Promoting socio-emotional interactions and regulation in Computer Supported Collaborative Learning

Design, implementation and evaluation of technology features and affordances to facilitate the socio-emotional side of CSCL

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To my children, Mariano and Alberto.

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Abstract

This dissertation contributes knowledge from research on improving the design of computer-supported collaborative learning tools for facilitating and promoting socio-emotional interactions, awareness and regulation. It presents the theoretical background, methods and results of research on this topic from a compilation of convergent publications.

The design-based research methodology that we used started with a field study in which we observed groups of students collaborating in a context outside school without utilising technology and with very little teacher supervision. We concluded that in such a context, socio-emotional issues unfold more frequently and openly than in contexts in which the teacher is supervising the task. We complemented that study with a review of literature on the social presence theory, the social identity model of deindividuation effects (SIDE) and the theory of socio-emotional regulation in collaborative learning. Based on our conclusions from our observations, and after addressing the gaps and opportunities identified in the literature, we designed a fully functional prototype of an asynchronous communication tool that integrates various features (i.e., a student profile panel, a set of avatars, a visual messages composer, an anonymous message feature and a self-emotions panel) to support and facilitate social interactions and regulation throughout the entire collaboration process by facilitating group cohesion and self-regulation, co-regulation and socially shared regulation and motivation within the group.

The students rated most highly the feature of the tool that enables the user to send anonymous messages in the collaborative chat. Our focus on this feature produced empirical evidence that anonymity increases not only social interactions but also trolling or unproductive messages. To maximise the positive results of anonymity (i.e., increased social interactions) while minimising its negative results (i.e., trolling or unproductive messaging), we developed and evaluated three forms of anonymity inspired by the SIDE model: full anonymity, anonymity on demand and anonymity to group members but not to the teacher. Our results showed that anonymity to the group members but not to the teacher is the most productive form of anonymity. Moreover, the behaviour of the students in anonymous login conditions changed if they knew each other previously. In addition, we contribute a taxonomy of off-task messages that sometimes facilitate a good and fun atmosphere in the group, to allow other researchers to better understand them. Finally, based on these results, we propose an extension of the SIDE model. This model describes that in situations of anonymity there is a cognitive and a strategic component. Our extension adds a social component that describes that anonymity not only facilitates positive social interactions such as a fun or joyful atmosphere, meeting each other or even making plans, but that students always prefer it, even though it may also involve unproductive behaviour.

Resumen

Esta tesis doctoral aporta conocimiento orientado a mejorar el diseño de herramientas de aprendizaje colaborativo asistido por ordenador (CSCL, de sus siglas en inglés) para facilitar y promover las interacciones y la regulación social y emocional de los grupos. La tesis presenta los antecedentes teóricos, los métodos y los resultados como una recopilación de publicaciones, que en su conjunto convergen para cumplir el objetivo general de la tesis.

La Metodología de Investigación Basada en Diseño seguida en la tesis, comienza por un estudio de campo en el que observamos grupos de estudiantes colaborando en un contexto fuera de la escuela sin el uso de tecnología y con muy poca supervisión docente. En este estudio concluimos que en esos contextos, las cuestiones socioemocionales se desarrollan con mayor frecuencia y más abiertamente que en contextos en los que el docente supervisa la tarea. Complementamos este estudio profundizando en la teoría de la Presencia Social, el modelo SIDE (Social Identity Model of Deindividuation Effects, de sus siglas en inglés) y la teoría de la regulación socioemocional en el aprendizaje colaborativo. Basándonos en las conclusiones extraídas de nuestras observaciones y abordando las brechas y oportunidades identificadas en investigaciones anteriores, diseñamos un prototipo completamente funcional. Este prototipo es una herramienta de comunicación asincrónica que integra varias características y herramientas para apoyar y facilitar las interacciones sociales y la regulación durante todo el proceso de colaboración.

En nuestros experimentos, los estudiantes calificaron la capacidad de enviar mensajes anónimos en el chat colaborativo como la característica más valorada de todas las anteriores. Un siguiente estudio centrado en esta característica aportó evidencia empírica que muestra que el anonimato aumenta las interacciones sociales, pero también los mensajes improductivos. Para maximizar los beneficios de una mayor interacción social desde el anonimato y al mismo tiempo minimizar los mensajes “fuera de tarea”, desarrollamos y evaluamos varias formas de anonimato. Al explorar las posibilidades de los conceptos del modelo SIDE, experimentamos con tres tipos diferentes de anonimato: anonimato total, anonimato bajo demanda y anonimato para los miembros del grupo pero no para el profesor. Nuestros resultados muestran que el anonimato para los miembros del grupo pero no para el profesor es el más productivo. El comportamiento de los estudiantes en condiciones de inicio de sesión anónimo cambia si los miembros se conocen previamente. Asimismo, contribuimos con una taxonomía de mensajes fuera de tarea (off-task en inglés) para comprenderlos mejor, porque muchos de ellos contribuyen a crear un ambiente bueno y distendido en el grupo. Finalmente, con base en estos resultados, proponemos una extensión al modelo SIDE. Este modelo describe que en situaciones de anonimato hay un componente cognitivo y otro estratégico. Nuestra extensión incorpora un componente social que describe que el anonimato facilita interacciones sociales positivas como una atmósfera divertida y alegre, conocerse o incluso hacer planes y que los estudiantes prefieren el anonimato aunque éste suponga soportar ciertos comportamientos poco productivos.

Preface

As I consider myself a designer, my main motivation for this dissertation was to create tools that students would find useful. To achieve this, problem finding and problem definition with real students in real-life situations were crucial. Simon (1995) distinguished problem-solving disciplines from design, in which problem finding and definition are as important as the solutions. Other authors have also stressed the importance of having a meaningful problem. Reeves et al. (2005) wrote that socially responsible research in education should address 'problems that detract from the quality of life [of] individuals and groups in society, especially those problems related to learning and human development' (p. 100). For me, at the beginning of this dissertation, theory gaps and academic contributions were very important as well, but were secondary.

Thus, finding and defining a meaningful problem for students was my first goal. I started with a focus on *students as learning designers* in settings outside of schools through mobile technology. I wanted to explore the learning possibilities of maths problem posing using mobile phones and conducted a case study with three observations and several interviews with teachers and students. In my interviews with students after my first observation, most of them did not show much interest in posing or creating their own maths tasks or problems. One of them was categorical: she would not do it at all – 'at least not alone, [but] maybe in a group'. This answer shifted my focus to group dynamics to see if my future work could be a kind of collaborative problem posing 'on the go' empowered by mobile technology.

I started to observe group dynamics in real settings without teacher supervision. While I was observing a group of girls trying to solve a maths task on a street in Seville (in a kind of maths treasure hunt), one of the girls started to verbally explain her proposal for a solution to the task (which was correct), but the others did not understand it and rejected it for the following reasons. First, her explanations were not clear; she seemed shy, and although she tried several times, she never managed to effectively communicate her idea. Second and more importantly, according to what I saw, she was not very self-confident, and the rest of the group had a clearly diminishing opinion of her, so they did not pay much attention to her. After a few trials, she rejected her own idea as 'nonsense'. Nevertheless, a few minutes later, when the girl who played the role of the leader of the group went somewhere else and the shy girl was alone with another girl, they started to complain that the 'leader' did not listen and merely embraced her own proposals and opinions. For me, it was clear that the group missed the chance to solve the problem mainly due to identity issues, as well as socio-emotional issues. I wondered if the design of a digital tool could help prevent these unfruitful situations in which the 'unpopular' girl kept being diminished and did not improve her self-esteem, and the group failed to solve the task and did not learn anything.

This was the starting point of the work presented here, which shaped our first research question, and which I hope will be useful, at least, for other groups like that in the future.

Table of contents

Acknowledgements..... .v
Abstract..... .vii
Resumen..... .ix
Preface..... .xiii
Table of contents..... .xvi
List of figures..... .xxiii
List of tables..... .xxvii
1 INTRODUCTION..... .1
1.1 Foundations..... .1
1.2 Theoretical Background..... .5
a) Sociocultural learning studies..... .5
b) Computer-supported collaborative learning (CSCL) models..... .5
c) Social and emotional factors of collaborative learning..... .7
Social presence..... .7
The regulation of learning..... .11
Anonymity..... .13
1.3 Research questions..... .15
1.4 Publications..... .18
1.5 Research Methodology..... .19
a) Methods and instruments..... .23
Observation..... .23
Thematic analysis..... .24
Content analysis..... .25
Questionnaires..... .25
User Centred Design..... .26
1.6 Main contributions..... .27
a) Grounding: Publications B1 and C1..... .29
Publication B1. Case study of Math Gymkhana (in the open streets of Seville) ..... .29
Publication C1: Design implications for the future tools..... .30
b) Conjecturing: publication C2..... .31

Publication C2: Design of the tools/features.....31
c) Iterating: publication C3.....33
Publication C3: design iterations, tests and conclusions of the features.....33
d) Reflecting: publications C4, J1 and J2.....34
Publications C4 and J1: The effect of anonymity during CSCL tasks.....34
Publication J2: Optimising anonymity.....35
1.7 Project.....36
1.8 Conclusions.....36
a) RQ1: What are the socio-emotional factors and issues that emerge among students while collaborating in contexts with complex situations of teacher supervision?.....37
b) RQ2: How do students perceive and rate the features and affordances of online collaboration tools in terms of facilitating participation, enhancing social, emotional, and motivational awareness, and supporting self-, co-, and socially shared regulation during online collaboration?.....39
c) RQ3: How do the anonymous and identified login modes in CSCL compare, and how can the choice of anonymity be optimised?.....42
1.9 Limitations.....45
a) Methodological.....45
b) COVID-19.....46
c) Data Collection.....46
1.10 Future research.....46
1.11 Structure of the Dissertation.....49
2 SOCIO-EMOTIONAL REGULATION IN COLLABORATIVE HYBRID LEARNING SPACES OF FORMAL–INFORMAL LEARNING.....51
2.1 Introduction.....51
2.2 Theoretical Background.....53
a) Social Interactions: Cognitive and Socio-emotional Effects.....53
b) Regulation in Collaborative Learning.....54
2.3 Review of Socio-emotional Regulation Tools in CSCL.....55
2.4 Discussion of Two Socio-emotional Regulation CSCL Tools.....57
a) S-REG Tool.....58
b) EmATool.....59
Conclusions of the Literature and Existing Tools Review.....60
2.5 Observations from an HLS Activity.....60

a) Context: Description of the Gymkhana Activity..... .61
b) Instrument, Participants and Data Analysis.....61
2.6 Illustrative Examples of Socio-emotional Issues in HLS..... .61
a) Example 1: Emotional Implications of Roles..... .62
b) Example 2: Roles Determine Unresolved Challenges in Emotional Regulation 62
2.7 Discussion and Further Research.....63
2.8 Limitations..... .64
2.9 Conclusion..... .64
2.10 Acknowledgements.....65
2.11 Open data, ethics and conflicts of interest..... .65
2.12 References.....65
3 COLLABORATIVE EDUCATIONAL LOCATION-BASED ACTIVITIES WITH NO TEACHER SUPERVISION: DESIGN IMPLICATIONS.....69
3.1 Introduction.....69
3.2 Previous Research and Research Questions..... .70
3.3 Methodology.....71
a) Design: A Case Study of the (maths) Gymkhana of Seville.....71
3.3 Methods and Instruments.....71
3.4 Participants.....73
a) Observations.....73
b) Questionnaires..... .74
3.5 Analysis.....74
a) Observations.....74
b) Questionnaire.....74
3.6 Results.....75
a) Questionnaire..... .75
b) Observations..... .76
3.7 Design Implications..... .78
3.8 Discussion.....79
3.9 Limitations.....79
3.10 Open Data, Ethics, Acknowledgements & Conflicts of Interest.....80
3.11 References.....80

4 AWARENESS TOOLS FOR MONITORING SOCIO-EMOTIONAL REGULATION DURING COLLABORATION IN SETTINGS OUTSIDE SCHOOL WITHOUT TEACHER SUPERVISION....83
4.1 Theoretical Background....83
4.2 Description of the emotional and motivational affordances of the prototype....84
a) Members' avatars selection (signing-up and profile panels)....85
b) Self- regulation: my emotions panel....85
c) Co-regulation: members' reported emotions (hedonic)....85
d) Socially-shared (and co-) regulation....85
4.3 Preliminary tests and future work....86
4.4 Acknowledgements....86
4.5 References....87
5 HOW TO DESIGN FEATURES FOR PROMOTING SOCIAL AND EMOTIONAL INTERACTIONS DURING COMPUTER SUPPORTED COLLABORATIVE LEARNING....89
5.1 Introduction....90
5.2 Theoretical background....90
a) CSCL and the socio-emotional side of learning....91
b) Existing CSCL tools for the socio-emotional side of learning....92
c) Research questions....93
5.3 Methods, participants and instruments....94
a) Methods....94
b) Participants....95
c) Instruments....96
The *me&co* prototype....96
The questionnaires and logs....103
5.4 Results....103
5.5 Discussion....105
5.6 Limitations....106
5.7 Conclusion....107
5.8 Future research....108
5.9 References....109
6 STUDENT PREFERENCES AND BEHAVIOUR IN ANONYMOUS COLLABORATIVE LEARNING....115
6.1 Introduction....115

6.2 Methods....116
6.3 Analysis and results....117
6.4 Discussion and future work....119
6.5 Acknowledgements....120
6.6 References....120
7 USER ANONYMITY VERSUS IDENTIFICATION IN COMPUTER-SUPPORTED COLLABORATIVE LEARNING: COMPARING LEARNERS' PREFERENCES AND BEHAVIOURS....123
7.1 Introduction....123
a) Theoretical background....124
b) Research questions....127
7.2 Material and methods....127
a) Participants....127
b) Learning tasks....128
The experimental setting....128
c) Procedure....129
d) Instruments....130
e) Coding criteria....131
Inter-rater agreement....133
7.3 Results....134
a) Students' opinions and preferences about anonymity versus identification....134
b) Analysis of conversation logs....135
c) Comparing students' opinions and behaviours....141
7.4 Discussion....144
a) What preferences and behaviours related to collaborating in anonymous versus identified login modes did students report?....144
b) How does the anonymous login mode of the CSCL tool affect students' collaboration in terms of the quantity and quality of their participation versus the identified mode?....145
c) To what extent did students' reports align with their actual behaviour?....145
d) 7.4.4 Implications for future research and practice....147
7.5 Conclusion....148
7.6 Limitations....149
7.7 Acknowledgments....149
7.8 References....149

8 OPTIMISING ANONYMITY IN CSCL: COMPARING COLLABORATION BETWEEN IDENTIFIED AND ANONYMOUS-TO-PEERS LOGIN MODES.....155
8.1 Introduction.....155
a) Anonymity in CSCL.....155
b) General theories about anonymity.....156
c) Students' opinions about anonymity.....158
d) Social interactions.....159
e) Research questions.....159
8.2 Materials and methods.....161
a) Study design and sample.....161
b) Procedure.....162
c) Instruments and measurement.....165
The conversation logs.....165
The questionnaire.....167
d) Coding criteria.....170
Content/cognitive categories.....170
Socio-emotional categories.....171
e) Data analysis.....173
8.3 Results.....173
a) Participation and Collaboration in Group Discussions (RQ1).....173
b) Students' Participation and Collaboration: Anonymous vs Identified Modality (RQ2).....175
c) Students' perception of online behaviour.....177
d) Patterns and purposes of off-task messages in the APM (RQ4).....178
Patterns of use.....178
Types of off-task messages.....179
8.4 Discussion.....181
a) RQ1: How do anonymized peer interactions benefit group collaboration and participation in the setting of the CSCL activities?.....182
b) RQ2: Which form of online interaction – Anonymous to Peers or Identified to Peers – reports higher levels of collaboration and participation among individual students?.....182
c) RQ3: Which modality of collaboration (APM or IDM) would students adopt after conducting a series of tasks within the CSCL platform?.....183

d) RQ4: When are off-task messages most frequent, and what purposes do they serve?.....184
8.5 Limitations.....185
8.6 Conclusion and further research.....186
8.7 Acknowledgements.....188
8.8 Declaration of interest and generative AI and AI-assisted technologies in the writing process.....188
8.9 References.....188
9 BIBLIOGRAPHY.....195

List of figures

Figure 1.1: A visual representation of the conceptual framework of the doctoral thesis. .4

Figure 1.2: Kreijns model depicting the educational and the social (psychological) dimension of social interaction (2003)..... .6

Figure 1.3: Kreijns & Kirschner model (2018)..... .7

Figure 1.4: Theoretical background overview of this thesis.....15

Figure 1.5: Overview of the thesis.....16

Figure 1.6: The DBR process model adapted from Hoadley and Campos (2022).....20

Figure 2.1: Kreijns model (2013)..... .53

Figure 2.2: Kreijns & Kirschner model (2018)..... .54

Figure 2.3: The S-Reg Tool. Järvenoja et al. (2017)..... .58

Figure 2.4: part of the interface of the EmATool. Järvenoja et al. (2018).....59

Figure 3.1: Visualisation of the relationship between self-esteem about maths and the experience of the gymkhana..... .75

Figure 4.1: Chat panel..... .85

Figure 4.2: “My emotions” panel..... .85

Figure 4.3: Members’ emotions.....85

Figure 4.4: Group motivational message composer..... .85

Figure 5.1: The avatars for members.....98

Figure 5.2: Iteration 1, only the avatar of the current student is shown in the tasks panel. ..... .99

Figure 5.3: Iteration 2, the tasks panel shows the avatars of all the members of the group.....99

Figure 5.4: In iteration 1, the members were on top and the icon under the user avatar indicated the person sending the message..... .99

Figure 5.5: The chat bubbles point to the avatars at the bottom to show who is sending the message.....99

Figure 5.6: In iteration 1, the anonymous message feature just included an explanation of that type of message..... .100

Figure 5.7: In iteration 2, the anonymous messages feature included ready-made sentences and an open-ended textfield.....100

Figure 5.8: In the first iteration there was a list of emotions, a description of it and a likert scale per emotion to select their intensity..... .101

Figure 5.9: In iteration 2 the likert scale was only one and linked to the selected emotion. We also included a background colour to make identifying emotions easier.....101

Figure 5.10: Iteration 1. Ready-made motivational messages feature.....102

Figure 5.11: In iteration2, the button “Motivational messages composer” in a more visible position (top-right).....102

Figure 5.12: Iteration 1 Group motivational messages composer feature.....102

Figure 5.13: In iteration 2 we provided a larger canvas to allow more complex messages.....102

Figure 7.1: Number of messages by type in the identified and anonymous login modes 136

Figure 7.2: Number of spam messages in Phase 1 (dark gray) and Phase 2 (light gray) of the pyramid pattern for classes 1, 2, and 3 (the upper graph) and for the normalised data (the bottom graph).....137

Figure 7.3: Number of spam messages in phases 1 and 2 of the pyramid pattern by login mode.....138

Figure 7.4: Number of spam messages in phases 1 and 2 of the pyramid pattern by task 138

Figure 7.5: Number of messages posted per user in the identified login mode versus the anonymous login mode; the sawtooth pattern corresponds to each task, (six in the identified mode and six in the anonymous mode).....139

Figure 7.6: Number of idea messages shared per user in the identified login mode (red) versus the anonymous login mode (blue); users’ names and identifiers have been hidden for privacy reasons.....140

Figure 7.7: Number of spam messages per user in the identified login mode versus the anonymous login mode; users’ names and identifiers have been hidden for privacy reasons.....141

Figure 7.8: Number of messages by class and task; cognitive messages appear in blue shades, and social-emotional messages appear in orange shades.....142

Figure 7.9: Preferences by login mode; legend: anonymous (dark), indifferent (grey), and identified (light) by classes 1 (left), 2 (centre), and 3 (right).....143

Figure 7.10: Behaviour reported in the post-task questionnaire concerning contributions by message type and class; legend: Class 1 in blue shades, Class 2 in orange shades, and Class 3 in green shades; more in darker shades, less in lighter shades.....143

Figure 7.11: Students’ answers to the question, “During your tasks/activities, did you experience any challenge that made you feel especially well or bad? (For example, some people worked much more/better than you expected or, on the contrary, didn’t work as much as you expected, the group had higher goals than you expected, or your goals were higher than the rest of the members’)”; legend: “yes” (light), “no” (dark), “I do not know or I think it wasn’t important” (middle shade).....144

Figure 8.1: The diagram displays the structure of the study design, observing the distribution of the tasks and the participation modality.....162

Figure 8.2: PyramidApp CSCL environment: Teachers’ Design and Students’ Submission Interfaces. This figure displays screenshots from the interfaces. Image 1 displays

the authoring tool for teachers. Images 2 and 3 show the login and submission screens for students..... .163

Figure 8.3: PyramidApp CSCL environment: Group Discussion (Chat Room) Interface. This figure displays screenshots from the chatroom in the setting of the CSCL environment. The interface features (1) a collaborative text editor; (2) a list of initial submissions for the group to discuss and create or improve a collaborative answer; (3) a chatroom to discuss with members of the class who have been allocated randomly.....164

Figure 8.4: Mean values for participation and collaboration in group discussions observed by interaction modality..... .174

Figure 8.5: Students' perception of online behaviour. Assessment of self (SP) and peer (PA) behaviour..... .178

List of tables

Table 1.1: Summary of problematic socio-emotional situations that groups of students can face during collaborative learning, from past research.....10

Table 1.2: DBR phases and the chapters, research objectives, RQs and publications that address them in this dissertation.....22

Table 1.3: Research design, method and data collection for each publication in this dissertation.....23

Table 1.4: Main contributions of this dissertation related to the main research questions 28

Table 1.5: Design implications for collaborative educational Design implications to foster socio-emotional awareness, interaction and regulation in CSCL.....40

Table 1.6: Features designed, their theoretical backgrounds and descriptions of their functionalities.....41

Table 1.7: Final proposed categories of off-task messages.....44

Table 1.8: Chapters of this dissertation related to the publications and the types of such publications.....49

Table 2.1: Socio-emotional Regulation Research Tools.....56

Table 3.1: Structure of the research: connection between Objective, RQs and thematic analysis.....73

Table 3.2: Design implications for collaborative ELbAs.....78

Table 5.1: Overview of tested theoretical constructs by previous research tools.....93

Table 5.2: Features integrated in the prototype related to the theoretical background that supports them and the provided functionality description.....97

Table 5.3: Feature and ratings of students per iteration.....104

Table 6.1: The distribution of more/equal/less ideas, feedback, questions, jokes, wasted time, and complaints in anonymous mode (as reported by the students).....118

Table 6.2: Results of content analysis of messages.....119

Table 7.1: Sequence of login modes per class and task.....129

Table 7.2: Questions in the post-task questionnaire.....131

Table 7.3: Coding categories and subcategories for chat messages.....132

Table 7.4: Distribution of students' reported expressions of ideas, feedback, questions, jokes, wasted time, and complaints in the anonymous login mode.....135

Table 8.1: Post-task questionnaire questions.....168

Table 8.2: Report of students' perceptions of their own and peer behaviour when interacting with APM.....170

Table 8.3: Intervention categories in group discussions.....175

Table 8.4: Students' participation and collaboration: APM vs IDM.....176

Table 8.5: Intervention categories observed by students' interactions: ADM vs IDM. 176
Table 8.6: Students' and peers' reported behaviour in APM vs. IDM.....177
Table 8.7: Final categories of the off-task messages.....181

1 INTRODUCTION

This first chapter is structured as follows. Section 1.1 justifies the need for this dissertation and the associated learning theories and concepts. Section 1.2 zeroes in on the theories that particularly fed our experiments and designs. Section 1.3 presents the main goals of this dissertation. This thesis is presented as a compilation of publications and section 1.4 presents the works that were part of this compendium. Section 1.5 explains the methodology followed through the different publications. Section 1.6 describes the main contributions of each publication and attempts to establish clear connections between them as well as to assess how they deepen the knowledge generated. Section 1.8 discusses our main conclusions. The general limitations of this research are discussed in Section 1.9. In Section 1.10, we outline possible pathways for further research. Finally, in section 1.11 we present the structure and contents of the rest of this dissertation.

