere haben die Licht - Benachrichtigung an Sie bemerkt?** *
Mark only one oval.

- ◯ Ja
- ◯ Nein
- ◯ Ich bin nicht sicher

21. **Wie störend empfanden Sie diese Art der Licht - Benachrichtigung für Ihre Umgebung in Bezug auf die Hauptaufgabe?**
Wenn Sie nicht sicher sind, ob die Benachrichtigung von anderen wahrgenommen wurde oder nicht bitte keines der Felder auswählen.
Mark only one oval.

	1	2	3	4	5	6	
hat alle Teilnehmer gestört	◯	◯	◯	◯	◯	◯	die Benachrichtigung wurde nicht bemerkt

22. **Haben Sie durch die Licht - Benachrichtigung an Sie öfter den Group Mirror beobachtet?** *
Mark only one oval.

	1	2	3	4	5	6	
hat mich nicht beeinflusst	◯	◯	◯	◯	◯	◯	hat mich motiviert zur Beobachtung

Skip to question 15.

Textnachrichten - Benachrichtigung

23. **Wie verständlich war die Textnachrichten - Benachrichtigung für Sie?** *
Mark only one oval.

	1	2	3	4	5	6	
komplett unverständlich	◯	◯	◯	◯	◯	◯	sehr leicht verständlich

24. **Wie schnell haben Sie auf die Textnachrichten - Benachrichtigung reagiert?** *
Mark only one oval.

	1	2	3	4	5	6	
Gar nicht	◯	◯	◯	◯	◯	◯	Fast zeitgleich

25. **Wie störend oder angenehm war die Textnachrichten - Benachrichtigung für Sie in Bezug auf Ihre Hauptaufgabe?** *
Mark only one oval.

	1	2	3	4	5	6	
hat mich komplett unterbrochen	◯	◯	◯	◯	◯	◯	hat die Hauptaufgabe nicht gestört

26. **Haben Sie das Gefühl, auch andere haben die Textnachrichten - Benachrichtigung an Sie bemerkt?** *
Mark only one oval.

- ◯ Ja
- ◯ Nein
- ◯ Ich bin nicht sicher

27. **Wie störend empfanden Sie die Textnachrichten - Benachrichtigung für Ihre Umgebung in Bezug auf die Hauptaufgabe?**
Wenn Sie nicht sicher sind, ob die Benachrichtigung von anderen wahrgenommen wurde oder nicht bitte keines der Felder auswählen.
Mark only one oval.

	1	2	3	4	5	6	
hat alle Teilnehmer gestört	◯	◯	◯	◯	◯	◯	die Benachrichtigung wurde nicht bemerkt

28. **Haben Sie durch die Textnachrichten - Benachrichtigung an Sie öfter den Group Mirror beobachtet?** *
Mark only one oval.

	1	2	3	4	5	6	
hat mich nicht beeinflusst	◯	◯	◯	◯	◯	◯	hat mich motiviert zur Beobachtung

Skip to question 14.

Vibrations - Benachrichtigung

29. **Wie verständlich war die Vibrations - Benachrichtigung für Sie?**
Mark only one oval.

	1	2	3	4	5	6	
komplett unverständlich	◯	◯	◯	◯	◯	◯	sehr leicht verständlich

30. **Wie schnell haben Sie auf die Vibrations - Benachrichtigung reagiert?**
Mark only one oval.

	1	2	3	4	5	6	
Gar nicht	◯	◯	◯	◯	◯	◯	fast zeitgleich

31. **Wie störend oder angenehm war die Vibrations - Benachrichtigung für Sie in Bezug auf Ihre Hauptaufgabe?** *
Mark only one oval.

	1	2	3	4	5	6	
hat mich komplett unterbrochen	◯	◯	◯	◯	◯	◯	hat die Hauptaufgabe nicht gestört

32. **Haben Sie das Gefühl, auch Andere haben die Vibrations - Benachrichtigung an Sie bemerkt?** *
Mark only one oval.

- ◯ Ja
- ◯ Nein
- ◯ Ich bin nicht sicher

33. **Wie störend empfanden Sie die Vibrations - Benachrichtigung für Ihre Umgebung in Bezug auf die Hauptaufgabe?**
Wenn Sie nicht sicher sind, ob die Benachrichtigung von anderen wahrgenommen wurde oder nicht bitte keines der Felder auswählen.
Mark only one oval.

	1	2	3	4	5	6	
hat alle Teilnehmer gestört	◯	◯	◯	◯	◯	◯	die Benachrichtigung wurde nicht bemerklt

34. **Haben Sie durch die Vibrations - Benachrichtigung an Sie öfter den Group Mirror beobachtet?** *

Mark only one oval.