1.1 Foundations

Several authors have suggested that two of the capacities that are most important to develop in the future of education are agency (Bandura, 2001; Morcom, 2022; Tchounikine, 2019; Wise, 2017; Xia & Borge, 2020) and collaboration (King & South, 2017; Supena et al., 2021; Warsah et al., 2021). Even international policymaking institutions, such as the European Commission (EC) and economic organisations, support this claim (EC, 2012; Organisation for Economic Co-operation and Development, 2018).

On the one hand, the EC establishes that collaboration requires 'transversal skills such as the ability to think critically, take [the] initiative, [solve problems] and work collaboratively will prepare individuals for today's varied and unpredictable career paths' (p. 3). The complexity of the problems that students must face in the near future will require them to collaborate and be proactive to 'make things happen'. Collaboration is important because when it is productive and successful, students will learn what they would likely not learn individually (Stahl, 2017). Collaboration is a complex emergent process that is more than the aggregation of the thoughts and actions of each member separately (Dillenbourg et al., 2009; Stahl et al., 2014).

Collaborative learning is a teaching method that involves forming small groups of students who work together to enhance their own learning and that of their peers (Kreijns & Kirschner, 2018). When computer technology evolved and the internet became the standard way to communicate between computers, *computer-supported collaborative learning* (CSCL) became possible. Koschman (2002) defined it as 'a field of study centrally concerned with meaning and the practices of meaning making in the context of joint activity, and the ways in which these practices are mediated through designed artefacts'. We agree with Stahl et al. (2014) that 'CSCL locates learning in meaning negotiation carried out in the social world rather than in individuals' heads.' It was develo-

ped in the 1990s, when the prevailing software supported isolated learning rather than collaborative learning among students (Stahl et al., 2014). To prevent isolation, researchers started to surface concepts such as social presence and social interactions, which gave a theoretical background to different widgets and features so as to support social affordances (Kreijns & Kirschner, 2018; Kreijns et al., 2003, 2013, 2022). This dissertation examines social interactions that occur during CSCL, which are very complex and multidimensional phenomena influenced by social factors and which affect socio-emotional processes in collaborative learning (Kreijns et al., 2003). We are interested in social interaction because it is the mechanism that shapes cognitive and socio-emotional processes in CSCL.

On the other hand, regarding how to support agency, this dissertation is aligned with the ideas of Bandura (2001) that agency occurs when students 'intentionally make things happen by [their] actions' (p. 2) and that 'agency enables people to play a part in their self-development, adaptation, and self-renewal with [the] changing times' (p. 2). Agency was also among the main priorities in the development of CSCL (Tchounikine, 2019; Wise, 2017). For Tchounikine (2019), 'Learners are not just a factor in CSCL setting enactment; they are the actors. They should be empowered to self-determine the media, and thus, the software applications that they want to use as a substratum for their activities' (p. 4). Other authors (Stahl et al., 2014; Wise, 2017) affirmed this, stating that the importance of agency in CSCL lies in supporting motivation, engagement and self-determination.

Collaboration and agency may seem to be opposite terms. Collaboration implies social interactions that influence the members of the group. Agency, as we have seen, usually refers to the individual. Nevertheless, some authors (Edwards & D'arcy, 2004; Kafai et al., 2012; Xia & Borge, 2020) are already creating constructs such as *collaborative agency*, which Kafai (2012) defines as 'unstructured, self-organised collaboration' (p. 65). However, as important as these capacities are, none of them is easy to develop.

When students collaborate in such an unstructured context in which roles, tasks and people are not specified, challenges may arise. As previous research has shown, the challenges that students may face can be cognitive, motivational or, as we saw in the *Preface* section, socio-emotional. For example, researchers have studied how smart groups fail (Barron, 2003) and have described how the interdependent content and relational spaces help explain how students manage their collaborative efforts. The way in which students handle these interrelated spaces is crucial to the results of their tasks and contributes to the differences observed in collaborative results. Moreover, in CSCL systems, the lack of social presence and social cues (Kreijns & Kirschner, 2018; Kreijns et al., 2003, 2013, 2022) in a group was viewed as a pitfall that reduced individuals' attraction to the group and decreased the group members' socio-emotional interactions (Draft & Lengel, 1984), as well as regulatory processes, leading to unproductive behaviour (Prentice-Dunn, 1989). This lack of social presence and the anonymity of the group members in CSCL have been described by the social identity model of deindividuation effects

(SIDE; Spears, 2017). This model studies the situational factors of anonymity to understand why it can lead to unproductive behaviour or facilitate group cohesion.

Agency challenges are closely connected to the aforementioned challenges: they arise because in social interactions, if one group member is 'intentionally trying to make things happen by [their] actions', those actions may collide with other members' actions or beliefs. To avoid these challenges and save time and effort, many students choose to cooperate (i.e., to divide their work independently) instead of truly collaborating (Dillenbourg, 1999).

Bandura (2001) tried to overcome these difficulties in his sociocognitive theory. Social cognitive theory differentiates between three types of agency: direct personal agency, proxy agency which depends on others to achieve desired results on one's behalf, and *collective agency* which is exercised through coordinated and interdependent social effort. The socio-cognitive theory posits that human behaviour is a product of the ongoing mutual interaction between individual, environmental, and behavioural elements (Schunk & Usher, 2018). It views individuals as proactive agents who can guide their actions and adjust to situational demands. However, they are also in a constant give-and-take relationship with their surroundings, both shaping and being shaped by external opportunities and limitations. The sociocognitive theory has had a marked influence on the theory of the social regulation of learning (Hadwin et al., 2017), which tries to describe interactions between the cognitive, motivational and socio-emotional factors of learning. Collaborative regulated learning is rooted in the socio-cognitive theory of self-regulated learning, as well as theories of cognition and metacognition (Schunk & Greene, 2018). It explores the cyclical process by which learners manage not only their own cognition, motivation, emotion, and behaviour, but also those of others and the group as a whole in a collaborative learning environment (Hadwin et al., 2018). In this dissertation, we focus on the motivational and socio-emotional factors, which have been less studied (Järvenoja et al., 2019) and thus, have caused ineffective collaboration. According to Isohätälä et al. (2020) and Järvelä et al. (2016), in many cases, students do not recognise or activate any kind of control or regulation over these affective aspects, since being aware of them requires learning and experience; and Boekaerts (2011) and Järvelä et al. (2015) argued that without the successful regulation of emotions, the cognitive side of learning can be ineffective). Pintrich (2000) pointed out that some teachers expect students to learn regulation skills merely by putting them to work together, but regulation is difficult and must be learned (Lyons et al., 2021).

Thus, the main motivation of this dissertation is to explore the possibilities of designing a tool for improving student collaboration by facilitating socio-emotional interactions during their CSCL tasks. More precisely, it is to do so by designing interactions, features[1] and affordances to support students in learning, gaining experience and becoming

1 In general, we call the prototype presented in publications C2 and C3 (see Publications section 1.4) a 'tool'. This tool integrates different 'features' (i.e., anonymous messages, self-emotions panel, profile page etc.) with social and hedonic affordances to support social interactions and group regulation during collaboration.

more aware of the socio-emotional aspects of collaborative learning while maintaining their agency and autonomy in contexts with complex teacher supervision.

Figure 1.1 summarises the conceptual foundations of this thesis:

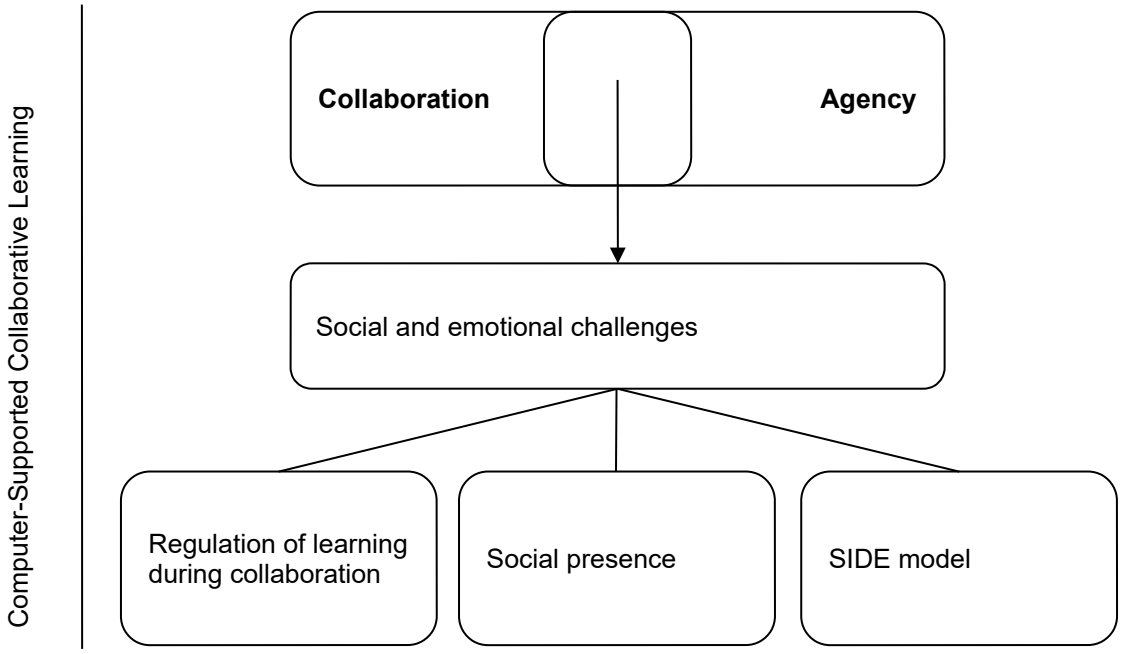

Figure 1.1: A visual representation of the conceptual framework of the doctoral thesis

Before we introduce the theoretical background of this dissertation, we finish this introduction by describing our point of view in this problem space: our theoretical standpoint (which will be further developed when we justify the *Methodology* section). Twining et al. (2017) suggested the need for the 'theoretical stance underpinning the research [to be] made explicit' (p. 4). Thus, our ontology is that there are multiple realities, and our epistemology is that meaning is culturally defined. More specifically, based on the object of our study and our view of knowledge and learning, we followed the epistemological tradition of social constructivism, which implies that knowledge is distributed in the world among individuals, tools and artefacts, as well as among communities and their practices (Danish & Gresalfi, 2018; Greeno et al., 1996). From this viewpoint, meaning is constructed through the interaction of individuals as they engage with the world and with historical and cultural norms. We believe that this perspective of learning is the most aligned with CSCL.

In the next section, we present this perspective in detail and elaborate our theoretical background.

1.2 Theoretical Background

In this theoretical background, we provide an overview of various theories that aided us in comprehending previous studies with the same objectives as ours. Integrating several features in a single tool requires using and mixing several theoretical supports. This overview has three subsections. The first subsection contextualises this dissertation within the socioconstructivist tradition. The second subsection outlines the fundamental CSCL models that guided our research. The third subsection introduces the theories that underpin this dissertation, both in a general sense and in terms of their contributions to CSCL.

a) Sociocultural learning studies

Educational theories basically have three perspectives related to learning: behaviourist, cognitive and socioconstructivist, which is what is adopted in this dissertation (Danish & Gresalfi, 2018; Greeno et al., 1996). Vygotsky was probably the first author to describe knowledge based on the socioconstructivist perspective – as constructed among groups of people interacting with each other and with artefacts in a certain context to perform a certain activity. Some other cognition and learning theories that have the same perspective are situated learning (Lave & Wenger, 1991), situated cognition (Brown et al., 1989), distributed cognition (Bell, 2011; Hutchins & Klausen, 1996), situated action (Suchman, 1987), Engeström's activity theory (Artefact, 2015; Kuutti et al., 1996; Nardi, 1995) and group cognition (Stahl, 2006).

Among all these theories, we based our investigations on *group cognition*, which Stahl (2006) developed from the earlier theories. It argues that meaning is constructed through a collaboration process, as a shared group product. However, this meaning must be interpreted by the group members involved. Stahl contends that the shared knowledge generated within a group is more than just the aggregation or sum of individual understandings. We strive to support this concept of group cognition by enhancing social interactions and awareness, focused on the frequently neglected facets of learning: the socio-emotional dimensions.

b) Computer-supported collaborative learning (CSCL) models

Research in the domain of collaborative learning encompasses a broad and theoretically varied collection of research frameworks. Rather than being a standalone theory of learning, collaborative learning research comprises various frameworks that coexist, each with its own focus of investigation and theoretical foundations, to elucidate learning processes within a social, collaborative context (Jeong & Hartley, 2018; O'Donnell & Hmelo-Silver, 2013). In this dissertation, we utilise three such frameworks that have been instrumental in studying collaborative learning: the domain of computer-supported

collaborative learning, research on regulated learning in collaboration, and the SIDE model.

Hallet and Cummings (1997) first observed the following:

> . . . having the majority of assignments in public forums with the entire class posting at a given time, and with numerous prompts and encouragement from the instructor, it was hoped that interaction among students would occur naturally. This was not what took place. (p. 105)

Kreijns et al. (2003) took this idea and the social presence theory as starting points for identifying the pitfalls of social interactions in CSCL and offered a model (Figure 1.2) that included cognitive and socio-emotional processes. A year later, they provided a framework for designing CSCL environments based on technological, educational and social affordances (Kirschner et al., 2004). *Technological affordances* focus on the design of the interactions provided by the system and on their usability. *Educational affordances* are the 'relationships between the properties of an educational intervention and the characteristics of the learners that enable [their] particular kinds of learning' (p. 10). *Social affordances* are 'the properties of a CSCL environment that act as social and contextual facilitators relevant for the learner's social interaction' (p. 9).

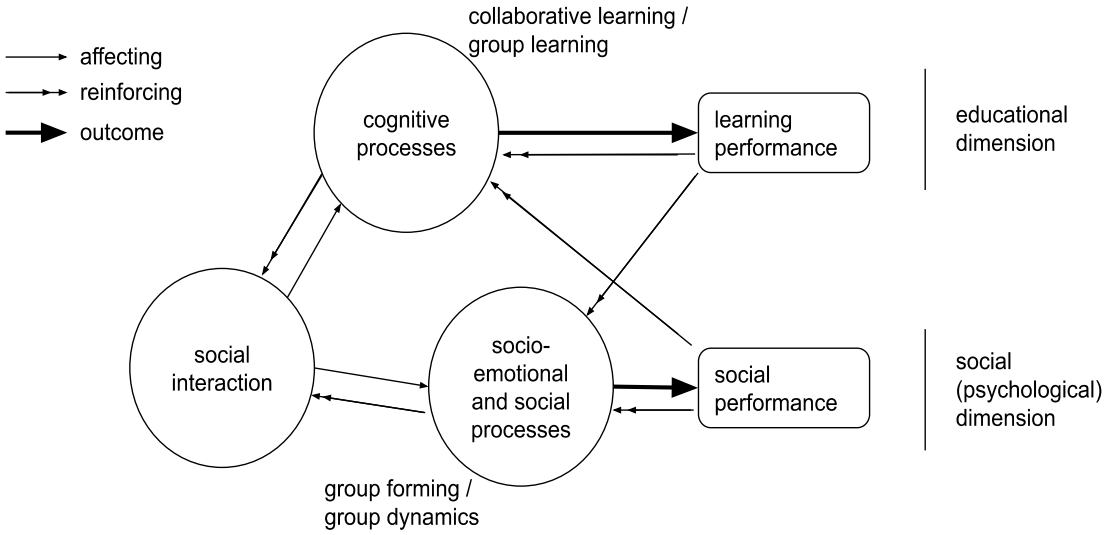

Figure 1.2: Kreijns model depicting the educational and the social (psychological) dimension of social interaction (2003)

Although social interactions have always been essential conditions of CSCL environments, researchers and teachers have found that the expected social interactions did not always occur (Kreijns et al., 2013). However, technology has changed and improved since then, and a few years later, Kreijns and Kirschner (2018) updated their model into the hedonicity, educability and sociability (HES) model (Figure 1.3). *Hedonicity* is the degree of enjoyment and other positive experiences derived from online collaborative learning tools. This concept leads them to posit that the influence of game mechanics

and putting a fun spin on interaction will result in learning that is not only effective but also something to be enjoyed. *Educability* refers to the educational affordances that support collaborative learning. They define *sociability* as the ability of CMC tools and digital platforms to facilitate the manifestation and experience of social presence, as well as the development of a social environment.

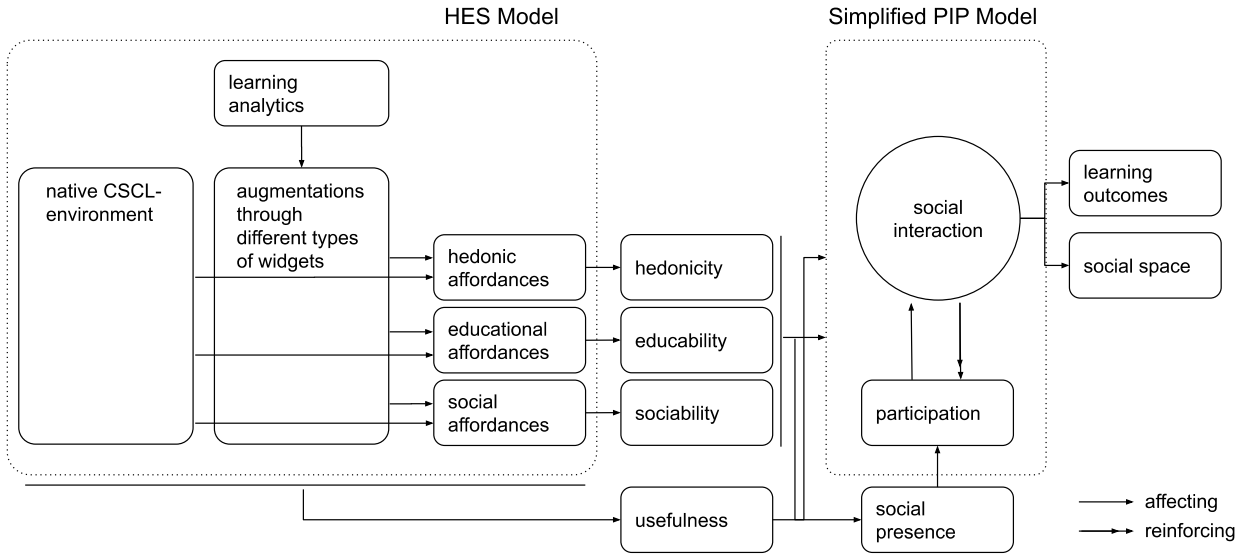

Figure 1.3: Kreijns & Kirschner model (2018)

The HES model is especially relevant to our work, since we find it more complete, up to date and more open to unstructured collaborations that mix formal and informal learning in contexts with complex teacher supervision. The work presented in the first four chapters of this dissertation is based on the design of hedonic and socio-emotional features and affordances for the socio-emotional side of CSCL.

c) Social and emotional factors of collaborative learning

Social presence

In general, social presence is linked to the utilisation of digital tools and platforms for CSCL. It measures how effectively these tools and platforms can replicate face-to-face interpersonal communication, group learning and dynamics in an online environment, which subsequently affects learning outcomes (Tu & McIsaac, 2002; Zhao et al., 2014).

Research has shown not only that social presence influences group learning and dynamics through social interaction (Tu, 2000) but also that, conversely, social interaction can enhance social presence (Song & Yuan, 2015). Poth (2018) emphasised that cultivating an individual's 'social presence' within a learning environment is crucial for fostering a more engaging and supportive educational experience, which will increase stu-

dent motivation and success (p. 89). Mykota (2017) evaluated social presence as a vital affective component of online learning and one of the key constructs in determining the level of interaction and effectiveness of learning in such a setting.

Social presence has been defined in a number of ways: as 'the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships' (Short et al., 1976, p. 65); 'the degree of feeling [and] perception [of], and reaction to[,] another intellectual entity' (Tu & McIsaac, 2002, p. 146); 'the ability of learners to project themselves socially and emotionally in a community of inquiry' (Anderson & Rourke, 2002, p. 3); and 'the degree to which a person is perceived as a real person in mediated communication' (Gunawardena & Zittle, 1997, p. 9).

Kreijns et al. (2022), argued that the absence of a clear definition of social presence has led to diverse interpretations of the term that seem to originate from completely different theoretical frameworks. Thus, they redefined *social presence* as a psychological phenomenon in which individuals perceive other individuals as physically 'real' to some degree in communication facilitated by CSCL tools and electronic platforms. Gunawardena et al. (1997) noted that this sense of reality is not solely dependent on the technology used but is also shaped by students' expression and projection of their identities. Consequently, Kreijns et al. (2022) suggested that the 'realness' of others is also influenced by social factors.

To further explain this social aspect, Kreijns et al. (2022) introduced two additional concepts: sociability and social space. They described *sociability* as the ability of computer-mediated communication (CMC) tools and electronic platforms to enable the expression and experience of social presence, as well as the development of a social space. They characterised a *social space* as a network of interpersonal relationships ingrained in group structures of norms, values, rules, roles and beliefs; a *robust social space* is demonstrated by a sense of community, group climate, mutual trust, social identity and group cohesion.

In conclusion, social presence, sociability and social space do not operate independently but are interconnected. Together, they shape how social interactions within groups are formed and sustained.

Stodel et al. (2006) offered a very clear function of social presence: 'to facilitate the attainment of the cognitive learning objectives by supporting critical thinking in a community of learners, as well as the affective learning objectives by making the group interactions enjoyable and rewarding' (p. 3). They analysed social presence using three categories, following Garrison et al. (2000): emotional expression, open communication and group cohesion. We address group cohesion next, followed by emotional expression and open communication, in the *Anonymity* section (1.2.c.).

Group cohesion was part of our aforementioned definition of social space. Carron et al. (1985) observed that the diverse definitions of cohesion could be classified into two pri-

mary categories: (a) Group Integration, which is a member's perception of the group as a whole, and (b) Individual Attraction to Group, which is a member's personal affinity for the group. They contended that both these perceptions contribute to strengthening the bond between members and their group (Chang & Bordia, 2001).

Emotional expression is a human need. Some emotions are felt more frequently than others during learning and differ from emotions related to other areas of life. Researchers have described three categories of emotions during learning: social, epistemic and achievement emotions (Lajoie et al., 2019; Pekrun, 2019a, 2019b; Pekrun et al., 2017). Examples of these emotions are surprise, curiosity, enjoyment, confusion, anxiety, frustration and boredom. Emotion regulation is important for reducing negative responses and improving the atmosphere in a group. In this research, we hypothesised that there was an opportunity to test, in real contexts, if students were aware, in the first place, of their emotions during CSCL tasks. We set as our *first research goal* the provision of specific features that target a limited range of the most common emotions experienced during collaboration to enhance students' awareness of these emotions and help them express such emotions. This goal is further discussed in RQ2 and Chapters 3, 4 and 5.

Zschocke et al. (2016) found that positive appraisals of the cognitive aspect of group work are a significant factor of the activation of positive emotions (Linnenbrink-Garcia et al., 2011). In turn, negative socio-emotional interactions can provoke negative emotions (Mänty et al., 2022), which can lead to off-task behaviour and disengagement from collaborative learning (Näykki et al., 2014, 2017).

Moreover, Barron (2003) discovered that feelings of wasted time, discouragement and socio-emotional challenges can make a group fail because during collaboration, there is a relational space that intertwines with the content space. Thus, awareness of the socio-emotional part of collaboration is a key factor of group performance (Järvelä et al., 2015).

Learners, while working together, may come across several interaction patterns that make their cooperation not only less productive but also more frustrating (Strauß & Rummel, 2021). If students are dissatisfied with the collaboration, they may reduce their engagement or even leave the collaboration. Thus, the effectiveness of collaborative learning is challenged by frustrating interaction patterns, since interaction between group members is necessary for collaborative learning to be successful. Strauß & Rummel (2021) further found that the worst interaction patterns are social laziness, beating the deadline, inadequate communication and unequal engagement.

Moreover, Lyons et al. (2021) observed that even if students realised that they were experiencing a socio-emotional issue in their group, they did not necessarily activate either regulatory processes or any strategy to address the issue. *Socio-emotional challenges* refer to issues in participation (i.e., free riders), personalities and identities (i.e., low self-esteem and low esteem of someone else in the group), different topic interests (Mänty et al., 2022) and communication issues (Khosa & Volet, 2014). Motivational challenges

can occur when members have different goals, different self-efficacy perceptions and different interests. These challenges should trigger the need to regulate the socio-emotional aspects of collaboration (Bakhtiar et al., 2018; Sobocinski et al., 2017). Researchers have found that to recognise challenges, group members need to be aware of their own and others' socio-emotional states (Järvelä & Hadwin, 2013). This was our *second research goal*: to design features to help students improve their motivation and address socio-emotional challenges during CSCL tasks. This goal is addressed through RQ2 and covered in detail in chapter 4 and 5.

Table 1.1: Summary of problematic socio-emotional situations that groups of students can face during collaborative learning, from past research

Problematic interaction patterns	Social laziness
	Deadline hurry
	Inadequate communication
	Unequal engagement
Socio-emotional challenges	Differences in participation
	Differences in personalities
	Differences in self-esteem
	Differences in interest in the topic
	Differences in communication
Motivational challenges	Different goals
	Different self efficacy perceptions
	Different interests

To design better social presence following the model of Kreijns and Kirschner (2018), we concentrated on providing social, educational and hedonic features. As mentioned, social presence is determined not only by technological factors. If it were so, a real-time 3D model of the group members would be the highest level of social presence that could be achieved. We followed the idea that there are also social factors that determine social presence (Gunawardena & Zittle, 1997), which allow students to project their identities. In this sense, we found that the social identity model of deindividuation effects (SIDE) could be our inspiration to improve the collaborative learning experience, through features that facilitate the socio-emotional side of learning. We will present this model in detail in the Anonymity section (Section 1.2.c). It was our way of facilitating open com-

munication and thus, a safe atmosphere for expressing ideas and emotions. However, we developed another aspect of SIDE that it has in common with social presence and group cohesion – the fact that with this model, 'what matters is how group members (and self) are visually represented online' (Spears & Postmes, 2015). For example, Lee (2004) investigated how visual representations of group members affected depersonalisation and conformity in CMC groups.

Thus, our *third research goal* was to explore how to reinforce social presence, group cohesion and a sense of community through the design of avatars and a personal profile, which is part of RQ2 and will be presented in Chapters 4 and 5. Avatars' representation liberates their users from feeling exposed, and how this affects the behaviour of their users in video games and social media has been studied (Beyea et al., 2021), as has been the effect of avatars in classroom contexts (Guegan et al., 2016), but not as collaboration facilitators (Ho, 2022). We also designed a panel in which students can present themselves as students and collaborators and answer questions about their identity that other group members can see. Finally, the avatars can be used and manipulated to create motivational messages for the group.

The regulation of learning

In order to better understand these problematic patterns and challenges, the theory of regulation of learning described three modes and three phases of regulation in collaborative learning (Hadwin et al., 2017; Järvelä & Hadwin, 2013). The modes are self-regulation, co-regulation (a student helps another student) and socially-shared regulation (that refers to the regulation of the group as such). In general, high performing groups use more regulatory processes (Linnenbrink-Garcia et al., 2011). More specifically, previous studies have reported better learning products and outcomes in groups that engaged in more Socially Shared Regulation of Learning (SSRL) (Malmberg et al., 2015). These processes, ideally, should be activated when a group of students encounter challenges that present a discrepancy between the current situation and a better one (Hadwin et al., 2018; Sobocinski et al., 2017).

The phases of regulation of learning are planning, monitoring and reflection (Järvenoja et al., 2018). Students evaluate their effectiveness and aptitude in the *planning* phase based on their motivated self-beliefs. They assess the worth of the particular learning task and their level of interest in it. They develop objectives that suit their motivational preferences and goal orientation based on these motivating factors. The awareness and observation of motivation as well as the development of goal-oriented work are part of the *monitoring* phase. In order to impact their motivation and to maintain, shape, or refocus goal-oriented work, students adjust to the right motivation management mechanisms as needed. They can also reconsider decisions they made during the planning stage and make changes. Finally, students evaluate their performance and results against their goals during the *reflection* phase, making causal attributions based on their success, efficacy, and talents.

In this dissertation, we focus on facilitating self-regulation, co-regulation and SSRL during the monitoring phase of regulation of learning, which is the least studied of the phases.

Concerning the regulation of learning in CSCL environments, Miller and Hadwin (2015) introduced an important distinction between scripting and awareness tools. *Scripting tools* organise and direct teamwork by defining, ordering and allocating tasks and responsibilities to be performed. *Awareness tools* are less invasive and could help students detect by themselves the challenges they face. Other scholars, following the theory of regulation of learning, have been inspired by the aforementioned findings to design their own tools (Hadwin et al., 2018; Isohätälä et al., 2020; Malmberg et al., 2015). We already reviewed most of these tools in one of our publications (Velamazán et al., 2020). The conclusions are as follows:

- Only five tools were specifically for socio-emotional regulation: Avry's Emotion Awareness Tool (EAT), SEST, S-Reg, Collabucate and EmATool. Of these five, only Avry's EAT, S-Reg and EmAtool are considered awareness tools.
- The integration of the tools into the collaboration flow was very cumbersome (except for Avry's EAT), and only two tools were integrated into a CSCL environment (i.e., Avry's EAT and Collabucate).
- The tools (except for Avry's EAT) tested emotional or motivational 'states' before or after (not during) collaboration to increase awareness. However, Avry's EAT was synchronous in formal settings and for dyads of students who could talk and hear each other (through headsets).
- Only one of the tools (Avry's EAT) focused on emotions with enough detail, but, as mentioned, it was limited to two-member groups. There was another tool (i.e., S-Reg) that tested the emotional state of students but as a block (*What is your emotional state?* on a Likert scale from positive to negative), without further granularity. We aimed at providing a research-based list of emotions to choose from. This would also provide knowledge about the emotions that learners most frequently have.
- None of the tools has been tested during unstructured collaboration and without any supervision (i.e., by a teacher or researcher).

Although the most important contributions of this dissertation are about anonymity (Chapters 6, 7 and 8), the features of our prototype focus on group awareness tools (discussed in Chapters 4 and 5) because, as we claimed in the *Introduction* section, one of our aims with our features is to foster students' collaborative agency in contexts of complex teacher supervision.

Thus, our *fourth goal* was focused on avoiding partial approaches to regulation and designing a complete communication tool that integrates all the features so that they

would be available (and could be tested) during the natural, asynchronous flow of collaboration. This goal is the origin of RQ2 and covered in Chapters 4 and 5.

Anonymity

Fostering social interactions among group members in CSCL has been the focus of researchers for many years. We have seen that sociability, social space and social presence are constructs used to compensate for the tendency of former CSCL environments to concentrate only on the cognitive side of learning (Hernández-Sellés et al. 2019; Kreijns et al., 2013, 2022).

The study of anonymity began in social psychology. Spears and Postmes (2002), Sassenberg and Postmes (2002), Spears (2017) and Christopherson (2007) presented different literature reviews on the development of such studies. The first studies in this field followed the deindividuation theory, which states that, within a group, members are not seen as individuals. These investigations pointed out the lack of social presence and social cues in CMC (Kiesler et al., 1984; Rutter, 1984). CMC was viewed as an impersonal medium that reduced attraction to the group and decreased socio-emotional interactions (Draft & Lengel, 1984) and regulatory processes, leading to unproductive behaviour (Prentice-Dunn, 1989).

New theories appeared to explain in detail how anonymity affects behaviour in computer-mediated systems, including the equalisation hypothesis and SIDE model (Christopherson, 2007). The equalisation hypothesis (Dubrovsky et al., 1991) posits that computer-mediated systems can promote more equal participation due to the lack of social cues, such as physical appearance, gender, race, age, physical disabilities and attractiveness (Haraway, 1987; Poster, 1990; Sproull et al., 1991). Lower-status students could also benefit from this absence of social cues (Postmes & Spears, 2002).

The SIDE model develops the deindividuation theory, focusing on the situational factors of anonymity. It has both cognitive and strategic aspects. From a cognitive point of view, it (Spears, 2017) distinguishes between (a) anonymity of the self to the group and (b) anonymity of the group to the self. It predicts that when all members are anonymous, group salience will increase and members will identify more with the group. However, when only a member is anonymous to the group, this person will identify with themselves more than with the group. From a strategic perspective, the same authors theorised that members would also use anonymity to meet their goals and needs. For example, Flanagin et al. (2002) reported that women tended to preserve their anonymity during their discussions, and Aggarwal & O'Brien (2008) observed that some group members used anonymity to have fun, distract or show antisocial behaviour, such as the free-rider effect. It seems that this strategic side of the use of technology is crucial to understanding whether anonymity leads to productive or unproductive behaviour in groups.

According to several studies, anonymity can have both positive and negative effects (Howard et al., 2010; Postmes et al., 2001; Roberts & Rajah-Kanagasabai, 2013). For its positive effects, it can increase attraction towards the group and group cohesiveness if a common group identity is salient. Thus, anonymity can be useful in CSCL contexts (Postmes, 2001). Moreover, previous research has found that anonymity can help increase participation, especially that of low-status individuals, social minorities and shy students, by creating an environment that is free from reprisal (Chester & Gwynne, 1998). Hoadley and Linn (2000) included in their study a feature in their SpeakEasy learning environment that allowed for anonymous contributions 'to establish a collaborative, safe environment, not a competitive environment'. Specifically, in an asynchronous setting, students (eighth graders) were allowed to show their faces or remain anonymous. The results showed that anonymity increased participation. Howard et al. (2010) reported that 'students who were anonymous were approximately five times more likely to provide substantively critical feedback than were those whose identities were known to their recipients.' Anonymity has also been shown to have positive effects in other contexts, such as in voting and debating (Ainsworth et al., 2011), peer assessment (Kobayashi, 2020; Lin, 2018; Panadero et al., 2023; Rotsaert et al., 2018; van den Bos & Tan, 2019; Vanderhoven et al., 2015), blended learning that mixes real and online identities (Miyazoe & Anderson, 2011), writing (Woodrich & Fan, 2017), sharing knowledge in a community of inquiry (Bagustari et al., 2019) and giving feedback (Howard et al., 2010; Panadero & Alqassab, 2019). For the negative effects, however, anonymity can channel antinormative or antisocial behaviour. Many students have reported that they tend to avoid making anonymous contributions (Hoadley, 2002), or that anonymity allows for jokes, insults or an unproductive group atmosphere (O'Sullivan & Flanagin, 2003). The lack of body language, facial expressions and tone of voice, among other factors, challenge the social side of online collaboration for learning.

It is important to recognize that the impact of anonymity on group behaviour in (CMC) is intimately tied to the interaction context" (Watt et al., 2002, p. 72). Furthermore, anonymity is not a binary condition but a spectrum (Scott, 1998). It is proposed that a more comprehensive comprehension of its effects can be achieved by breaking down anonymity into its various components (Lea et al., 2001).

As a conclusion of this line of previous research papers and according to several researchers (Hara et al., 2018; Wodzicki et al., 2011), varying levels of anonymity and how they are represented might promote beneficial interactions while avoiding some of the well-known downsides of anonymity.

As a consequence, the *last goal* of this dissertation is to look for ways to promote social interactions and awareness of socio-emotional challenges during collaboration using anonymity. We designed, implemented and tested different ways in which anonymity could be used for the stated purpose: only in certain messages, with full anonymity to all actors and with anonymity to peers but not to the teacher. This goal shaped RQ3 and is covered in detail in Chapters 6, 7 and 8.

Figure 1.4 shows a diagram of the aforementioned theoretical background of this dissertation. Considering all the previous literature reviewed and having explicitly identified clear gaps in them and explicitly established corresponding goals, in the following subsection, we present more precisely our dissertation goals and describe the methodology we selected for achieving them.

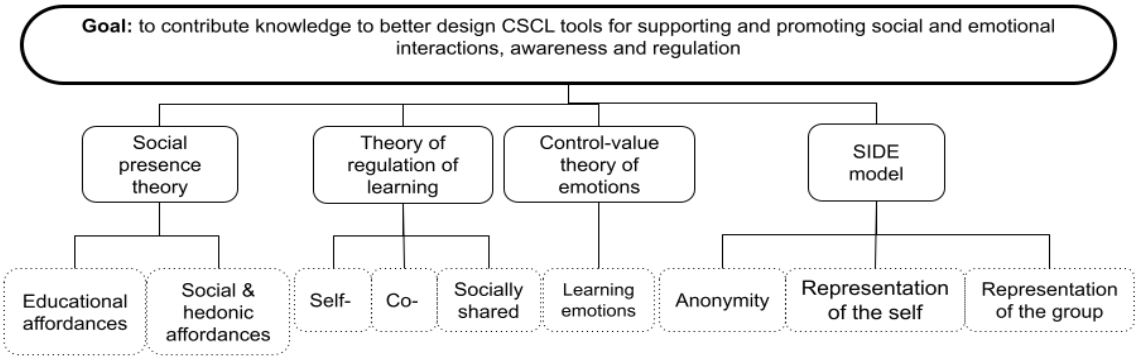

Figure 1.4: Theoretical background overview of this thesis

1.3 Research questions

Drawing from the theoretical framework of our research, which encompasses the principal features of our context and the gaps identified in existing literature, the primary aim of this dissertation is: **to advance the knowledge base for an improved design of Computer-Supported Collaborative Learning (CSCL) tools, intended to support and enhance socio-emotional interactions, awareness, and regulation.**

In Figure 1.5, we present an overview of this dissertation. We describe our starting point in the *Preface* section. The *Introduction* section presents our motivation for this dissertation, which is to study ways to help students address socio-emotional challenges during CSCL. We have introduced the main research goals through the theoretical background, which has confirmed and justified the salience of our main motivation. Our starting point and our motivation shaped the first research question. The four research goals are the foundation for the second research question. And our last goal is addressed in the third research question. After we explain our research questions, we present the research methodology and, specifically, the development of our experiments and publications. We finish this chapter with a description of the main contributions of this dissertation and possible lines of future research.

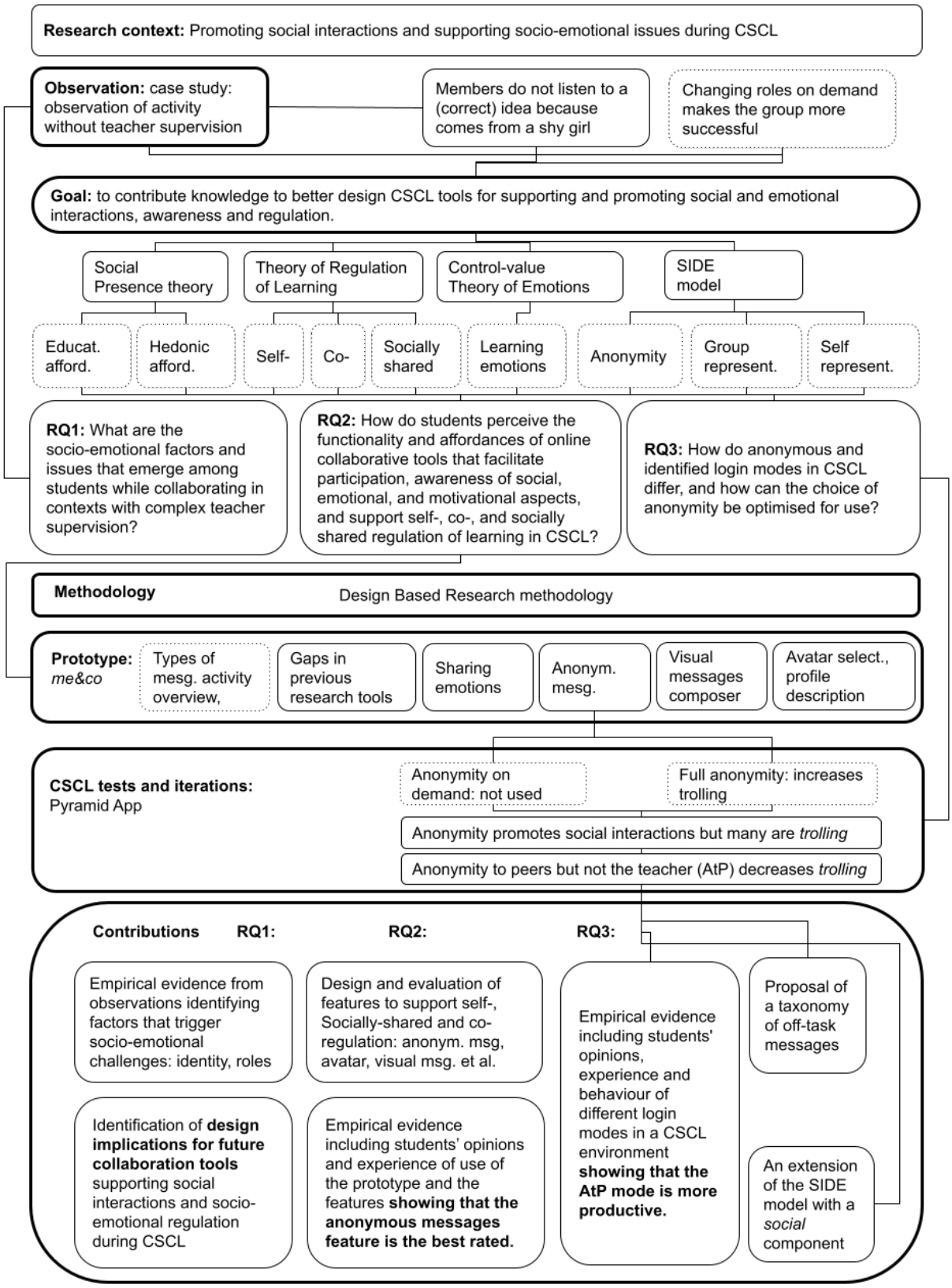

Figure 1.5: Overview of the thesis

Our main research question is as follows:

How can socio-emotional awareness, interactions and regulation be enhanced and facilitated through the incorporation of specific features within the design of a CSCL environment?

This general research question can be divided into the following research questions (RQs):

- RQ1: What are the socio-emotional factors and issues that emerge among students while collaborating in contexts with complex teacher supervision?
- RQ2: How do students perceive the functionality and affordances of online collaborative tools that facilitate participation, enhance awareness of social, emotional, and motivational aspects, and support self-regulation, co-regulation, and socially shared regulation of learning in online collaborative settings?
- RQ3: How do anonymous and identified login modes in CSCL environments differ, and how can the option of anonymity be optimised for use?

RQ1 refers to a case study in which we observed and surveyed students collaboratively solving a problem in a setting outside school without teacher supervision, during which socio-emotional issues unfold more freely. We aimed to identify socio-emotional factors of collaboration in such a setting in order to establish some principles for the design of pertinent asynchronous collaboration tools.

RQ2 was meant to inform our implementation of the principles from RQ1 for the design of socio-emotional affordances for asynchronous mobile collaborative tools that would support students' regulation, motivation and awareness of socio-emotional challenges with social and hedonic affordances in contexts with complex situations of teacher supervision, by conducting experiments that would integrate socio-emotional factors into a conventional communication tool. Our goal was to determine which of the features proposed were preferred by students.

With RQ3, our aim was to test different levels of anonymity (no anonymity, full anonymity and anonymity to peers but not to the teacher) with students, know their opinions and preferences after the tests, and analyse their conversations during their collaboration to check if such conversations aligned with their reported preferences. We also aimed to better understand how anonymity changes students' behaviour, what students use it for and, more precisely, if it increases participation and social interactions without decreasing productivity. With this evidence, we will understand better the optimum type of anonymity for CSCL.

1.4 Publications

This dissertation is presented as a compendium of the following papers, which will be presented in the following chapters.

Publications in JCR-indexed international peer-reviewed journals:

J1. Accepted

Velamazán, M., Santos, P., Hernández-Leo, D., & Vicent, L. (2023). User anonymity versus identification in computer-supported collaborative learning: Comparing learners' preferences and behaviours. *Computers & Education*, 104848. https://doi.org/10.1016/j.compedu.2023.104848 (Journal in JCR Q1).

J2. Under review

Velamazán, M., Santos, P., Sánchez-Reina, J. R. & Hernández-Leo, D. (2024). Optimising anonymity in CSCL: comparing collaboration between identified and anonymous-to-peers login modes. *Submitted to journal.*

Publications as book chapters:

B1. Accepted

Velamazán, M., Santos, & P., Hernández-Leo, D. (2022). Socio-Emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning. In: Gil, E., Mor, Y., Dimitriadis, Y., Köppe, C. (eds) Hybrid Learning Spaces. Understanding Teaching-Learning Practice. Springer, Cham. https://doi.org/10.1007/978-3-030-88520-5_7

Publications in international conference proceedings:

C1. Accepted

Velamazán, M., Santos, P. & Hernández-Leo, D. (2020) Collaborative educational location-based activities with no teacher supervision: design implications. In: Söbke H, Baalsrud Hauge J, Wolf M, Wehking F, editors. Proceedings of DELbA 2020 - Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020); 2020 Sep 15; Heidelberg, Germany. Aachen: CEUR; 2020. http://ceur-ws.org/Vol-2685/paper4.pdf

C2. Accepted

Velamazán, M., Santos, P., & Hernández-Leo, D. (2021). Awareness Tools for Monitoring Socio-emotional Regulation During Collaboration in Settings Outside School Without Teacher Supervision. In: De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A. (eds) Technology-Enhanced Learning for a Free, Safe, and Sustainable World. EC-TEL 2021. Lecture Notes in Computer Science (pp. 389-393), vol 12884. Springer, Cham. https://doi.org/10.1007/978-3-030-86436-1_41

C3. Accepted

Velamazán, M., Santos, P. & Hernández-Leo, D. (2021). How to design features for promoting social and emotional interactions during computer supported collaborative learning. *Accepted in HCI International 2024 Conference*.