	1	2	3	4	5	6	
hat mich nicht beeinflusst	◯	◯	◯	◯	◯	◯	hat mich motiviert zur Beobachtung

Benachrichtigungen an andere Teilnehmer

35. **Haben Sie eine Benachrichtigung bei einem anderen Gruppenmitglied bemerkt?** *

Mark only one oval.

- ◯ Ja *Skip to question 35.*
- ◯ Nein *Skip to question 46.*

36. **Haben Sie eine Ring - Benachrichtigung bei einem anderen Gruppenmitglied bemerkt?** *

Mark only one oval.

- ◯ Ja *Skip to question 38.*
- ◯ Nein

37. **Haben Sie eine Smartphone - Benachrichtigung bei einem Gruppenmitglied bemerkt?** *

Mark only one oval.

- ◯ Ja *Skip to question 41.*
- ◯ Nein *Skip to question 37.*

38. **Haben Sie eine Smartwatch - Benachrichtigung bei einem Gruppenmitglied bemerkt?** *

Mark only one oval.

- ◯ Ja *Skip to question 44.*
- ◯ Nein *Skip to question 46.*

Ring Benachrichtigung an Andere

39. **Wie haben Sie die Benachrichtigung bemerkt?** *

Tick all that apply.

- ☐ Lichtwechsel der Diode
- ☐ Vibrationsgeräusch
- ☐ Reaktion des Teilnehmer auf das Gerät
- ☐ Other: _____

40. **Wie empfanden Sie die Benachrichtigung?** *
Mark only one oval.

	1	2	3	4	5	
sehr störend	◯	◯	◯	◯	◯	unauffällig und angenehm

41. **Haben Sie außerdem noch eine Benachrichtigungsart bemerkt ?** *
Mark only one oval.

◯ Ja *Skip to question 36.*
◯ Nein *Skip to question 46.*

Smartphone Benachrichtigung

42. **Wie haben Sie die Benachrichtigung bemerkt?** *
Tick all that apply.

☐ Lichtwechsel der Diode
☐ Vibrationsgeräusch
☐ Reaktion des Teilnehmer auf das Gerät
☐ Other: _____

43. **Wie empfanden Sie die Benachrichtigung?** *
Mark only one oval.

	1	2	3	4	5	
sehr störend	◯	◯	◯	◯	◯	unauffällig und angenehm

44. **Haben Sie außerdem noch eine Benachrichtigungsart bemerkt?** *
Mark only one oval.

◯ Ja *Skip to question 37.*
◯ Nein *Skip to question 46.*

Smartwatch Benachrichtigung

45. **Wie haben Sie die Benachrichtigung bemerkt?** *
Tick all that apply.

☐ Lichtwechsel der Diode
☐ Vibrationsgeräusch
☐ Reaktion des Teilnehmer auf das Gerät
☐ Other: _____

46. **Wie empfanden Sie die Benachrichtigung?** *
Mark only one oval.

	1	2	3	4	5	6	
sehr störend	◯	◯	◯	◯	◯	◯	unauffällig und angenehm

47. **Welchen Einfluss haben die Geräte Ihrer Meinung nach auf die Gruppenarbeit?**
Wenn Sie finden, dass die Geräte KEINEN Einfluss haben lassen Sie die Felder bitte frei.
Mark only one oval.

	1	2	3	4	5	6	
wirken unterbrechend und lenken nur ab	◯	◯	◯	◯	◯	◯	gut integrierte technische Stütze

48. **Hat das Gerät Einfluss gehabt auf die Einhaltung Ihrer zugewiesenen Rolle?**
Wenn Sie meinen es hätte KEINEN Einfluss gehabt bitte Felder frei lassen.
Mark only one oval.

	1	2	3	4	5	6	
negativen Einfluss	◯	◯	◯	◯	◯	◯	postiven Einfluss

49. **Fanden Sie ein Benachrichtigungsmedium besonders gut oder schlecht für die Gruppe?**
Bitte Art (Ring / Smartwatch oder Smartphone) nennen und mit Stichpunkt begründen.

50. **Welche der Geräte finden Sie bis jetzt am hilfreichsten für die Gruppenarbeit?** *
Mehrfachantworten sind möglich.
Tick all that apply.

- ☐ Smartphone
- ☐ Ring
- ☐ Smartwatch
- ☐ Keines der oben gennanten.

51. **Würden Sie Ihr Gerät wieder bei einer ähnlichen Arbeit benutzen?** *
Mark only one oval.

	1	2	3	4	5	6	
nein überhaupt nicht	◯	◯	◯	◯	◯	◯	ja sehr gerne

52. **Haben Sie noch Gedanken zur Studie, die Sie mit mir teilen möchten?**

Danke für die Teilnahme!

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