C4. Accepted

Velamazán, M., Santos, P., Hernández-Leo, D., & Amarasinghe, I. (2022). Student preferences and behaviour in anonymous collaborative learning. In Weinberger, A. Chen, W., Hernández-Leo, D., & Chen, B. (Eds.), Proceedings of the 15th International Conference on Computer-Supported Collaborative Learning - CSCL 2022 (pp. 419-422). International Society of the Learning Sciences. https://repository.isls.org//handle/1/8323

1.5 Research Methodology

This section begins with an explanation of the research philosophy that forms the foundation of this dissertation. Following this, a model and a summary of the research methodology are provided. Then, the implementation of the methodology is elaborated. Finally, the methods employed throughout the research are specified.

This dissertation was founded on the constructivist or interpretivist theoretical perspective (Twining et al., 2017). Although a common way of conducting scientific inquiry is to use the objectivist or positivist view, which emphasises quantifiable measurements and data, our constructivist epistemology guides most studies in social science. It focuses on collecting qualitative data – such as from open-ended answers, interviews, participant observations, field notes and reflections – and analysing them for patterns, features and themes that emerge in order to understand and interpret the subject of the study, which, in this dissertation, is social interactions. The results of this kind of research are often specific to the group being studied and are not transferable to other groups.

However, design was also fundamentally used to conduct this research. In general, design devises courses of action aimed at changing existing situations into preferred ones (Simon, 1969). It draws on methods and theories from other fields to help conduct the research, using the objectivist and interpretivist perspectives as convenient. However, there are problems associated with the cross-application of approaches and concepts from other fields into design because ontologies and epistemologies are mixed (Kali & Hoadley, 2021). Thus, Zimmerman and Forlizzi (2007) argued that it is very important for design researchers to pay attention to the foundational differences between research methods. Some authors have proposed design as an independent epistemology (Nelson & Stolterman, 2014) or as a third paradigm that 'negotiates' between positivist and interpretivist epistemologies (Hoadley & Campos, 2022). They argued, as Simon (1995) did, that design is not merely a problem-solving discipline, since problem finding and problem definition are also key to it. Hoadley and Campos (2022) connected the design paradigm to the pragmatist philosophy, in which knowledge is seen as actionable and

contextually grounded but general enough to be transferred to different situations (Bakker, 2018), and the resulting designs of which can embody questions that challenge the status quo (Zimmerman et al., 2007). The authors also saw a different end point of pragmatist research. While the interpretivist approach produces knowledge that is descriptive and explanatory, and the positivist approach generates knowledge that is descriptive and predictive, the pragmatist approach yields knowledge that is usable and changes the original phenomenon or situation.

The learning sciences have adopted this view of design research, starting with the 'design experiments' of Brown (1992) and Collins (1992), to find theoretical models of learning based on empirical evidence. This is why we chose this methodology. With it, we moved away from studies in the laboratory to study learning in context, informed by evidence from experiments carried out in real settings. The use of the design approach in the learning sciences has been named the *design-based research* (DBR) method.

DBR tries to change the world by trying to understand it better. However, it does not assume that the interventions are designed perfectly but, rather, acknowledges that the actual implementation may differ from the original plan in a complex social context, where the participants and the designer-researchers influence each other (Hoadley & Campos, 2022). Since we wanted to test our features in real contexts with complex teacher supervision during collaboration, we decided to follow Hoadley and Campos (2022) suggestion; that the testing has to integrate a good design of the tool. This implies not only a good theoretical background to inspire the features but also a good graphic and interaction design so that students feel it is a sound alternative to their usual communication software.

We believe in a constructivist or interpretivist world view, and we maintain this mindset in this research. However, we find the pragmatist ground of DBR especially suitable for achieving the central aim of this dissertation: to explore ways in which the socio-emotional side of collaboration can be supported to help students address potential challenges when working together online. Therefore, the methodology we employed in this research was based on this core assertion.

Consequently, we used the Hoadley and Campos process model of DBR shown in Figure 1.6.

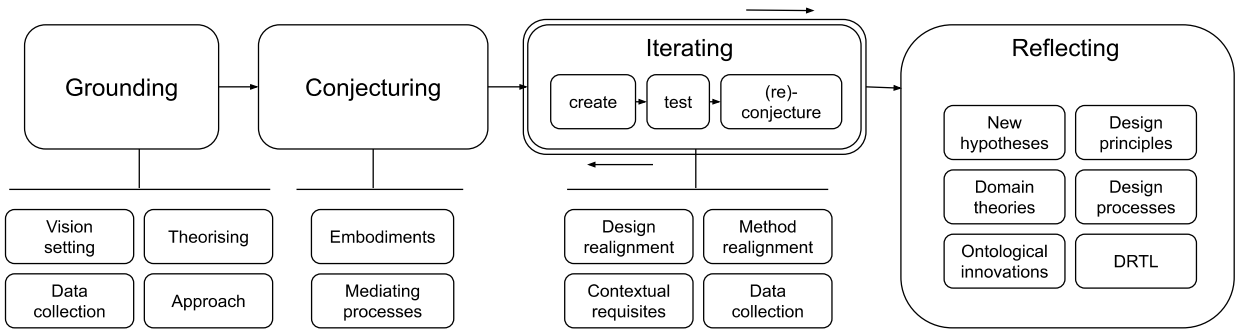

Figure 1.6: The DBR process model adapted from Hoadley and Campos (2022)

We now explain the main phases of the DBR process model by Hoadley and Campos (2022), which framed this research in general and one of our main experiments in particular (publication C3).

Grounding: In this first phase, researchers find a theoretical gap or a practical problem that they want to explore by designing and implementing an intervention in a real-world setting (Kali & Hoadley, 2021). They also need to have an idea of the contexts in which they can test their intervention (Hoadley & Campos, 2022).

Conjecturing: In this stage, the researchers formulate some broad hypotheses that will shape their creation and evaluation of a design. Hypothesising makes the problems from the grounding phase more tangible by outlining a logic of action.

Iterating: A research project may have some unclear or complex aspects that require iterative cycles of building, testing and revising to gain further understanding and practical knowledge (Lewis et al., 2020). This means taking abstract ideas – such as psychological theories, learning trajectories and design principles – and making them concrete designs that can elicit the expected processes.

Reflecting: In this phase, the research team tries to understand how their initial ideas and theories of learning relate to the data they gathered from various sources. They also try to figure out which factors or events may have caused some changes in the situation they studied (Bakker, 2018). This phase is based on the idea of reflection through design, which means that building and testing something in a real-world context helps the team learn from their experience (Schön, 1992).

Table 1.2 lists the chapters and publications in which each DBR phase is discussed, and the objectives of their discussion. The introduction of each chapter explains how the chapter relates to the overall dissertation and where it fits within the DBR methodology that was used in this dissertation.

Table 1.2: DBR phases and the chapters, research objectives, RQs and publications that address them in this dissertation

DBR Phase	Chapter	Objectives	RQ	Publications
GROUNDING	2, 3	To better understand from experience and reality the needs and challenges of students while collaborating, focusing on unaddressed socio-emotional challenges.	1	B1
		To explore design possibilities and implications in order to properly define the problem.	2	C1
CONJECTURING	4	To ideate, design and implement a prototype with features and affordances that can make students more aware of the socio-emotional side of collaboration and support the addressing of socio-emotional challenges.	2	C2
ITERATING	5	To conduct several tests for improving the prototype by adapting to the students' evaluation of their experience in using the prototype	2	C3
		To distil the most suitable features according to the students' preferences: anonymous messages.		
REFLECTING	6, 7, 8	To contribute to theory and practice after reflecting on the students' preferences regarding anonymity	3	C4, J1, J2
		To optimise the anonymous message feature according to the new theoretical and practical understanding achieved.		

In the following section, we present all the methods and instruments used in this dissertation.

a) Methods and instruments

As presented in the previous subsection, the research conducted for this dissertation followed a flexible design approach to answer the diverse RQs of our papers. We coherently and consistently used a mixed-methods approach (typical of DBR) that involved, apart from classical qualitative methods such observation and content analysis, at least one purely quantitative method (i.e., two surveys using questionnaires) and another qualitative method that employed a quantitative approach (i.e., manifest content analysis). Thus, we used observation, questionnaires, and content and thematic analyses within the overall DBR approach.

We followed the guidelines provided by Twinning et al. (2017), the standards for reporting qualitative research (O'Brien et al., 2014) and the guidelines for doctoral research using DBR (Herrington et al., 2007) to describe the qualitative aspects of this research. We have presented our instruments, context, devices and methods for data capture in each publication according to their appropriateness to the RQs. In this subsection, we present general descriptions of all the methods used and brief descriptions of why they were chosen for the pertinent publications. Table 1.3 summarises the type of research reported in each publication, with the methods used and the data gathering technique.

Table 1.3: Research design, method and data collection for each publication in this dissertation

Research design	**Method/instrument**	**Data gathering**	**Publication**
Qualitative + quantitative	Observation Thematic analysis Survey	Notes and pictures Analysis of notes Post activity questionnaire	B1
Literature review	Reflection on previous publication	N/A	C1
Demonstration User Centred Design	Not applicable	N/A	C2
Qualitative and quantitative User Centred Design	Survey Content analysis	Post activity questionnaire Analysis of conversations data logs	C3, C4, J1, J2

Observation

We used this method for our research reported in publications 1 and 2 to obtain knowledge about how groups collaborated in settings outside school, without technology and in complex situations of teacher supervision.

According to Merriam and Tisdell (2015) and Katz-Buonincontro and Anderson (2020), observation is the process of gathering data by paying attention to people's activities, interactions and conversations in individual or group settings. This is a well-established technique that is considered a key component of qualitative research in education (Rossman & Rallis, 1998). According to Katz-Buonincontro and Anderson (2020), the focus of qualitative observation is on processes and interactions that are inductively described a posteriori rather than specific behaviours that need to be defined a priori. We chose to use observation because we wanted to obtain insights from the behaviour of students rather than a priori assumptions about students' behaviours.

One way to classify the different methods of observation is based on how much the researcher interacts with the participants and reveals their identities. Merriam and Tisdell (2015) identified four main types of observation methods based on this parameter: the complete-participant, participant-observer, observer-participant and complete-observer methods. In the *complete-participant* method, the researcher conceals their role and acts as one of the participants, which makes it unsuitable for research involving vulnerable groups (such as minors) or situations wherein ethical principles would be violated, such as in educational settings. In the *participant-observer* method, the researcher engages in the same activities as the participants but the participants know the researcher is also observing. In the *observer-participant* method, the group is aware of the researcher's role, and the researcher engages enough with the group members to gain an insider's perspective without joining the group's activity. Finally, *complete observers* are the most distant from the participants' experiences, such as when they observe from behind a one-way mirror or in a crowded public space (Merriam & Tisdell, 2015).

Our aim was to obtain insights from the students' 'life' context as it unfolded, without us having any control over it (Baškarada, 2014). Thus, we used the *observer-participant* method. We documented the students' interactions and conversations about their socio-emotional challenges, strategies and regulation during their collaboration using field notes to summarise dialogues, conversations and processes, and still pictures to analyse recorded data about personal interactions and their context.

Thematic analysis

We used this method to analyse the students' conversations and behaviour from the aforementioned observation notes.

This is a technique for finding, examining and reporting patterns (i.e., themes) in data. The themes that we found were interpretations of the different aspects that we were researching or observing (Braun & Clarke, 2006).

Braun and Clarke (2006) proposed different ways of conducting thematic analysis. They argued that thematic analysis can be a realist or essentialist method that reports the reality, meanings and experiences of the participants, or it can be a constructionist method that examines how social discourses shape various phenomena, such as events, realities,

meanings and experiences. They also suggested a 'contextualist' method that combines the essentialist and constructionist perspectives. We used a contextualist approach for our thematic analysis of the notes we took during our observations. Therefore, we based our themes on what we observed. We did not force our themes to match any pre-existing framework or our own assumptions.

Content analysis

We used this method to analyse the conversation logs, as reported in publications C4, J1 and J2.

Content analysis uses selected data that reflect key concepts to detect and analyse meaning in recorded forms of communication. We had an enormous volume of chat utterances that needed to be coded, so we grouped them according to the categories of the collaborative learning messages used in previous research. This allowed us to explain not only the degree of participation in our research but also the quality of such participation. Content analysis is very helpful when there are many unanalysed textual data (Kleinheksel et al., 2020).

Content analysis is founded on the idea that texts are rich sources of data that have the power to reveal important details about certain events. When we coded the messages, we considered their contexts and senders. Each message was assigned to more than one category to find patterns and relationships among related categories. Due to this method's adaptability and capacity to be used in both qualitative and quantitative investigations, it is regarded as a high-yield method in the field of educational research.

Content analysis can be conducted using two approaches: manifest and latent. We will describe only the first, since it is what we used in this study.

Manifest content analysis is focused on data that researchers and the coders who help them with their investigations can quickly observe, without the need to infer their deeper meaning or determine their purpose. Such data require little training to recognise and count. This approach implies that data that can be found with very little interpretation have objective truth, and this approach analyses phenomena merely by assigning the data to a category and counting the frequency of their occurrence. The prevalence of a category (i.e., code) is determined by counting how frequently it appears in the text. This was the base of the analysis we made in publications C4, J1 and J2.

Questionnaires

We used this method as reported in several of the publications. In publications C4, J1 and J2, we used it to determine the students' preferred login mode. When we tested our prototype (as discussed in publications C2 and C3), we used this method to determine

the students' opinions about the different functionalities proposed in the prototype that they used to collaborate in contexts with complex situations of teacher supervision.

For a typical qualitative questionnaire, the researcher formulates a series of open-ended questions on a certain subject – in our case, the experience of collaborating outside school in contexts with complex situations of teacher supervision (i.e., the treasure hunt in publication B1) or the experience of using our prototype (publications C2 and C3). The questions are self-answered, and all the respondents receive the same set of questions in the same sequence. Fully qualitative surveys can generate rich and complex accounts of the type of sense-making in which qualitative researchers are typically interested, such as the respondents' subjective experiences, narratives, practices, positionings and discourses. The respondents answer by typing their responses in their own words rather than choosing from predetermined response options. Our questionnaire mixed open-ended questions with closed questions (e.g., Likert-scale questions and yes or no questions) to include quantitative data that supported the open-ended questions. This gave us a 'wide-angle lens' of our topic of interest (Toerien & Wilkinson, 2004).

In three of our publications (C4, J1 and J2), we also used online questionnaires that included open-ended questions. This online qualitative research method is often questioned (issues with reliability like memory leaks, dishonesty, etc.), but we chose to follow the suggestions of Braun et al. (2021) so that we could obtain personal information from a large number of students (n = 183 in publications C4 and J1 and n = 109 in publication J2) rigorously and reliably. We chose this method because we were studying students' behaviour in the anonymous login mode in a CSCL tool, and we thought that an online survey would encourage their disclosure and participation so that we could obtain a wide perspective on a personal topic and could thus make our studies more reliable.

User Centred Design

For the design of our interactive tool (see Chapters 3, 4 and 5) we used the User Centred Design (UCD) approach. UCD is defined in an ISO norm (International Organization for Standardization [ISO], 2019) that states that human-centred design is a methodology in the development of interactive systems that prioritises the users, their needs, and requirements. It applies knowledge and techniques from human factors/ergonomics and usability to create systems that are not only usable but also useful. This approach boosts efficiency and effectiveness, enhances user satisfaction, promotes accessibility and sustainability, and improves human well-being. Moreover, it mitigates potential negative impacts on human health, safety, and performance that may arise from system usage. UCD consists of four general phases, which are: (1) specifying the context of use, (2) specifying user requirements, (3) designing solutions, and (4) evaluating the design. Other authors like Sharp, Preece, and Rogers (Sharp et al., 2019) defined the UCD as a "user-centred approach" which has five basic principles. These principles are: 1) The development process is centred around users' tasks and goals. 2) Extensive study of users' behaviour and context informs system design to ensure effective support. 3)

Users' unique characteristics are considered during design. 4) Their input is actively incorporated from early stages to the final product. 5) All design decisions are made within the context of users, their work, and their environment. Furthermore, they outlined four basic phases of interaction design in which such principles could be applied. The phases consist of: (1) requirements discovery, (2) solution design, (3) prototyping, and (4) evaluation.

It is an iterative process in which final users are part of some or all the steps, and designers and tool developers obtain insights from their participation.

Different evidence-based strategies are typically used for UCD processes such as focus groups, co-creation sessions, associative object-based techniques or surveying (Dopp et al., 2019). We apply different techniques from UCD, like questionnaires, interviews and paper prototyping to identify the final functionalities needed and how to organise them in a graphical interface (Design stage).

1.6 Main contributions

This section outlines the most relevant achievements, evaluation studies and publications included in this dissertation. Shown first (in Table 1.4) are the principal contributions of this dissertation. Then, they are discussed in detail in the following subsections according to the order of completion of the publications.

In the following sections, we discuss in detail each of the publications that described and documented the process and the learnings outlined in the previous paragraphs.

Table 1.4: Main contributions of this dissertation related to the main research questions

RQs	Contributions	Publication
RQ1. What are the socio-emotional factors and issues that emerge among students while collaborating in contexts with complex teacher supervision?	**Empirical evidence, from observations, of factors that trigger socio-emotional challenges and interactions in contexts with little or complex teacher supervision**: (a) formal class culture, from which identity and emotional issues outside school without teacher supervision are inherited and amplified, at least, partly; (b) students' unwillingness to address socio-emotional challenges; (c) students' ability to change roles on demand to adapt to the necessities of the task and the collaboration, which enables their group to perform better; and (d) hedonic experience or having fun, which is very important in contexts with little or complex teacher supervision.	B1
	Identification of design implications for future collaboration tools that support social interactions and socio-emotional regulation during collaboration (see Section 3.7). These design implications were used to design and implement the *me&co* prototype.	C1
RQ2: How do students perceive the functionality and affordances of online collaborative tools that facilitate participation, enhance awareness of social, emotional, and motivational aspects, and support self-regulation, co-regulation, and socially shared regulation of learning in online collaborative settings?	**Design and evaluation of features that support social presence and identity, group cohesion, self-regulation, co-regulation and socially shared regulation of learning** (through the *me&co* prototype): Several iterations that refined the features that support socio-emotional interactions and regulation: anonymous messages, a self-emotions panel, a visual messages composer, a profile panel for the students to present themselves as collaborators, avatars for social identity and group cohesion. These features were the results of a DBR process.	C2, C3
	Empirical evidence of students' opinions and experience in using the prototype and its features. Findings: Students found the prototype useful, as it made them more aware of the socio-emotional side of computer-supported collaborative learning (CSCL). They considered the following its most effective features: (1) anonymous messages, (2) the visual messages composer and (3) the users' ability to choose their avatar. Hedonic features, in general, were the most highly rated.	C2, C3
RQ3. How do anonymous and identified login modes in CSCL environments differ, and how can the option of anonymity be optimised for use?	**Empirical evidence of students' opinions, experience and behaviour regarding different levels of anonymity** in a CSCL environment (Pyramid App): anonymous, identified and anonymous to peers (AtP) but not to the teacher. **Findings:** AtP is the most productive and optimised login mode, as it promotes participation and prevents trolling messages.	C4, J1, J2
	An **extension of the SIDE model** with a social component.	J1, J2
	Proposal for a **taxonomy of off-task messages**.	J2

a) Grounding: Publications B1 and C1

Publication B1. Case study of Math Gymkhana (in the open streets of Seville)

Velamazán, M., Santos, & P., Hernández-Leo, D. (2022). Socio-Emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning. In: Gil, E., Mor, Y., Dimitriadis, Y., Köppe, C. (eds) Hybrid Learning Spaces. Understanding Teaching-Learning Practice. Springer, Cham. https://doi.org/10.1007/978-3-030-88520-5_7

We conducted a case study of a maths treasure hunt in which almost 1,000 students from 20 high schools participated. In our context, this treasure hunt was an outdoor game where 15-year-old students had to use clues and riddles to find and solve maths tasks that were located throughout the streets of one of the city's neighbourhoods. The students were dispersed to around 20 base points with tasks located in situ. By solving these maths tasks, the students, in groups of four members each, earned points. They were unsupervised and allowed to use any resource to solve the problems. We observed the social interactions and socio-emotional regulation in two groups that were not supported by any technology.

The main instruments of this case study were as follows:

- Observation of a simulation of the activity to get to know the dynamics of the game;
- Observation, during the activity, of two groups of students solving maths tasks outdoors. These groups were chosen asking teachers to recommend an average group that was neither outstanding nor mediocre;
- Evaluation questionnaire distributed to 150 student participants; and
- Analysis of the documentation (i.e., of the problems and statistics of the results of the activity).

From our observations, we were able to find two examples of how emotional processes impacted group dynamics and academic performance (see sections 2.7.a and 2.7.b). In the first example, identity and preconceived notions among the group members and roles affected the socio-emotional climate during the collaboration and directly impacted the group members' learning outcomes. As we already mentioned (*Preface* section), a girl who was shy and not self-confident had the right intuition to answer one of the maths tasks, but she ultimately rejected her own solution as 'nonsense', since she thought her companions were ignoring her only because they thought less of her. Thus, our findings from this observation are that (a) **identity and emotional issues outside school without teacher supervision are inherited and amplified, at least, partly, from formal class culture and (b) students avoid addressing these socio-emotional challenges.**

In the second example, we saw that groups with more static or hierarchical roles tended to be more passive, whereas groups with more flexible roles were more engaged. Examples of these flexible roles are leading the group, seeking information, proposing ideas, checking the solutions and performing maths operations. Additionally, this observation played a significant role in the dynamics inside the group, which, in turn, affected the students' capacity to learn. Our insight from this observation is that **when students can change roles on demand to adapt to the necessities of the task and the collaboration, their group performs better**. From this group and the others, in general, we observed that **hedonic experience is key. Having fun is very important in contexts with little or complex teacher supervision.**

In this publication, we hypothesised that contexts outside school without teacher supervision are richer in socio-emotional challenges than formal education contexts. To validate this hypothesis, we explored existing research. We also investigated tools for emotional regulation and identified the need to design tools integrating emotional awareness affordances that support socio-emotional regulation throughout the collaborative activities (not only at the beginning or end).

Publication C1: Design implications for the future tools

Velamazán, M., Santos, P. & Hernández-Leo, D. (2020) Collaborative educational location-based activities with no teacher supervision: design implications. In: Söbke H, Baalsrud Hauge J, Wolf M, Wehking F, editors. Proceedings of DELbA 2020 - Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020); 2020 Sep 15; Heidelberg, Germany. Aachen: CEUR; 2020. http://ceur-ws.org/Vol-2685/paper4.pdf

After the treasure hunt observations, we conducted a survey using an online questionnaire to obtain information about the students' individual experiences during the gymkhana. A mix of quantitative and qualitative questions was used. The qualitative questions were aimed at obtaining details about (a) what the students thought was the best part of the treasure hunt, (b) their perceived learning outcomes and (c) their opinions on the best aspects of the activity.

All the responses to the open question: What *did you enjoy most about this treasure hunt?* fell into one of the following responses: 'collaboration' (28.4%), 'having fun with maths' (25.7%) and 'being outside or on our own' (20.3%). This final answer raised the topic of agency (i.e., being on their own, without teacher intervention) that we introduced in the *Foundations* section.

The main design implications elicited, which are our contributions from this publication, are as follows:

- Allow the sending of **anonymous or private messages to the group to provide an error-safe space**.
- **Provide affordances for sharing emotions** during collaborative learning.
- **Provide affordances for sending motivational messages** to the group.
- **Visually show different kinds of messages**: proposals (Stahl, 2005), facts and decisions. Also, show the connection between messages to clearly and quickly see the previous message and message threads.
- **Always show all the members of the group** (and, of course, who is sending any message). This should help provide an active image of all the people as a working group. Users were identified by default. If they chose to send an anonymous message, they would not be identified.
- **Gamify the types of messages**: the number of proposals, ideas and positive feedback. Provide statistics about roles (elicited from the kinds of messages sent). These should promote active participation in the group.
- **Allow evaluations of the performance of the group members** and make such information visible to the group: For example, using simplified versions of the RADAR and OurEvaluator tools (Järvelä et al., 2015).

We used these design implications to design the first version of the prototype of a communication tool for supporting socio-emotional regulation during CSCL tasks in contexts with complex teacher supervision.

b) Conjecturing: publication C2

Publication C2: Design of the tools/features

Velamazán, M., Santos, P., & Hernández-Leo, D. (2021). Awareness Tools for Monitoring Socio-emotional Regulation During Collaboration in Settings Outside School Without Teacher Supervision. In: De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A. (eds) Technology-Enhanced Learning for a Free, Safe, and Sustainable World. EC-TEL 2021. Lecture Notes in Computer Science (pp. 389-393), vol 12884. Springer, Cham. https://doi.org/10.1007/978-3-030-86436-1_41

Based on our observations in publication 1 and the design implications mentioned in the previous subsection, we started to define a fully functional asynchronous communication tool for use during collaborative tasks of secondary school (13- to 16-year-old) students.

We started to draft two affordances or features based on the following hypotheses:

- For the first case presented in publication B1 (about the shy, unpopular girl whose group members did not accept her correct idea), we hypothesised that the possibility of sending anonymous messages to the group would increase or at least facilitate the participation of shy or not-so-self-confident group members.
- For the second case presented in publication B1 (about groups without static roles performing better than those with a very fixed and hierarchical pattern of behaviour), we hypothesised that if students could see that they could actually send different types of messages or contributions to the group, their participation in all those types of contributions would be fostered, and they would reflect about their type of contribution.
- Based on our research presented in publication B1, we also designed several features and affordances to make students more aware of the socio-emotional side of learning:
    - *A self-emotions panel* on which students can select, grade and share how they are feeling;
    - *Personal avatars* to be selected by each user;
    - *A motivational messages composer* that allows students to create motivational messages and send them to the chat using the avatars; and
    - Other cognitive and content-related features to make collaboration easier.

The features and affordances of the interface are presented next, although they underwent several iterations and improvements that were covered in publication C3. **These features** (that resulted from a DBR process) **are our main contributions from this publication**:

Members' avatar selection (for the sign-up and profile panels)

When students create their account in the prototype, they can choose an avatar from the provided options. This feature was included for two reasons: (a) to provide hedonic affordances to the group (Kreijns & Kirschner, 2018) and (b) to facilitate young students' expression and sharing of their emotions in the group conversations. The avatars were designed with common graphical characteristics to support group cohesion.

Self-regulation: Self-emotions panel

We designed this panel for each member with a list of specific emotions during collaborative learning. The members could indicate on a Likert scale how much of each emotion they felt and could see how the other members felt. We hypothesised that students could benefit from being more aware of emotions such as relief, enjoyment, curiosity and admiration (Lajoie et al., 2019; Pekrun, 2019a; Vogl et al., 2019) because such awareness would help them self-regulate and co-regulate their emotional moods during collaborative learning.

Co-regulation: Members' reported emotions (hedonic)

When members of the group have expressed and shared their emotions using the self-emotions panel, the rest of the group can see their report by clicking on those users' avatars.

Co-regulation and socially shared regulation of learning (SSRL)

For these types of regulation, we developed the following two awareness tools:

Motivational messages composer with avatars

We tried to support a positive, hedonic group atmosphere (Zschocke et al., 2016) through appraisals and motivation of members using a tool that also incorporated a creative and fun user experience. With the socio-emotional and motivational messages composer, students can visually create fun messages using the members' avatars together with other texts and graphics in order to support co-regulation and socially shared regulation of learning.

Anonymous messages

The socially shared emotional regulation feature enables students to send anonymous messages to the group. Motivated by our observations in our case study in publication B1, we hypothesised that including the feature of sending anonymous messages to the chat could facilitate and increase the participation of shy members and support their confrontation of socio-emotional challenges. We soon realised that this was the students' favourite feature. However, the effect of anonymity in the context of collaborative learning was understudied. In publications C4, J1 and J2, we tried to add knowledge by studying the students' opinions and behaviour while collaborating in the anonymous versus identified modes.

c) Iterating: publication C3

Publication C3: design iterations, tests and conclusions of the features

> Velamazán, M., Santos, P. & Hernández-Leo, D. (2021). How to design features for promoting social and emotional interactions during computer supported collaborative learning. *Accepted in HCI International 2024 Conference*.

Following the DBR methodology, we iterated twice our prototype after refining its design, functionality and interaction. We tested each iteration with real students doing real tasks and in contexts outside school with complex teacher or researcher supervision. Our goal was to make students more aware of the potential socio-emotional challenges that may unfold during CSCL tasks and to enable them to address such challenges by facilitating their social interactions and group regulatory skills. This publication re-

ported on two gaps presented in publication C1 and understudied in the theory of regulation of learning. First, the regulation of learning in CSCL has been studied mainly in specific research-defined moments (i.e., before, in the middle of or after collaboration), so we tested our prototype during the entire collaboration process. Second, the regulation of learning in CSCL has been studied only in formal settings, but a theory that describes group regulation should also be tested in contexts where the teacher is not supervising the activity, which is when students would truly regulate their learning on their own (referred to as 'students' agency').

One of the main improvements we made in these iterations was the design of a new future: a **personal profile panel** that enables users to describe or present themselves to the rest of the group as students. This profile panel includes a survey based on Emotional and Motivation Self-Regulation Questionnaire (EMSR-Q) to let the members present to each other how they see themselves as collaborators (Alonso-Tapia et al., 2014).

The main contribution of this publication is the finding, from the tests and the conversations, **that students think the most useful features of our prototype are the anonymous messages** tool, **the avatar selection and the messages composer** for creating visual motivational messages using the avatars. During the tests and our presentation of our prototype to other researchers in our research group and in the European Conference on Technology Enhanced Learning (ECTEL) Conference, we received the feedback that the anonymous messages feature was very interesting to facilitate and increase student participation, but, at the same time, could be a source of unproductive and disturbing messages.

d) Reflecting: publications C4, J1 and J2

Publications C4 and J1: The effect of anonymity during CSCL tasks

Velamazán, M., Santos, P., Hernández-Leo, D., & Amarasinghe, I. (2022). Student preferences and behaviour in anonymous collaborative learning. In Weinberger, A. Chen, W., Hernández-Leo, D., & Chen, B. (Eds.), Proceedings of the 15th International Conference on Computer-Supported Collaborative Learning - CSCL 2022 (pp. 419-422). International Society of the Learning Sciences. https://repository.isls.org//handle/1/8323

Velamazán, M., Santos, P., Hernández-Leo, D., & Vicent, L. (2023). User anonymity versus identification in computer-supported collaborative learning: Comparing learners' preferences and behaviours. *Computers & Education*, 104848. https://doi.org/10.1016/j.compedu.2023.104848

To better understand and try to improve the anonymous messages feature (which was the favourite of the students during the tests in publication C3), we decided to test in detail how anonymity affects the behaviour of students who did not know each other through a new quasi-experiment with a bigger *n*.

Regarding the aforementioned feedback that we received, previous research had already studied the effect of anonymity on collaborative learning, albeit with ambiguous results. Scholars have indicated that anonymity can boost member participation but can also encourage off-task behaviour, trolling and spam. We found an interesting gap: to the best of our knowledge, none of the previous studies had compared the behaviour of small groups of students with their opinions of and preferences for the anonymous or identified login condition in authentic settings. We hypothesised that greater knowledge of the students' experiences in each mode could offer valuable information for the design of new features and tools for promoting awareness of socio-emotional challenges in a group of students collaborating without teacher supervision.

The results of our survey and our content analysis of the logs of the conversations of 186 university students revealed a more unproductive atmosphere in the anonymous mode, although it was the students' preferred login mode, and although we earlier discovered that anonymity affected the quantity and quality of the collaboration and work balance in a group. On the one hand, there was a large number of unproductive off-task messages in the anonymous mode; but, on the other hand, we hypothesised that in some groups, these messages had a positive social component because they afforded a layer of humour and personal exchange that, at times, increased group cohesion and improved the group atmosphere.

Publication J2: Optimising anonymity

> Velamazán, M., Santos, P., Sánchez-Reina, J. R. & Hernández-Leo, D. (2023). Optimising anonymity in CSCL: comparing collaboration between identified and anonymous-to-peers login modes. *Under review.*

In our previous publication, we used a 'fully' anonymous condition in the sense that all the group members were anonymous all the time during the task (or identified all the time during a different task). We hypothesised that anonymity could be optimised by avoiding its negative side (i.e., the increase in off-task and spam messages). Inspired by the SIDE model's distinction between 'anonymous to the group' and 'anonymous to the self', we decided to compare again the students' behaviour and preferences in an AtP condition but not anonymous to the teacher.

Our main contributions from these three publications are that students reported their preference for the Anonymous to Peers but not to the teacher (APM) condi-

tion over the identified login mode. When students do not know each other and have to collaborate doing short tasks this mode is not only more positive in terms of Discussion Productivity and participation, but also preferred by them. Students' behaviour was much more productive than in our previous test, because, at the same time, the share of cognitive messages increased. There were still plenty of what we called 'trolling' messages with a lot of humour and a strong social component, but they were not as disturbing as in our previous experiment. **We analysed in detail all these off-task messages and proposed the following taxonomy** for them:

- Fun or humour;
- Fake participation or fooling the system;
- Getting to know each other, meeting outside and making plans (Stodel et al., 2006);
- Normative; and
- Disturbing.

Our final contribution is that continuing to work towards understanding why and how to support different types of login modes is important because **most students prefer the anonymous mode even when they experience misbehaviour** by people whom we have called 'spammers'. Our study and related works (O'Sullivan & Flanagin, 2003) suggest that **anonymity allows for socio-emotional interaction, which most students enjoyed, according to their responses. We referred to this enjoyment as the 'social component of the SIDE theory'.**

1.7 Project

This work was supported in part by PID2020-112584RB-C33 funded by MCIN/ AEI / 10.13039/501100011033 (H2OLearn).

1.8 Conclusions

This dissertation contributes to the body of knowledge on promoting socio-emotional awareness in CSCL environments. More precisely, we have contributed new knowledge about the socio-emotional side of CSCL with the aim of facilitating social interactions and regulation through technology support features.

In this section, we outline the answers to our research questions.

a) RQ1: What are the socio-emotional factors and issues that emerge among students while collaborating in contexts with complex situations of teacher supervision?

From our first field study and in our experiments reported in publications B1 and C1, we saw that, in contexts of complex teachers supervision (including no presence of the teacher), having fun is more important to the students (Muñoz-Carril et al., 2021; Vogler et al., 2019), and excitement about such an off-task topic or boredom can lead to reduced attention for the task (Lobczowski et al., 2021). The expression of emotions in academic settings can be shaped by informal and formal norms at the societal, class, and peer levels. When the teacher is not present, socio-emotional challenges unfold more easily and openly than in contexts in which the teacher is directly supervising the task. For example, we saw (publication B1) that the group peers of the shy girl did not pay attention to her proposal because they had a diminishing idea of her. The girl did not face the problem although she criticised the group leader later when she was not present. Our results are aligned with those of previous studies in which, when the students encountered challenges, they did not face them (Lyons et al., 2021). In publication J1 and J2 students reported that they had experienced socio-emotional challenges (free-rider, social loafing mainly) but they did not even mention them to the rest of the group. By avoiding confronting these socio-emotional challenges, students can miss the opportunity to accomplish the task (aside from perpetuating a discriminatory attitude towards some members; Velamazán et al., 2022).

We also found that groups that do not have strong and static roles perform better. More precisely, we saw that groups in which there was a good atmosphere and all the members felt free to participate without fear of failing in front of their peers performed better and enjoyed the collaboration experience more. Moreover, if students were capable of changing roles to adapt to the demands of the task, they performed better (Velamazán et al., 2022). Groups with static roles (e.g., a strong authoritative leader) tend to have passive members and to perform more poorly than groups with flexible roles. Our observations suggested that the next step of this research should focus on tools for integrating emotional awareness affordances in the monitoring phase, during collaboration. Thus, the results of this study (in publication B1) opened questions that were addressed in the rest of our studies. Among these questions, we highlight the following: *How can emotional regulation be organically integrated into an asynchronous collaboration tool in such a way that it would not become an obstacle to the tool's usability or to cognitive load? How could we design technology that would prevent the failure we described about the insecure girl that did not convince the group of her correct idea because the other members had a diminishing idea of her (*see the *Preface)? Could such technology be that which would allow students to send anonymous messages (i.e., text, photos or drawings) to the chat?* Publication C1 ended with a list of design implications (see Section 1.6.a) that we used in our next experiments to design a prototype of a fully functional communication tool with features and affordances (i.e., social and hedonic) that su-

pport socio-emotional regulation and students' social interactions. How important could these affordances be for students?

When students tested the prototype, which we called the *me&co* tool (see publications C2 and C3), in contexts with minimal teacher supervision, we observed that certain groups experienced socio-emotional challenges that remained, again, unaddressed, primarily associated with social loafing and the free-rider effect. In addition, the students generally asserted that when they knew their group members from a class, they did not really need the features provided. Moreover, these features were seldom used for practical purposes or real challenges during the tests. For example, a common issue reported was uneven work distribution among group members. These challenges have been documented in research (Järvelä et al., 2016, 2020), and students have acknowledged them. However, in our research, when the students were given specific features in a dedicated tool for tackling these issues, they refrained from using them. This was evident from their underutilisation of the anonymous message tool even though they found it useful for other groups (in which members did not know each other). We speculate that using these features might have made the students feel less 'mature' or feel as if they were 'hiding' from their classmates. They recognised collaboration challenges, such as differences in the degrees of commitment and effort, but chose not to address them. They focused on completing the task, earning a good grade and enjoying the process.

In publications C4, J1 and J2, we saw that when the students used the Pyramid App CSCL environment with little supervision from the teacher, there was a strong increase in trolling or off-task messages when the students logged in using the anonymous mode. These types of messages are very disturbing at times, but in this study, many groups sent them when they had finished the task. In those cases, off-task messages had a social dimension that fostered a good atmosphere and improved group cohesion (see Section 1.8.c for details). Another significant behaviour in the anonymous mode was faking participation. We observed that many students tried to fool the system by sending empty or meaningless messages (such as random letters) merely to increase the number of messages registered by the system. In publication J2, we also found significant differences in the behaviours of the students regarding gender. Female students sent much fewer trolling, spam or off-task messages than male students (for further explanations, see the next RQ answers and the *Future Research* section).

In conclusion, when students are familiar with each other and engage in face-to-face interactions, issues of identity and emotions that occur outside of school (with complex teacher supervision) are, at least in part, a consequence of the formal classroom culture, resulting in students not addressing these issues. Most of them are related to the *free-rider* and *social loafing* effect but others have to do with being shy and not being able to get your proposals considered or with keeping the leader role even though that might imply making mistakes that will affect all the group. If students do not know each other in a CSCL environment, students take advantage of the absence of the teacher to have fun, fake participation, make jokes, make plans and meet outside school.

b) RQ2: How do students perceive and rate the features and affordances of online collaboration tools in terms of facilitating participation, enhancing social, emotional, and motivational awareness, and supporting self-, co-, and socially shared regulation during online collaboration?

In publications C2 and C3, we integrated design features in a functional tool to explore how to promote a good atmosphere, social interactions and regulation while making the students more aware of socio-emotional challenges by doing the following:

1. Based on the literature and the design implications from publication B1 (see Table 1.5), we propose a concrete list of features and affordances (Table 1.6, from publication C3), to make the students more aware of those challenges and to facilitate their addressing and solving of such challenges. The features we designed were based on previous literature and inspired by previously developed tools, such as RADAR (Phielix et al., 2010) and S-REG (Järvelä et al., 2016).
2. Integrating the design of the previous research tools and the different proposed features into a fully functional tool for supporting and promoting socio-emotional interactions, awareness and regulation; improving group cohesion; and facilitating hedonic experiences (Kreijns & Kirschner, 2018; Kreijns et al., 2022). In our design of a fully functional tool that could be used without supervision, we tried to integrate those features into the students' natural collaborative workflow and to embody them seamlessly in the students' learning routines.
3. Test the students' use of these features and discover their opinions about these features.

In publication C1, we distilled design implications that we used to start designing the features. Table 1.5 shows these design implications.

Table 1.5: Design implications for collaborative educational Design implications to foster socio-emotional awareness, interaction and regulation in CSCL

Type	Design implications
Collaboration: Group awareness	1. Always show all the members of the group (and, of course, who is sending any message if it is not an anonymous message). This should help provide an active image of all the people as a working group.
	2. Allow evaluations of the general performance of the group, and make that information visible to the group: For example, using simplified versions of the RADAR and OurEvaluator tools (Järvelä et al., 2015).
	3. Allow the sending of anonymous or private messages to the group to provide an error-safe space.
	4. Provide affordances for showing that members are paying attention through quick answer or feedback icons ('understood', 'I need more information', 'I didn't understand' etc.).
Collaboration: Visualisation of group activity	5. Visually show different kinds of messages: proposals (Stahl, 2005), facts and decisions. Also, show the connection between messages to allow the students to clearly and quickly see the previous message and message threads.
	6. Visually show times of inactivity.
Roles or tasks	7. Gamify the types of messages: the number of proposals, ideas and positive feedback. In addition, provide statistics about roles (elicited from the kinds of messages sent). These should promote active participation in the group.
	8. Provide affordances for making decisions and visually show them. This would facilitate making decisions and moving forward to the next steps.
	9. Promote the students' awareness of roles and tasks, and let them evaluate each other in the roles. However, do not force them into assigned or scripted roles.
Features and affordances	10. Provide affordances for a shared creative or modelling canvas to draw the students together (Stahl, 2005).
	11. Allow taking, sending and drawing of pictures (as in regular apps, such as Instagram). Provide quick access to a calculator and a formulas cheat sheet.

A summary of the features that we designed and implemented in *me&co* are presented in Table 1.6.

Table 1.6: Features designed, their theoretical backgrounds and descriptions of their functionalities

Feature	Theory support	Description
Anonymous messages	Co-regulation and SSRL	We hypothesised that including the possibility of sending on-demand anonymous messages to the chat could facilitate and increase the participation of shy members and support their confrontation of socio-emotional challenges.
Avatar selection	Representation of the self-identity. SIDE model. Hedonic affordances.	When students create their account in the prototype, they can choose an avatar from the provided options.
Profile page	Self-regulation and co-regulation	We designed a personal profile panel to let students describe or present themselves to the rest of the group as collaborator students. The profile panel included a survey based on the Emotion and Motivation Self-Regulation Questionnaire (EMSR-Q) to let the members present to each other how they see themselves as collaborators.
Self-emotions panel	Self-regulation and co-regulation	We designed a panel for each member with a list of emotions experienced during collaborative learning. The members could indicate, on a Likert scale, how much of the emotion they felt and could see how the rest of the members felt. We hypothesised that students could benefit from being more aware of emotions because this would help them self-regulate and co-regulate.
Visual messages composer	Co-regulation and SSRL	Students can visually create fun motivational messages using the members' avatars together with other texts and graphics. Our aim was to provide some kind of hedonic support – a fun way of motivating the group and facilitating SSRL.

The students highly appreciated and thoroughly used the hedonic features of selecting the user avatar and the motivational messages composer (using the avatars), which became sources of fun and a good atmosphere in the group. The self-emotions panel was

not highly used and was only moderately rated by the students. Finally, most of the students used the personal profile page and rated in third place of usefulness.

In publications C4, J1 and J2, we observed that female students preferred the AtP login mode (64.5%) more than male students (32%). Only 12.9% of the female students preferred the identified mode, which is consistent with the findings of O'Sullivan and Flanagin (2003). Female students reported that they preferred the AtP mode as it gave them greater freedom and made them feel less shy. Upon analysing their behaviour, we found that they used this freedom to send cognitive messages; they hardly sent off-task messages.

The students freely noted that the features were useful in making them more aware of the socio-emotional side of learning, although most of them did not use the features for our intended purpose or according to our hypothesis. They explained that this was because they did not need the features because they already knew each other and they were already aware of the socio-emotional challenges of the group.

The feature in the post-task questionnaire that the students rated most highly was the anonymous messages composer. Thus, we chose to further develop and study it (see next subsection for more details).

In conclusion, the proposed features did not provoke a change in student behaviour, but the students admitted that such features made them more aware of the socio-emotional side of learning.

c) RQ3: How do the anonymous and identified login modes in CSCL compare, and how can the choice of anonymity be optimised?

Based on our aforementioned findings in the previous subsection, in publications C4, J1 and J2, we studied the most highly rated feature (i.e., the anonymous messages tool) in groups in which the students hardly knew each other.

In publications C4 and J1, we concluded that the overall behaviour of the group in the anonymous mode was less productive in terms of the quality of participation. As for the quantity of participation, the students posted more messages in the anonymous mode, but most of those messages were coded as disturbing messages. In conclusion, even though the students' behaviour in the anonymous mode was not very productive, they still preferred such mode, so we attempted to find different ways to optimise anonymity. We tested the following alternatives for anonymity while trying to avoid the negative side (the increase in trolling messages):

- Anonymous messages on demand (while the default is the identified login mode), which were tested in the prototype for the previous RQ;
- Anonymity all the time for all students and teachers; and
- Anonymity all the time but only among members (AtP), not to the teacher.

We concluded that for positive and productive collaboration, the most efficient level of anonymity is AtP. This efficiency also refers to greater participation and greater proneness of the groups to co-regulation and SSRL. In this condition, students feel free to share opinions, ask questions and crack jokes without fear of being judged, while the negative side of anonymity is neutralised: disturbing messages that make the collaboration more difficult and end up making a few members do extra work to accomplish the task. Even though we started studying contexts with complex situations of teacher supervision, we ended up concluding that the presence of the teacher (even merely indirect presence) makes students' behaviour more productive. It seems that merely knowing that the teacher might read the messages makes the students regulate their behaviour, at least to the point of avoiding sending disturbing messages.

One of our conclusions in publications C4 and J1 was to code the messages into more than one category because there were times when messages did not completely fit one category. Thus, in publication J2 (summarised in Section 1.6.d and reproduced in Chapter 8), we coded some messages in two categories: a main and a secondary category. For example, a message could be coded as a *feedback* (the main category) but also as *inside humour or a joke* (the second category) if the message was somehow meant to make the students smile. Among these second categories, the most important to students was humour or jokes. More precisely, we found that the features with a fun or hedonic experience are more likely to be used, found useful and accepted. In our experiments, these features were the avatars, which the students used to present themselves in a fun way (Beyea et al., 2021; Ho, 2022), and the visual messages composer. Thus, we suggest that designers of CSCL environments research how to design and **create features that promote humour and fun** (Muñoz-Carril et al., 2021; Vogler et al., 2019) **and hedonic affordances** (Kreijns & Kirschner, 2018; Kreijns et al., 2022).

Humour has been proven to help build trust in management settings (Kurtzberg et al., 2009), as well as when used by teachers. The benefits of humour to learning outcomes of students (Ziv, 1988) have been studied and replicated. As we have seen, students themselves also use humour, and its use does not derail a 'learning-focused discussion', as had been assumed (Vogler et al., 2019). Of two types of humour – 'self-enhancing' and 'self-defeating' humour – only the second type fosters relationships in a group setting (Blasco Royo, 2023). In our studies, however, we saw many examples of humour that did not fall under the self-enhancing or self-defeating categories, and instead, we categorised humour as on-task and off-task.

Humour in learning has been a prolific line of research lately. For example, high-performing groups use positive and relaxed humour, such as using humorous memes to resolve guilt, ease embarrassment and ensure that negative socio-emotional interactions would not persist (Tao et al., 2022). According to Hu et al. (2021), humour can play an important role in decreasing differences between team members, thereby facilitating compromise in the process of collaborative problem solving. This is important because when team members have inconsistent views, strong disagreements will occur. Positive

socio-emotional interactions, such as humour, can facilitate regulation and buffering of this process (Andriessen et al., 2013). Moreover, we have seen, consistent with previous research, that teenagers prioritise hedonic motivations, such as joy and fun (Menon & Shilpa, 2023).

We also contributed knowledge on, and extended, the SIDE model (Spears, 2017) in publications J1 and J2. In Section 1.2.b., we mentioned that this model foresees a strategic aspect and a cognitive aspect of collaborative learning in anonymous groups. In our experiments, we saw examples of both. An example of the cognitive aspect is the low self-initiative of most members of a group of students with low social identity, which thereby disturbed the work of the group. Students sending a sentence broken into different messages to fake their degree of participation to fool the system (and thus, the teacher) is an example of the strategic use of anonymity. In contrast, in both experiments, we observed that anonymity had a general positive effect (especially in the AtP mode); for most of the students, it increased the positive atmosphere and social interactions. However, even when the students experienced misbehaviour and trolling messages, most of them still preferred the anonymous mode. Thus, we proposed a new social component, which explains the increase in participation and, above all, the participation directed towards meeting other members, making plans with them and having fun while collaborating. This kind of participation was clearer in our AtP condition. We realised that students prefer to work with a kind of anonymity that promotes social interactions and makes collaboration more fun.

Finally, we have also added knowledge about the patterns of these social interactions (most of which take place after students have finished the activity) and a first proposal for typology of these off-task messages (see Table 1.7) that could help designers and teachers improve the collaboration experience.

Table 1.7: Final proposed categories of off-task messages

Content-related	Fun or humour	Jokes that have nothing to do with the task
	Socialising	Getting to know each other, meeting outside, making plans
	Trolling	Disturbing the collaboration
Context-related	Normative	Off-task messages that are accepted by the group: when someone starts and the rest of the members follow.
	Fake participation	Deceiving the CSCL system and the teacher
	Greetings	Saying hello or goodbye to the group

Concerning the patterns that we found when sending off-task messages, we advise teachers to check the messages of the groups especially in the last minutes of the session, as this is when most unproductive behaviour occurs. The teachers could use those minutes for other activities or allow students to socialise through the tool (we did not observe any insults or flaming after the students completed the task in the AtP mode).

In conclusion, our results show that anonymity has a positive effect on humour and social interactions, and we have seen that this positive effect increases cognitive and content-related messages.

1.9 Limitations

a) Methodological

A general limitation of this research and of qualitative studies in general pertains to the reproducibility and generalisability of the findings. Our published studies did not have diverse samples, due to which the results might be limited to the subjects.

In our participant recruitment strategy, we utilised convenience sampling due to the practical constraints inherent in the nature of the research. For example, this is especially the case of publication B1 in which the groups observed were not gender balanced and the groups were selected by the teacher among the students who were willing to participate in the experiment. In addition, some of the instruments that we used in the study to assess the impact of our interventions were developed only during the research process and thus, had not been subjected to extensive empirical testing for validity and reliability. Therefore, a mixed method was applied, so a triangulation of quantitative methods (specifically, close-ended questions in the pre- and post-tests) and qualitative techniques was employed.

A constraint in the methodology of this research is the use of *ad hoc* questionnaires to assess students' socio-emotional experiences while collaborating using several research tools and features. When the quasi-experiments were conducted, to the best of our knowledge, there was no comparable questionnaire available in the literature, prompting the creation of our own questionnaires to align with the study's learning goals. The employment of an *ad hoc* questionnaire restricted the data analysis and potential comparisons with earlier studies.

Each of the publications covered in this dissertation, presented in the following chapters, includes a detailed *Limitations* section that critically discusses the constraints and their potential impacts on the outcomes of that publication. This summary highlights the most significant limitations across the studies, emphasising the need for cautious interpretation of the findings and consideration of these constraints in future research.

The main limitation of the first (B1) and second (C1) publications is that only three groups were observed, and we did not produce audio and video records to support our notes.

Publications C2 and C3 limitations were about the fact that many of the groups did not really use the tool to solve the task assigned but doing it just for fun, especially in the first iteration.

Regarding publications C4, J1 and J2, that have similar limitations, the main limitation was again that we relied on the students' post-task self-reports through a questionnaire, which raises issues of validity concerning the students' poor recall or dishonesty with what they did and how they behaved. We believe, though, that our large samples laid a solid foundation for our conclusions.

b) COVID-19

The onset of the COVID-19 pandemic in 2020's spring caused significant disruptions to scheduled school activities, workshops and interviews, resulting in numerous cancellations and postponements. This led to a delay in both the implementation of experiments and the gathering of data, extending the research timeline. Consequently, the work was carried out in extended cycles with simultaneous evaluation of the proposed methods, instead of shorter cycles that would have allowed for a more isolated analysis of the results.

c) Data Collection

Within the same context, gathering data in real-life settings like classrooms can introduce additional challenges, including external factors that might affect the data. Although this method can offer important perspectives on actual situations, meticulous planning of the study is required to overcome this hurdle. Furthermore, the longitudinal aspect of this research led to a considerable loss of data due to students not attending all classes sessions, failing to complete either the pre or post-questionnaires, or losing interest over the course of the task. Lastly, the data for this thesis was collected in the period following COVID-19, and elements such as the use of masks in classrooms (Smerdon, 2022) and the anxiety levels of students during this time (Rashid et al., 2022) could have potentially added confounding factors to the research.

1.10 Future research

Social interactions are prominent in CSCL, but their effects on learning outcomes depend on several factors depending on the nature and context of the interactions. We have studied the factor of anonymity in greater depth, although we detected other interesting factors. This section outlines the related research work that is in progress and that is

expected in the near future. We also present the different research lines associated with our contributions.

Concerning the **factors that trigger socio-emotional challenges and interactions**, we propose to keep studying and observing students collaborating in situations without teacher supervision or with complex teacher supervision because we have seen that it is in those contexts that socio-emotional challenges appear more openly. Thus, we believe that the research community may find several future research opportunities in those contexts, including user needs that can only be revealed in such contexts. As for identity issues from class culture, the different roles that students assume during collaboration and, as we elaborate subsequently, hedonic features that make collaboration more fun without losing productivity should be investigated more deeply (see publication B1 in Chapter 2).

Regarding the **design implications for future socio-emotional tools and features** that we discussed in this dissertation, future research should focus on different ways of gamifying the collaboration process, new features that allow for peer evaluation of group members and for making decisions. Finally, it would also be interesting to make students reflect about their process of collaboration with short questionnaires after finishing the collaborative task as individuals and as a group in order to make students more aware of the socio-emotional aspects that they can improve during their collaboration.

Relating to **the features we designed for our *me&co* prototype**, more iterations of the DBR are needed, including testing in new scenarios. For example, in publication C3, the students already knew each other from their years together in class. In contrast, in publications J1 and J2, they hardly knew each other (but did not use the same tool). The behaviours of the students in these two scenarios differed. In publication C3, the students made jokes about each other, whereas in publications 6 and 7, the students tried to meet each other and make plans after class. For future research, we suggest studying in detail whether features that support social participation and socio-emotional regulation would be more effective for students who do not know each other. Moreover, we observed that testing the application in situations wherein the students performed tasks that had to be solved in a CSCL environment offered new insights. Our evaluation of our features involved performing tasks that could be divided and done asynchronously and individually. Different types of collaborative tasks, performed synchronously (in other contexts: performed by students of different ages, in different settings and at different educational levels), could shed more light on the usefulness of those features.

With reference to our **empirical evidence about students' opinions,** we believe that it is important to further investigate how to collect data beyond self-reports. However, although we said in the previous section that self-reports imply validity issues, finding a way to avoid such issues, such as by developing more detailed and refined questionnaires, is worthwhile to know students' preferences and experiences in using socio-emotional features, as these information are highly personal and context-dependent, and thus,

have to be validated with the students themselves. We propose user-centred methodologies, such as DBR or user-centred design, including co-design and participatory design, to test and refine our proposed features or features that may be proposed in the future.

With respect to **anonymity**, we suggest that CSCL system designers and developers implement the AtP login mode, which is more effective than the fully anonymous login mode. This suggestion could be tested in different contexts, such as with younger students and with students in primary and secondary education or outside school. Studying its effects in Massive Open Online Courses (MOOCs) could also be valuable.

Concerning the **SIDE model**, we suggest that students' opinions and preferences in other contexts, as mentioned in the previous paragraph, be further explored, as well as a possible shift in their preference for some kind of anonymity to a preference for any type of identified login mode. If such a change is seen, further research should study whether anonymity still increases socio-emotional participation, to validate our proposal for a social component of the SIDE model.

As we have seen, the SIDE model also thoroughly studies the visual representations of group members trying to foster group cohesion. Drawing from our research, we found several possible visual representations for development. In our studies, the students knew that their teacher could read their messages and identify them, but how would collaboration be affected if the teacher is seen in the CSCL environment as a member of the group, as someone who is visibly among the students? Moreover, since the students enjoyed our avatars so much, designing avatars that can be 'personalised' with personality traits and/or that could be used to express emotions with their faces would also be interesting.

With regard to the **categories of off-task messages** that we identified, they currently apply to the context we studied. Further research should validate, refine and update them if appropriate. There are other more precise possibilities, such as automatically identifying off-task messages (e.g., fake participation and trolling) using a combination of artificial intelligence, sentiment and/or semantic analysis in real time. This could help teachers monitor the groups more easily and intervene right away if necessary. This automatisation could also be useful for researchers in coding the messages more quickly, since, at present, coding is a slow process. Moreover, teachers could use the categories we developed to evaluate the collaboration process of the groups.

Finally, we concluded, similarly to related research, that humour and fun have a positive effect on collaboration. To understand them better, we suggest researching the role of humour in CSCL environments and further categorising types of humour, especially, off-task humour. This could help, for example, in the design of more features that can be integrated into CSCL environments, such as bots or automatic agents that bring some humour to conversations while keeping the group members focused on the task when needed (and off the task, when possible).

1.11 Structure of the Dissertation

This dissertation is structured as a collection of papers. The ensuing chapters consist of papers that have either been published or are on the verge of publication (meaning they have been submitted for publication or are being prepared for submission). Table 1.8 presents a detailed overview of the ensuing chapters, their titles, and the types and numbers of publications included in each chapter.

Table 1.8: Chapters of this dissertation related to the publications and the types of such publications

Chapter	Title	Publication	Type of publication
2	Socio-Emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning	B1	Book Chapter
3	Collaborative educational location-based activities with no teacher supervision: design implications.	C1	Workshop
4	How to design features for promoting social and emotional interactions during computer supported collaborative learning.	C2	Conference long paper
5	How to design features for promoting social and emotional interactions during computer supported collaborative learning.	C3	Conference long paper
6	Student preferences and behaviour in anonymous collaborative learning.	C4	Conference short paper
7	User anonymity versus identification in computer-supported collaborative learning: Comparing learners' preferences and behaviours.	J1	Journal
8	Optimising anonymity in CSCL: comparing collaboration between identified and anonymous-to-peers login modes.	J2	Journal

2 SOCIO-EMOTIONAL REGULATION IN COLLABORATIVE HYBRID LEARNING SPACES OF FORMAL–INFORMAL LEARNING

This chapter includes our paper:

Velamazán, M., Santos, & P., Hernández-Leo, D. (2022). Socio-Emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning. In: Gil, E., Mor, Y., Dimitriadis, Y., Köppe, C. (eds) Hybrid Learning Spaces. Understanding Teaching-Learning Practice. Springer, Cham. https://doi.org/10.1007/978-3-030-88520-5_7

It has been suggested that a group's regulation in hybrid learning contexts is correlated to their social and emotional interactions (Isohätälä et al., 2020). How these socio-emotional interactions influence collaboration has primarily been studied in formal learning contexts. However, the influence of these factors is potentially more challenging in outside-of-school activities, which may happen synchronously or asynchronously and without teacher supervision. The chapter explores the role of emotions in co-regulation and socially shared regulation during collaboration in hybrid contexts that mix formal and informal learning. This chapter provides an overview of the literature and the research tools related to socio-emotional regulation in computer-supported collaborative learning (CSCL) and problematizes the need for a better understanding of how socio-emotional factors unfold and operate in hybrid contexts where formal and informal learning are mixed. This problematization is illustrated with examples observed during a well-established physically sited (maths) gymkhana (In our context, a gymkhana is an outdoor game where (15-year-old) students must use clues and riddles to find and solve (maths) problems that are located throughout the streets of one of the city's neighbourhoods). The discussion opens the question to further investigate and design how to support students in improving their socio-emotional regulatory skills through CSCL for hybrid learning contexts.

2.1 Introduction

This chapter explores hybrid learning spaces (HLS) in the sense of spaces outside school where students collaborate in groups without teacher intervention. These learning opportunities may have been designed by teachers but they are actually enacted informally. This kind of hybridity –that mixes formal and informal learning– (Ellis & Goodyear, 2016) is the main focus of this study.

Two of the five trends in HLS (Ellis & Goodyear, 2016), imply two key challenges: (a) giving more agency to students, and (b) that agency needs/implies the students' regula-

tion. Agency is one of the most important capacities to be developed in education and collaborative learning because it has to do with student motivations and interests (Ahn & Clegg, 2017; (Ingold 2008; Goodyear et al. 2018); Scardamalia & Bereiter, 1991; Tchounikine, 2019). The regulation of learning is needed when, for example, students are outside of school and there is no teacher orchestrating the situation. If we add collaboration to that mix —another key skill for the twenty-first century (OECD, 2017)— we place this chapter in the field of co-regulation and socially shared regulation (Hadwin et al., 2018; Järvelä & Hadwin, 2013).

In the case of the gymkhana that we present, three groups of students are observed collaborating during an outdoor activity (solving maths problems). At that age, more experience collaborating for school purposes is a skill that should be promoted. But if emotional issues arise, they can have a strong impact on the students' performance. As we will show, in this kind of context, socio-emotional factors seem to emerge more freely than in more formal settings.

These socio-emotional processes requiring some kind of control are invisible to members and do not activate automatically; being aware of them requires learning and experience (Järvelä et al., 2020). According to Järvelä and colleagues (2016), groups do not necessarily recognize nor react to challenging collaborative situations. Thus, they need to be alerted to and learn to regulate those processes.

The gap that we try to describe and address is that among all these regulatory processes, the least studied are emotion and motivation (Järvenoja et al., 2019). Feelings of wasted time, discouragement and socio-emotional challenges can make a group fail (Barron, 2003). Thus, regulation of social and emotional issues during collaboration is a key factor in a group's performance (Järvelä et al., 2015) and is under-researched in HLS (and adjacent areas of research such as computer-supported collaborative learning, CSCL) in contexts outside school without teacher intervention.

Our main research question is: how has socio-emotional regulation been tested with the use of technology. In the chapter we explore existing research and tools for emotional regulation.We identify the need to design tools that support socio-emotional regulation during collaborative activities in HLS (not only at the beginning). In order to support the need for further knowledge to understand this gap, we studied social interactions and socio-emotional regulation in groups that were not supported by any technology. Our goal for future research is to gather insights for how to support students' needs with asynchronous tools that afford their collaboration in HLS where the digital and physical merge. This is another dimension of hybridity that we plan to develop in our future work.

This chapter is structured as follows: The first section is an overview of previous research about social and emotional regulation in CSCL from a situational perspective in order to set a common background of core concepts. Then, the chapter presents a review of the tools designed by researchers in order to learn about socio-emotional regulation

during collaboration. Finally, we present an analysis of the observations of students collaborating in a hybrid learning context that illustrates the gap described earlier.

2.2 Theoretical Background

a) Social Interactions: Cognitive and Socio-emotional Effects

Learning in collaboration involves social interactions that affect cognitive and socio-emotional processes (Isohätälä et al., 2020; Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). For example, cognitive processes comprise thinking, shared knowledge building and shared understanding. Socio-emotional processes refer, for example, to forming groups or establishing a group climate (Kreijns et al., 2003). Some of these processes are internal; they take place inside individual learners' minds and emotions. However, they also unfold when members interact with each other (Goffman, 1983). These social aspects of CSCL were studied and modelled by Kreijns et al. (2003) shown in Figure 2.1.

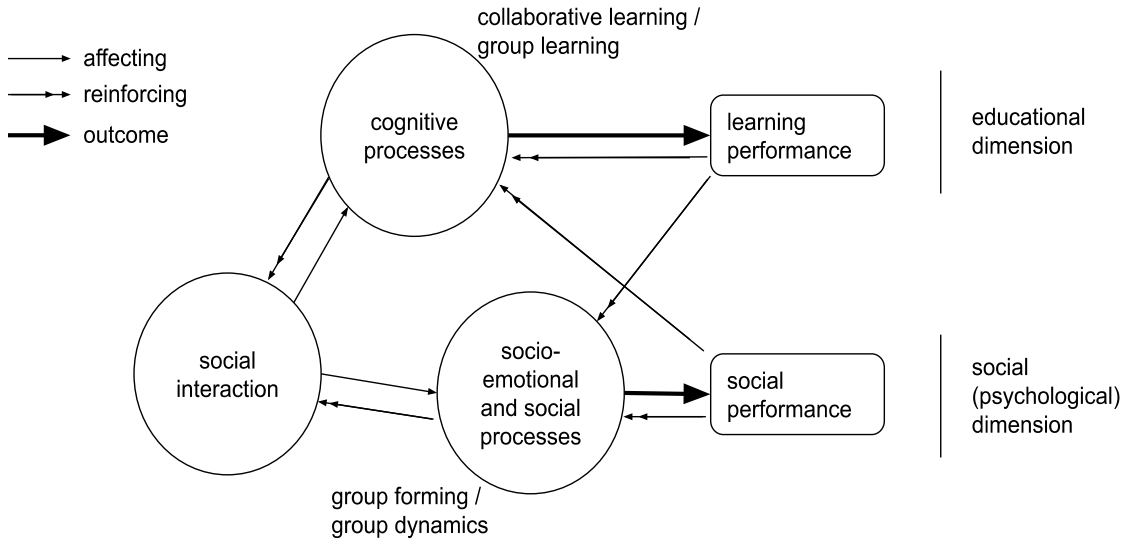

Figure 2.1: Kreijns model (2013)

The model was extended 10 years later through the addition of an 'educability' attribute (Kreijns et al., 2013). This refers to the educational affordances that support collaborative learning. A few years later, Kreijns and Kirschner (2018) proposed a second extension; the hedonicity attribute. This concept expresses the degree of enjoyment and positive experience that (online) collaborative learning tools provide. With this concept, they posit that the influence of the games and putting a fun spin on interaction will result in learning that is not only effective but also something to be enjoyed.

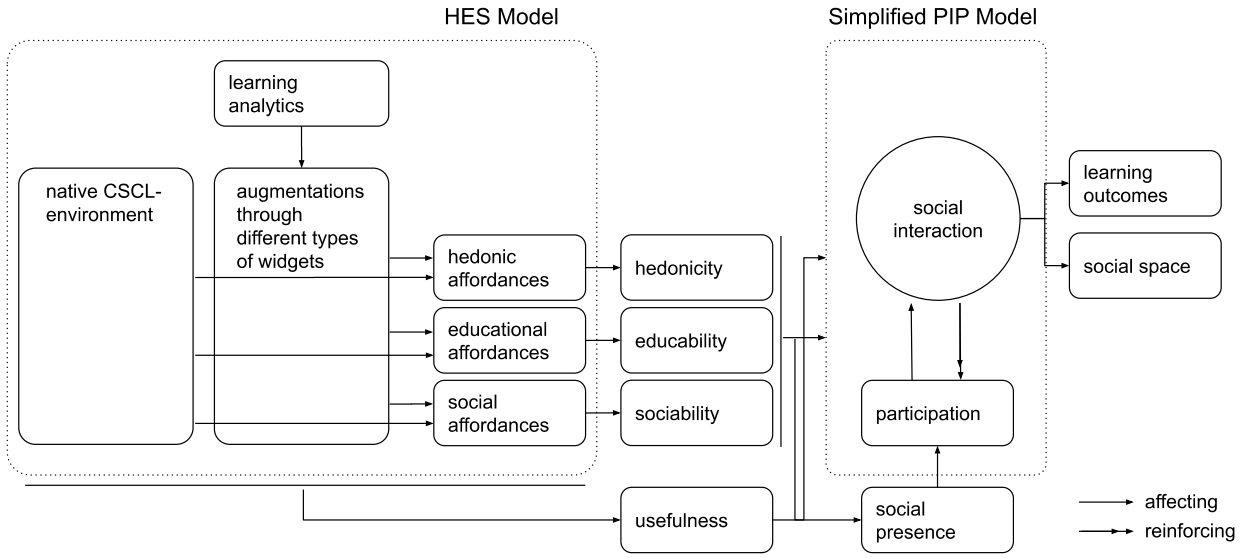

Figure 2.2: Kreijns & Kirschner model (2018)

The Kreijns & Kirschner model (2018) shown in Figure 2.2, a mix of formal and informal learning, is especially relevant in HLS because the above-mentioned 'hedonicity' attribute makes the model more complete, up-to-date, and appropriate for young collaborators.

We now focus the scope of our study on a particular type of social interaction during collaboration: regulation.

b) Regulation in Collaborative Learning

Regulation of learning is a key strategy for cyclically planning for, monitoring and reflecting on the cognitive, behavioural and emotional (including motivational) conditions of learning whenever needed (Isohätälä et al., 2020; Pintrich, 2000; Zimmerman & Martinez-Pons, 1988).

A recent review of self-regulation learning models (Panadero, 2017) describes their history and evolution and compares them according to different aspects, including their conceptualization of motivation, emotion and context. The model proposed by Järvelä and Hadwin (2013) is based on situated perspectives of learning (Greeno et al., 1996) and proposes three modes of regulation in collaborative settings: self-regulation, co-regulation (one member helps regulate another member) and socially shared regulation (regulation of the group as such).

All models of regulation refer to three phases: planning, monitoring and reflection. Some also mention the influence of personal history and previous experiences of collaborating.

In this chapter, we are focusing on social interactions but more specifically on interactions that lead to co-regulation and socially shared regulation. We are focusing on the monitoring phase of regulation because, as we will show, the monitoring phase is the least researched.

Now we will zoom in a bit to focus more on a kind of regulation: socio-emotional regulation. This, above all, is manifested when students encounter social challenges during collaboration. These challenges have been described (Hadwin et al., 2018) and refer to communication, unmotivated group member(s), unequal participation or distribution of work, unsupportive group climate, different styles of interacting and difficulty communicating due to language barriers.

Several tools have been developed by researchers to support different modes of regulation in collaboration. Below, we present some categories that previous researchers have suggested.

From the point of view of how CSCL tools can be leveraged to support groups in regulating collaboration, Miller and Hadwin (2015) proposed two types: (a) scripting tools that structure and guide collaboration by specifying, sequencing and distributing activities and roles to be enacted (Dillenbourg, 2002; Fischer et al., 2013), and (b) group awareness tools that help group members access information about behaviour, knowledge or social aspects so that they can use this information to coordinate collaboration by themselves (Janssen & Bodemer, 2013).

Regulation in scripting tools is usually performed by teachers, who flexibly orchestrate and modify the structured sequences of activities (Amarashinge et al., in press). Conversely, HLS contexts (outside school, no teacher supervision) require self-regulation support approaches that promote students' agency.

Järvelä and her colleagues (2015) used the concept of affordances (Gibson, 1977) to categorise many of the research tools that have been designed for CSCL. They observed that most of them have focused on the educational and/or technological affordances, and too often have overlooked the social affordances proposed in our chosen model of social aspects of CSCL (Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). We have found no research tools exploring hedonistic affordances in CSCL (Kreijns & Kirschner, 2018).

2.3 Review of Socio-emotional Regulation Tools in CSCL

We have reviewed (see Table 2.1) a set of scripting and awareness tools designed to support different aspects of socio-emotional regulation according to the model of regulation presented by Järvelä and Hadwin (2013). The table provides the name of the tool, the authors, a description and an indication of the regulation studied.

None of the prior research has studied regulation in hybrid contexts without teacher supervision, in the way that we propose in this chapter. All of the tools are tested in formal contexts and address higher education or university students (except the EmATool, which was used by primary school students).

Most of the tools deal with the planning or reflecting phase of regulation. Only three are specific to socio-emotional regulation: SEST, S-Reg and EmAtool. From these three, only the last two are awareness tools.

Table 2.1: Socio-emotional Regulation Research Tools

Tool	**Description**	**Regulation**
Reflector (originally part of VCRI and tailored by Phielix et al., (2010) and (Järvenoja et al. 2013)	Stimulate group members to reflect and/or co-reflect on their individual behaviour and the overall group performance.	Social aspects of groups in CSCL
Radar (originally part of VCRI, then tailored) Phielix 2012?; Järvenoja & Järvelä, (2009); Järvenoja et al., (2013)	The radar tool was tailored (from VCRI) to promote awareness of individual SRL and SSRL. The students completed the tool individually. After that, they could see each others' Radars on the screen	Self and socially shared regulation
SEST: Socio-emotional sampling tool (scripting tool) Webster & Hadwin, (2013)	SEST supports learner regulation by scripting and prompting learners to monitor and evaluate their current emotions before, during and after the task. SEST requires learners to fill in the blanks and choose items from drop-down menus.	Self and socially shared regulation: emotions
IPT & SPT: Individual & shared planning tool (scripting tool) Hadwin et al., 2013; Miller et al., 2013; Miller & Hadwin, 2015	IPT and SPT help learners define tasks, set goals, make plans and reflect on the challenges encountered individually (IPT) or collaboratively (SPT) using a series of questions asking them to fill in blank text boxes before each task.	Self and socially shared regulation: planning
OurPlanner	OurPlanner and OurEvaluator	Socially shared

Tool	Description	Regulation
Järvelä et al. (2015)	facilitate shared planning and evaluation based on SPT. OurPlanner promotes aspects of SSRL such as task understanding, planning, goal setting and strategy use.	regulation: planning
OurEvaluator Järvelä et al. (2015)	The focus is on evaluating what the group has been doing. OurEvaluator provides an opportunity for the group to evaluate their joint efforts and to reflect on which aspects of their regulation might need to be changed for future performance.	Socially shared regulation: evaluation
S-REG tool Järvenoja et al. (2017)	This tool aims to support group members' awareness of the motivational, emotional, and cognitive states of the collaborative learning and prompts groups to activate appropriate group-level regulation to respond to the group's situational needs.	Co-regulation and socially shared regulation
EmAtool Järvenoja et al. (2018)	This tool aims to increase awareness of motivation and emotions in a given situation. The tool also helps the student become more aware of motivation and emotions, which may in turn aid the student in self-regulation	Self-regulated learning Monitoring

2.4 Discussion of Two Socio-emotional Regulation CSCL Tools

Because our point of interest is the agency of students in contexts outside of school without supervision, we chose to analyse in more detail the two tools that are awareness tools, provide social affordances and deal with socio-emotional regulation: S-REG and EmATool.

a) S-REG Tool

This tool was designed to explore how and when students enacted co-regulation and socially shared emotion and motivation regulation in collaborative learning activities. The S-REG tool (Figure 2.3) prompted the group to find the most appropriate regulation strategy for a given situation. After the tool was introduced, students were instructed to use it at the beginning of each collaborative session.

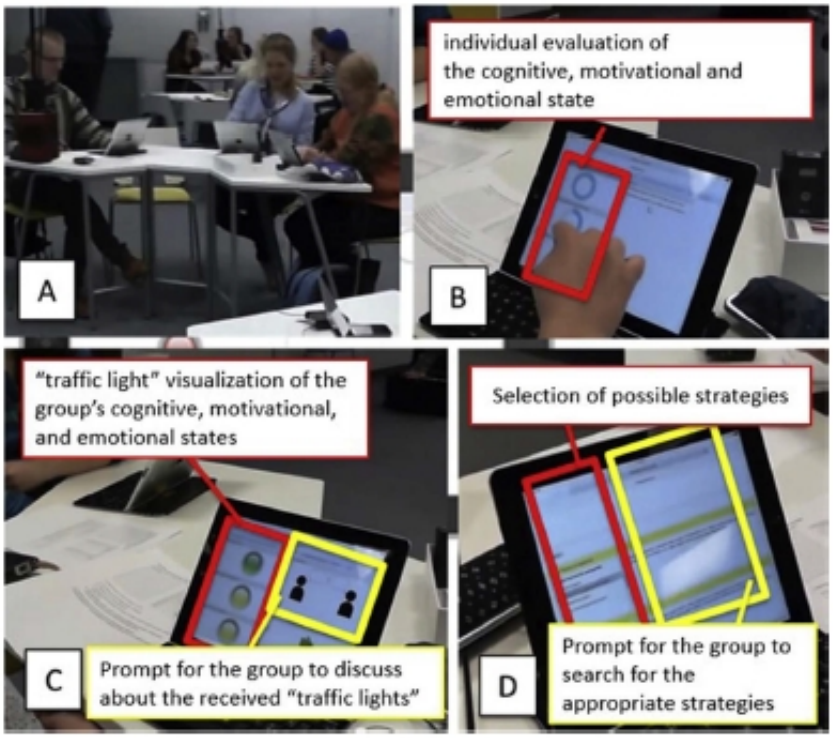

Figure 2.3: The S-Reg Tool. Järvenoja et al. (2017)

We describe some characteristics of the tool and the experiment that we think needs further discussion:

- The tool was tested and used in phases and in a quite rigid structure that could become an obstacle to a natural, fluid collaboration among members. As we said before, students were instructed to use the tool at the beginning of each session. We think that testing the tool this way could make it become an obstacle; it was not designed to be available when needed by students. Thus, it does not support the process of emergent co-regulation and shared regulation.
- The tool does not fit the context of collaboration because it requires changing attention from face-to-face collaboration to using a screen.
- There is a traffic light indicator that represents the emotional and cognitive state of the group. If it is either red or yellow, the tool prompts the members to explain why from a list of "pre-stocked options, namely challenges." We wonder if

a list of predefined options is a good way to check the emotional state of a member.

The authors imply that because the tool was used at the beginning of each collaboration session, it influenced the observed increase in co-regulation moments. The discussion of the utility of the tool concluded that the tool was "useful for creating a balanced condition for collaborative learning", but we are concerned about the limitations presented above, especially those referring to testing the tool only at the beginning of each session.

b) EmATool

This tool (Figure 2.4) was designed for trying to raise students' awareness of their perceived emotional state and motivational goals. More precisely, the tool did that through three components: (1) an evaluation of the student's emotional states in terms of valence (negative–positive), (2) an explanation for their emotional state, and (3) the selection of their motivational goals.

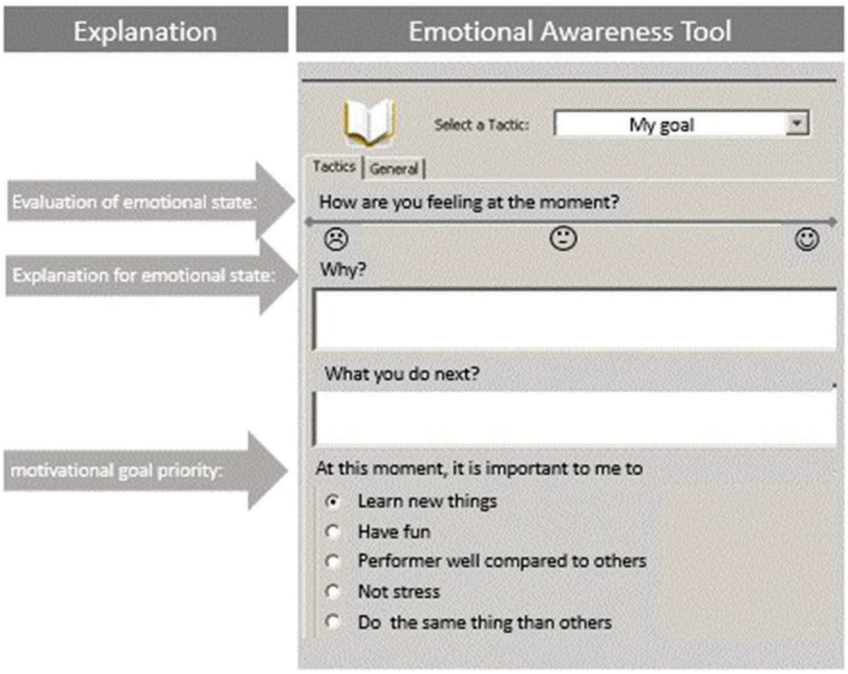

Figure 2.4: part of the interface of the EmATool. Järvenoja et al. (2018)

The emotional state of the student (1) was input on a slider from negative to positive using smiley emoticons. The explanation for that emotional state (2) was introduced by answering an open question: "Why?" The motivational goal of the moment (3) was chosen from five options: "learn new things", "have fun", "perform well compared to others", "not stress" and "do the same thing as others". The authors considered that the-

se three EmAtool components were enough to capture a students' situational emotion and motivation.

From the analysis offered by the authors, we hypothesise some pitfalls that could be further investigated:

- From the paper, it seems that the EmATool was also used only at the beginning of each session.
- Situational motivation was operationalized to include students' evaluations of emotional state and motivational goals at that time, but "that time" meant only the beginning of that session. From our observations (see our Illustrative Case Study section below) it appears that emotions and motivation fluctuate during collaboration as well.
- It seems to us that the tool does not cover the complexity of goals, emotions and challenges that students may encounter during collaboration. The five options to set motivational goals seem inadequate.
- We find it difficult to report the emotional states and their fluctuation during collaboration because it requires a shift from face to face collaboration to the digital, disconnected use of the tool.

Conclusions of the Literature and Existing Tools Review

As we have shown in the theoretical background and in the review of socio-emotional regulation tools, there is a lack of research about social interactions and emotional regulation in spaces outside school without teacher supervision. As we will show in the following section, hybrid learning contexts are rich in socio-emotional challenges.

We have seen that the tools do not test important research (reviewed above) about regulation in collaboration. For example, they include a very small set of emotions, very few options about strategies and the integration of the tool within the flow of collaboration is very cumbersome. In general, the two selected tools have tested emotional and motivational "states" before collaboration (or at the beginning of it) in order to increase awareness. Only one of them was integrated in a CSCL tool. Furthermore, no hedonicity affordances (Kreijns & Kirschner, 2018) have been tested.

2.5 Observations from an HLS Activity

In this section, we observe an innovative formal–informal hybrid learning activity to explore the extent to which previous work missed tackling some socio-emotional regulation issues present in this kind of scenario.

a) Context: Description of the Gymkhana Activity

This particular gymkhana has been taking place for 20 years, with around 20 high schools participating each year. It gathers approximately one thousand fourth-grade secondary school regular students (15-year-old) in groups of four. The groups disperse around base points that have maths word problems located in the open streets of the old Jewish quarters in Seville. Students must first find these base points and locate the object of the problem in order to solve it and move forward. Students get points for the problems they solve. During the gymkhana, the groups of students work on their own, with no teacher supervision, and are free to use any resource they have in solving the problems.

b) Instrument, Participants and Data Analysis

Our research instrument was observations. Our aim was to obtain insights from the "life" context as it unfolded without any control over it (Baškarada 2014); Zelkowitz & Wallace, 1998). The main criteria for the observations was to document interactions and conversations about socio-emotional regulation. The data collection instruments included field notes and still pictures that were analysed concurrent with data collection (Twining et al., 2017). The field notes summarised dialogues, conversations and processes. The (58) photographs analysed recorded data about personal interactions and the context. The role of the researcher (first author) was observer-as-participant. Due to the context of the activity (being outdoors on the move) the data was analysed concurrently to collect them (Twining et al., 2017). This real time analysis consisted of choosing to annotate just the data related to our research question.

The participants were three groups observed (A, B and C) that had four members of secondary school students. Data collection took place during two rounds of the activity (the years 2018 –groups A and B– and 2019, group C). Data collection took 2.5 hours for each group A and B and 4 hours for group C. In all cases, the groups were formed on the basis of previous friendships; teachers were not involved in group formation.

In order to analyse the data, a thematic analysis approach (Braun & Clarke, 2006) was used to identify, analyse and report on patterns (themes) in the collected data. The observation notes were reviewed, looking for examples of socio-emotional regulation. We chose two examples based on how roles emerge in the context of our study.

2.6 Illustrative Examples of Socio-emotional Issues in HLS

As we noted in the Introduction, we will now show that the hybrid learning context of these examples (students collaborating on their own, outside school, mixing formal and informal learning) demands regulatory awareness and skills anywhere, anytime during collaboration. To begin with, we introduce an example of how emergent roles determine

social interactions (and performance) during group work. The second case describes unresolved socio-emotional issues within a group due to a lack of awareness and a lack of an emotional regulation strategy or solution.

a) Example 1: Emotional Implications of Roles

The roles that emerged were tightly connected to the tasks they had to perform. In spite of that, in all three groups, we observed the casual emergence of leaders whose opinion counted more than the others (according to the comments of the other members, based on their better grades). This had a clear effect on the social interactions of the group, and previous research about self-regulation has not explicitly tackled this issue. Based on the analysis of what students did and said during our observations we can briefly describe the role of the leaders of each group and how this affected the emotional dynamics of that group. The leader of one of the groups (A) was also a listening person, who was open to hearing her friends' opinions. The members of the group were very active and engaged; they kept attention and were focused. This contributed to better group dynamics; more proposals were generated, resulting in more constructive feedback and a better learning experience for the group's members. The leader of the other group (B) was somewhat reserved and did not promote much conversation. The dynamic of the group was very static, and no real collaboration was observed. The members had a positive climate and no issues, but they worked on their own and basically accepted the leader's opinions. The third leader (group C) was quite authoritarian and nothing could be done or decided without her approval.

We observed that if roles change among members of the group (like in group A), the interactions were more productive. If the roles were clearly established and fixed, the members tended to accept the opinions of the leaders and/or students who usually had better grades (groups B and C). These groups also had more trouble making decisions and had a tendency to remain blocked when the leader did not know what to do. We observed members of group C wasting a lot of time because they were all waiting for the leader to make up her mind about what to do. If they had been in class with the teacher, the teacher could have taken the initiative to unblock the group, but without her presence, the group remained passive. Could the design of a digital tool provide affordances to foster role changing?

b) Example 2: Roles Determine Unresolved Challenges in Emotional Regulation

Building a shared understanding of the problem was also a source of personal friction. Verbalising how to model or approach a problem was difficult and led to misunderstandings and lost opportunities. For example, a problem about the area of a "star of David" made out of ceramics and embedded in a wall led one student to draw a model on her notebook. They all agreed about the drawing but were not able to see how to use it to

calculate the area of the star given the area of one of the external triangles. One of the girls started to verbally explain her proposal (which was actually correct) but the others did not understand it. There were several reasons for the refusal of her proposal. First, her explanations were not entirely clear; she seemed shy, and although she tried several times, she never managed to communicate her idea. Second, she was not very self-confident, and the rest of the group had a slightly diminishing opinion of her so that they did not pay much attention to her. After a few trials, she had begun rejecting her own proposal as "nonsense". Nevertheless, a few minutes later, when the girl who played the role of the leader of the group went somewhere else and the shy girl was alone with another girl, they started to complain about the "leader" not listening and just keeping to her own proposals and opinions. Could the design of a new digital tool avoid these situations?

2.7 Discussion and Further Research

As we have shown from our observations, we detected that identity and emotional issues outside school without teacher supervision are inherited, at least partly, from formal class culture. Moreover, these aspects unfold more freely and openly in hybrid contexts that mix formal and informal learning outside school and there is no teacher supervision. Considering the examples of observations we just presented, we hypothesise this situation would be very different if teachers had been present, but we have no way to assure this apart from our impressions of what we have seen in other situations when the same students were in front of the teacher.

There were few socio-emotional challenges, but they appeared during collaboration. When students are in an informal context (outside school without teacher supervision), we doubt that having an awareness tool at the beginning of the collaboration, such as those proposed by the analysed related work, would be efficient enough to help them regulate later, when they need it. Our observations suggest that future work in this vein should consider a focus on tools for integrating emotional awareness affordances that are available in the monitoring phase, during collaboration. Research questions would include: How important are these affordances for students? How can emotional regulation be organically integrated in an asynchronous collaboration tool so that it does not become an obstacle for usability or cognitive load? What happens if socio-emotional issues remain unresolved? What information (if any) should be made available to teachers?

We have chosen examples that show socio-emotional challenges, but during the observations, we also saw that students enjoyed the activity and had real fun. This connects with the concept of hedonicity (Kreijns & Kirschner, 2018) that we introduced earlier and that we did not see supported in the previous studies or with the tools.

It is our understanding that the challenges described by previous researchers (Hadwin et al., 2018) in the theoretical background do not pay enough attention to the importance during collaboration of roles that are inherited from class culture. We have shown with our examples that these are very important when students are young and are outside school without teacher supervision. This issue has been addressed in CSCL through macro scripts that assign fixed roles to students. Nevertheless, we think more effort could be put into understanding how to design for (socially) regulating emergent roles. This way, as we stated in the introduction, we are promoting students' agency, which is key in HLS (Carvalho et al. 2016; Goodyear et al. 2018).

Concerning HLS, the case observed and described in this chapter is based on an activity where digital technology was not used. However, based on our observations during the activity, we wonder how this kind of activity could be digitised. For example, how could we design technology that afforded to avoid the failure described in Example 2? Could it be allowing the possibility to send anonymous messages (text, photos or drawings) to the chat?

2.8 Limitations

Our data collection was limited in the number of groups observed. Although we found a few clarifying examples from three groups, more observations are needed to understand more different behaviours and reactions and shared patterns across groups. It could also be argued that being the gymkhana presented here, such a specific activity, the observations and conclusions of this chapter are difficult to generalise.

Another limitation is the lack of recorded audio/video material. The decision to not record audio/video was made because the students being observed preferred not to be recorded. In order to keep the researcher in a more invisible and unobtrusive position within the group work, field notes were selected as the method of collecting data. However, we know this decision has a price in terms of the amount of data gathered, particularly related to body language and non verbal interactions.

2.9 Conclusion

We think we have described an area where more (designed-based) research is needed. The HLS case described in this chapter contributed to giving students freedom to open more socio-emotional issues, a sense of agency and a change in their understanding of some previously unknown spaces into appropriated learning places (Ellis & Goodyear, 2016). Not only did they discover and enjoy parts of the city previously unknown to many of them but we could say that because of the nature of the gymkhana and the problems, ordinary spaces become places as teachers and students appropriated them through the activity. This results in students acquiring a broader sense of the subject matter

because they did not know maths could be embedded in those things or places. We were positively impressed by their surprise ("I didn't know this could be maths") and thus, by their change of perception of the topic. We think there is room for a deeper understanding and appreciation of formal school if we provide scaffolds and opportunities for students to connect it with their personal interests and motivations (Carvalho et al. 2016).

Looking into the future, our plan is to design and develop a mobile collaboration application that would include affordances for socio-emotional regulation on top of usual knowledge-building features. This app would be developed following a design based research methodology and tested to check if students improve their regulatory skills during collaboration (especially the monitoring and reflecting phases).

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2.11 Open data, ethics and conflicts of interest

The ethics procedure followed the principles, tools and procedures for high- quality research (e.g. privacy, confidentiality, clear information, security, anonymity; Santiago-Delefosse et al., 2016; Twining et al., 2017). Consent was obtained from all participants. Anonymized data excerpts were taken from the observation notes. There are no potential conflicts of interest in the work.

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3 COLLABORATIVE EDUCATIONAL LOCATION-BASED ACTIVITIES WITH NO TEACHER SUPERVISION: DESIGN IMPLICATIONS

This chapter includes the following publication:

Velamazán, M., Santos, P. & Hernández-Leo, D. (2020) Collaborative educational location-based activities with no teacher supervision: design implications. In: Söbke H, Baalsrud Hauge J, Wolf M, Wehking F, editors. Proceedings of DELbA 2020 - Workshop on Designing and Facilitating Educational Location-based Applications co-located with the Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020); 2020 Sep 15; Heidelberg, Germany. Aachen: CEUR; 2020. http://ceur-ws.org/Vol-2685/paper4.pdf

This chapter analyses a gamified collaborative formal–informal outdoor activity and uses the findings to inform the design of future mobile collaboration tools. We present a case study framed in two editions (in 2018 and 2019) of a (maths) gymkhana for 15- and 16-year-old students, during which small groups worked collaboratively outside school, with no teacher supervision. From the case study, we present the analysis of the observations of three groups that participated in the activity and the post-activity questionnaire answered by 80 students. The analysis of the questionnaire reveals factors that students appreciated as promoting productive work (i.e. working together, a sense of agency because they were completely on their own and a change of perception of the nature of the subject matter). The analysis of the observations points to other elements that promote successful collaborative work, most of them confirming findings from previous research, such as engaged feedback, joint attention and alignment of goals. But other elements require more research, such as the importance of role changes over time and a broader view of the subject matter, as well as those specific to collaborating outdoors, such as finding/locating the task and matching the description of the task with the real object/place. From those elements, we derive design implications that should inform the design of future mobile educational location-based apps (ELbAs) for collaboration.

3.1 Introduction

Collaboration is one of the key components of the digital literacy framework of the EU (Vuorikari & Punie, 2016), but there is a lack of research on collaboration in settings that mix formal and informal learning (more precisely, outside school with no teacher intervention). Educational location-based Apps (ELbAs) can benefit from research that improves collaboration since working together outdoors is something that students find

that improves their learning experience. This paper analyses a case study of a (maths) gymkhana in Seville. The purpose was to gather data and evidence of other factors that are important when working outside of school and no teachers are supervising. From those factors, we derived some design implications in order to improve future collaborative ELbAs.

3.2 Previous Research and Research Questions

This section identifies the gaps in the literature and summarises the main theories and principles that guided our study.

There are numerous studies that aimed to understand which collaborative learning (CL) conditions lead to good learning outcomes. There is evidence of multiple factors. We summarise here the findings from reviews of group dynamics and computer-supported collaborative learning (CSCL) conducted by Barron (2003), Dillenbourg (2009), Greeno (2000), Stahl (2005), Stahl et al. (2014), and Tchounikine (2019). Their findings were used to categorise the observations in the case study presented in this paper (Analysis of the Observations):

- The amount and/or frequency of discussions. Opportunities to explain one's thinking, negotiate and share knowledge and ideas (see design implication 6 in Table 3.2).
- Making many proposals and actively listening to proposals with constructive feedback (see design implication 4 in Table 3.2).
- Alignment of goals (see design implications 2 and 8 in Table 3.2).
- Body language for keeping/managing joint attention: silences, intonation, facial expressions, pointing, tapping, tum taking coherency, gestures, laughter, jokes and eye gaze, for example (see design implication 4 in Table 3.2).

While the primary focus of our study was location-based learning apps, we proceed now to give an overview of the existing research into mobile collaboration because numerous studies have been done on mobile learning but only a handful have examined mobile and collaborative learning. Fu & Hwang's (2018) literature review is one of the few papers especially focused on mobile and collaborative learning. The authors conclude with the importance of advancing the research in this field: "How can researchers or teachers design activities to engage students in more meaningful and authentic collaborative learning contexts to provide them with better chances to connect the learning content with real-life experiences, and hence construct knowledge and develop higher order thinking competences." (p. 21). Our approach to advancing the research into collaborative location-based apps was to observe and analyse face-to-face mobile collaboration not mediated through technology and not constrained by the supervision of teachers. With this

evidence, we used the findings to propose a set of design implications that could potentially improve future collaborative ELbAs.

Our main research questions (RQs) are:

- What factors shape collaboration in outdoor location-based activities without teacher supervision?
- What are students' experiences with outdoor location-based activities?

3.3 Methodology

a) Design: A Case Study of the (maths) Gymkhana of Seville

In order to answer our RQs, a case study design was selected due to the opportunities it provides to holistically understand phenomena (Baskarada, 2014). A case study is a good choice for testing and expanding upon existing research with new contexts (Baskarada, 2014), which is the purpose of this paper.

Description of the Gymkhana Activity. This particular gymkhana has been taking place for 20 years, with around 20 high schools participating each year. It gathers around a thousand fourth-grade secondary school students(15-year-olds) in groups of four. The groups disperse around base points that have maths word problems located in situ. Students must first find these base points and locate the object of the problem in order to solve them and move forward. Students get points for the problems they solve. During the gymkhana, the groups of students work on their own, with no teacher supervision, and are free to use any resource they have in solving the problems.

3.3 Methods and Instruments

The research instruments used for this case study were:

- Observation during the activity of three groups of students (11 students per group) as they solved maths problems in real outdoor settings during two editions of the gymkhana: 2018 and 2019. The observations included field notes and still pictures.
- Post-activity evaluation questionnaire completed by 80 participants.

The main purpose of the observations is to give us a view of the group collaboration while the data collected from the questionnaire gave us insight into individual experiences of the activity. By combining the two, we can obtain a more holistic view of the activity.

We conducted a semi-structured observation following the details suggested by Cohen et al. (2007). The main criteria for the observation was to document any interactions that were new and different from the existing research. Field notes were used to describe conversations, attitudes and processes and still pictures to capture body language and personal interactions. The role of the researcher was observer-as-participant (Gold, 1958). The data were analysed concurrent with data collection (Kuper, Lingard, & Levinson, 2008; Twining et al., 2017). This real-time analysis meant the researchers had to focus on annotating the data most closely related to our research questions.

The purpose of the questionnaire was to obtain information about the individual experience of the gymkhana. The purpose was to find out what was the best of the activity and why, what was their opinion about collaborating and what they thought they had learned. Questions were generated around RQ2 (see Table 3.1). Those categories were chosen in order to (a) test if they think collaboration is useful in terms of learning outcomes and fun and (b) detect if their personal attitude towards maths affected somehow the experience of the gymkhana. A mix of quantitative and qualitative questions was used (See httvs://tinyurl.com/design-collaborative-ELbAs for more details) with the goals of the qualitative questions aimed at obtaining details about (a) what they thought was the best part of the gymkhana, (b) their perceived learning outcomes and (c) their opinion on the best aspects of the activity.

In order to analyse the data, a thematic analysis approach (Braun & Clarke, 2006) was used to identify, analyse and report on patterns (themes) in the collected data.

Table 3.1: Structure of the research: connection between Objective, RQs and thematic analysis

Objective	Collaborative mobile location-based learning outside the classroom without teacher supervision	
RQs	RQ1: Factors that can shape the interactions that lead to productive collaborative mobile work outside the classroom	RQ2: Factors that students feel/think that make collaborative mobile work outside the classroom a worth experience
Instruments	Observations	Questionnaire
Categories	Personal interactions (testing previous research) New or especially relevant factors to collaborating outside school without teacher supervision	Personal feelings about maths Experience of the activity (the Gymkhana) and collaborative experience
Themes	Change of roles Difficulties connecting the formal and the informal (linking the written word problems with the real objects/places)	New perspective of the subject matter Fun (collaboration with friends) Agency (empowered without external support)
Results	Design implications to improve future asynchronous collaboration tools	

3.4 Participants

a) Observations

Fortunately, the groups making up the gymkhana teams followed Stahl's recommendation (2014) of four members as the most fruitful unit of analysis when studying collaborative meaning-making (one of our groups had three members because one was sick). Our target was secondary school students, a group that was identified by Fu & Hwang (2018) as needing further research in collaborative location-based activities. Data collection took place during two editions of the activity (the years 2018 and 2019). In 2018, one researcher shadowed two groups (A and B, seven students in total) for 2h 30min each. In order to get a deeper observation of the interactions in groups, in 2019, a third group (C) was observed for 5 hours. Group A was composed of three girls and a boy, group B was composed of three girls and group C was composed of four girls. In

all cases the groups were formed on the basis of previous friendships and independently of the teacher's opinion.

b) Questionnaires

The 14-item questionnaire was completed by a total of 80 students from five different high schools. They completed the questionnaire during their regular maths class with their regular maths teacher in their regular high-school within two weeks after the gymkhana.

3.5 Analysis

a) Observations

The observation notes were reviewed and clustered using ATLAS.ti software (ATLAS.ti Scientific Software Development, Berlin) in two categories derived from our RQ 1:

Personal Interactions Among Members (testing findings from previous research): experience, feelings (positive or negative), roles, conversations, proposals, alignment of goals, body language, problems/frictions

New Phases/Factors/Opportunities Detected: strategies/gamification finding/solving problems outdoors (connecting the formal and the informal), tools, problems/frictions

Second, we coded the pictures taken during the observations. This process revealed the importance of perception, meaning not only looking and searching with the eyes but also touching and pointing. Here, we use perception in terms of sensory processes like seeing, touching or hearing. Perception was the cause of a wide variety of interactions and became a new category that encompassed many of the notes categorised in new phases and factors/opportunities detected for collaborating outside school.

We reviewed the notes and pictures clustered in each category, and from those categories, we defined themes, following the methodology proposed by Braun and Clark (2006).

b) Questionnaire

The analysis of the qualitative answers was created by clustering similar answers and detecting and highlighting atypical cases.

Combining our observations with their opinions and feelings provided us with a more holistic picture of the activity and a student centred design approach.

3.6 Results

In this section we present the results of the questionnaire and a holistic view of the observations.

a) Questionnaire

Identity and Individual Experience during Collaboration. Figure 3.1 shows that students had a very positive experience of the gymkhana, even if they had a low self-perception of their maths performance. This indicates that the students generally think maths is useful in their everyday lives, even if they consider their performance low. The responses also reflected that students valued working in groups much more than their feelings about their maths performance.

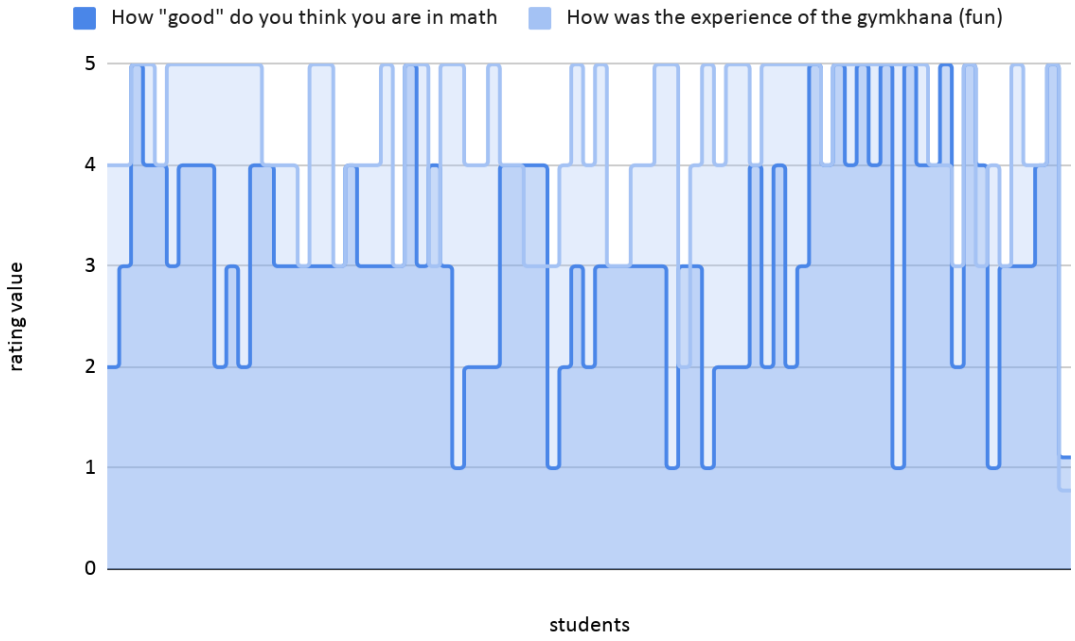

Figure 3.1: Visualisation of the relationship between self-esteem about maths and the experience of the gymkhana

Collaboration. Responses to the open question "What did you enjoy most about this gymkhana?" all fell into one of the following: "collaboration" (28.4%), "having fun with maths" (25.7%) and "being outside/on our own" (20.3%). This final answer raised the new topic of agency (i.e. being on their own, without teacher intervention).

Roles. Most groups did not have any kind of organisation of tasks, but that also highlights that an important percentage of them did (38.8%). More insights about this topic are presented with the results of the roles observations. In conclusion, the results of the questionnaire show that collaborating and solving problems outside school is something that should be promoted because students find it to be a positive experience.

b) Observations

We followed the recommendations of Cohen et al. (2007) and Braun and Clarke (2006) for making meaning from data and now present the results of the holistic observations of the activity.

Rules/Gamification Create Strategies. Rules refers to the gamified rules of the gymkhana: getting points by solving problems according to difficulty, having to move around the city to find the problems and having to find the objects of the problems in a given amount of time. These were the origins of authentic and situated maths problems; for example, optimising time and distances resulted in the unfolding of a number of interesting maths problems that students were probably unaware of.

Strategies refers to the decisions taken in order to maximise the possibilities of collecting and solving problems. Basically, this meant saving time walking and choosing the best problems to solve and the best moments to do it. For example, if a group chose to collect as many problems from base points as possible in order to try to solve them later, the interactions between the members were focused on getting to the base points. Alternatively, if a group chose to solve problems as they were collected, the dynamics of that group were more collaborative in all aspects. As already noted, the game dynamics embedded in the activity add an extra layer of maths thinking that was enjoyed by students (see design implication 7 in Table 3.2).

Roles. Roles/tasks refers to the functions assumed by each member of the group, including whether these functions changed over time. Because these students had only minimal experience with collaborating, their emergent roles were either tasks or roles that existed before the gymkhana and were dependent on each member's grades. If roles changed among members of the group (as they did in group A), the interactions were more productive. If the roles were clearly established and fixed, the members tended to accept the opinions of the leaders and/or students who usually obtain better grades.

These groups also had more difficulty making decisions and had a tendency to remain blocked if the leader did not know what to do. This effect is not entirely new (see Shirouzu, Miyake, & Masukawa, 2002), but we posit a more adaptive view of roles: members who are able to dynamically change roles (for example from leader to listener) and complete different tasks, in the process learning how they can be useful in a variety of situations, make the group more successful with both the learning outcomes and positive experience of the activity (see design implications 1, 2, 5 and 9 in Table 3.2).

Tools. Concerning the tools students used or needed, a problem many groups faced was having to write or draw the solutions to the word problems on paper, which was hindered by aspects such as being in a standing position and adverse weather conditions. Providing some kind of drawing tool (see design implications 10 and 11 in Table 3.2) could help students better explain themselves and share their knowledge with the other members while simultaneously helping to mathematicize the problem.

Collaboration Issues. Some of the issues with collaboration prompted positive interactions and collaboration, and some prompted more negative situations that students then had to handle.

Among the positive outcomes noted in the questionnaires, 35% of students referred to enjoying working in a group. Most of these kinds of answers were about being useful to the group, even when the respondents did not consider themselves "good at maths". They graded themselves, on average, 3.20/5 points (1. 10 SD) on this aspect. We observed that they seemed more confident and freer to voice their opinions when working without the teacher's presence. One student described the best part of the experience: "Even being bad at maths, I could still propose things that were useful for the others" (all responses translated from Spanish by the author). These students did not have much experience collaborating, and the fact that they were among friends without any teachers involved and far from the classroom culture of right/wrong opened up far-reaching opportunities for sharing and learning through their conversations.

For the students who had little prior experience (and even less with maths), being in this situation made the entire situation easier and more enjoyable.

There were also opportunities for learning from experiences that were not altogether positive. Some students complained that other members of the group did not work as hard as they did or that not all members were engaged equally with the goals of the group. Others complained that even if they gave their opinions and made proposals, they felt it was futile because the group always did "what the members with better grades said".

We find that tools for trying to promote collaborative learning should afford anonymous sharing of opinions in order to avoid the fear of proposing wrong answers and the kind of negative situations mentioned (see design implication 3 in Table 3.2).

A Broader Perspective of the Subject Matter. Finally, on the post gymkhana questionnaire, 17.5% of the students referred to some degree of surprise about maths. This was reflected in responses that included "taking a closer look at things" or "maths is more important than we thought" as one of their learning outcomes (this was also an open question). This is as though being in a group outside the classroom and looking at things in a new, closer way was an "eye-opening" experience that led to a new or at least broader perception of maths; some students remarked that they "didn't know that was maths". We interpreted these answers as confirmation that the perception and relationship students have with maths can be significantly improved. On the questionnaire, these students ranked the usefulness of maths in their everyday lives at 3.56/5 avg. (1.01 SD). Their perception of maths was as something they do at school (Esmonde et al., 2013; Martin & Gourley-Delaney, 2014) and we hypothesise that this perception can be improved and broadened, and furthermore, would be welcomed by students. Thus, design for maths learning outside school could be successful if it tries to promote an active perception and observation of everyday situations while also connecting with formal lectures.

3.7 Design Implications

From the results just discussed, we distilled design implications that should promote more active participation and could inform the design of future asynchronous mobile collaborative tools. Some of these design implications come from existing literature and some are new proposals that need to be tested in the future.

Table 3.2: Design implications for collaborative ELbAs

Type	Design Implication
Collaboration: group awareness	1. Always show all the members of the group (and of course, who is sending any message). This should help to have an active image of all the people as a working group.
	2. Allow evaluations to be made of the general performance of the group, and let that information be visible to the group: For example, a simplified version of the Radar and OurEvaluator tool (Järvelä et al., 2015).
	3. Allow sending of anonymous/private messages to the group to provide an error-safe space.
	4. Provide affordances for showing that members are paying attention through quick answer/feedback icons. ("understood", "I need more information", "I didn't understand", etc.)
Collaboration: Visualisation of group activity	5. Visually show different kinds of messages: proposals (Stahl, 2005), facts, decisions. Also show the connection between messages to clearly and quickly see the previous message and message threads.
	6. Visually show times of inactivity.
Roles/tasks	7. Gamify the types of messages: number of proposals, ideas and positive feedback. Provide stats about roles (elicited from kinds of messages sent). This should promote active participation in the group.
	8. Provide affordances for taking decisions and visually show them. This would facilitate taking decisions and moving forward to next steps.
	9. Awareness of roles and tasks and let them evaluate each other in the roles. However, do not force students into assigned or scripted roles.

Type	Design Implication
Tools	10. Provide affordances for a shared creative/modelling canvas to draw together (Stahl, 2005).
	11. Allow taking/sending/drawing on pictures (as in regular apps like Instagram). Quick access to calculator and formulas cheat-sheet.

3.8 Discussion

This study was built on top-down and bottom-up methodologies, specifically, a literature review and a case study, to identify factors that shape collaborative problem-solving in hybrid contexts. The observed case study is a gamified activity that combines formal education with an informal setting. While the gymkhana was enjoyed by students, some questions arose. First, if we implement these design implications in a mobile collaborative ELbA, we wonder if students would engage as much as they did with this face-to-face activity or if they would just try to finish the activity as quickly as possible, without truly collaborating. Second, how much of the positive experience of collaboration was about being physically together out of school for one day and how much was collaboration and learning. Finally, data needs to be obtained from other types of groups, especially those who do not work together as well or who are minimally motivated.

From the questionnaires, we learned that students not only enjoyed collaborating and the sense of agency they got from working on their own but that this experience also helped them change their perception of maths. At the same time, the problems were very similar to those you can find in a regular textbook except that they were located in a real place. We wonder if the experience of the activity would improve if the problems were more connected to the students' interests. The problems were also of the "well-structured", one-solution type. Problems that are less structured and more open-ended would require more personal interaction and collaboration. We hypothesise that those kinds of tasks would offer better opportunities for learning. We also cannot be certain the students actually learned any new mathematics with the activity, and if they did not, a thoughtful determination of what can be done will be required.

These design implications should inform the design of future mobile collaborative ELbA's, but we are also curious how these design implications can be organically integrated into a collaboration tool.

3.9 Limitations

Most of the groups that are created without teacher intervention are not gender balanced, and this was true in our study. Another limitation is our lack of video recorded ma-

terial. The decision to not take video recordings was taken because the students being observed preferred to not be recorded. The chosen method of data collection was aimed at keeping the researcher in a more invisible and unobtrusive position while taking field notes. Ethical issues and the potential emotional implications for the students led to the decision that video recording could produce awkward behaviour from the students and affected their personal interactions. A final limitation of the study is the small number of groups observed with only three. Future research must thoroughly test and iterate the prototypes based on the design implications proposed here.

3.10 Open Data, Ethics, Acknowledgements & Conflicts of Interest

The observation notes and questionnaire results are published online at htms://tinyurl.-com/design-collaborative-ELbAs. The ethics procedure for this study followed the principles, tools and procedures for the quality of research (Santiago-Delefosse, Gavin, Bruchez, Roux, & Stephen, 2016; Twining et al., 2017)

Consent was obtained from all participants for observation, questionnaire and taking anonymous pictures. The authors would like t o thank all students and teachers who participated in this study. This work has been partially funded by the EU Regional Development Fund and the National Research Agency of the Spanish Ministry of Science (TIN201 7-85 179-C3 -3-R). D. Hernandez-Leo acknowledges the support by the ICREA Academia programme.

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4 AWARENESS TOOLS FOR MONITORING SOCIO-EMOTIONAL REGULATION DURING COLLABORATION IN SETTINGS OUTSIDE SCHOOL WITHOUT TEACHER SUPERVISION

This chapter includes the following publication:

Velamazán, M., Santos, P., & Hernández-Leo, D. (2021). Awareness Tools for Monitoring Socio-emotional Regulation During Collaboration in Settings Outside School Without Teacher Supervision. In: De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A. (eds) Technology-Enhanced Learning for a Free, Safe, and Sustainable World. EC-TEL 2021. Lecture Notes in Computer Science (pp. 389-393), vol 12884. Springer, Cham. https://doi.org/10.1007/978-3-030-86436-1_41

There are several awareness tools developed to research how to support different phases and modes of socio-emotional regulation of learning. Most of these tools have focused on only one mode of regulation (self-, co- or socially-shared) or on one phase (planning, monitoring or reflection) and have been tested in formal settings and at specific, researchers' predetermined, moments of collaboration (at the beginning, in the middle or at the end of collaboration). In this paper we extend previous research in this area to propose a new tool that could be more naturally integrated during the whole process of collaboration in the underexplored context of informal settings without teacher supervision. The tool presented introduces some features that aim at facilitating a better understanding of social and emotional interactions and regulation of learning. More precisely, the tool supports a communication flow during the monitoring phase of regulation and includes: a) the possibility to be used by a large number of groups of learners, b) awareness tools for monitoring self-, co- and socially-shared emotional regulation c) at any time needed during collaboration, and d) includes other affordances that should indirectly support a better asynchronous collaboration.

4.1 Theoretical Background

Agency [1], [2] and collaboration [3] are two of the most important capacities to be developed in education. But if emotional issues arise during collaboration, they can have a strong impact on the groups' performance [4]. Learners do not necessarily activate their regulatory skills to face these problems and being aware of them requires learning and experience [5]. This is more critical when students have little experience collaborating for school purposes and they do it without teacher supervision. Regulatory skills in individuals and in collaboration have been extensively studied. Modes and phases have been described in previous studies. Among all these processes, socio-emotional regula-

tion and interactions have been the least studied [6]. Socio-emotional regulation in collaboration refers to the processes and strategies that students enact in order to consciously recognize, control and influence which emotions they experience and express while learning together [6].

We have analysed previous research [7]–[11] and tools about social and emotional awareness and regulation. For example, Cernea and colleagues [12] tried to increase emotional awareness through a virtual agent that supported collaboration with the help of lightweight electroencephalographic portable devices. Since one of our goals is to promote young students' agency and awareness of their emotional state, instead of reading students' brain waves, we propose a tool in which students can choose to share their emotions with others. This approach is more similar to Molinari's et al. [13], who developed an Emotional Awareness Tool (EAT) which allowed sharing members self reported emotions. They concluded that it did not influence the perception of emotions of group members but the collaboration they tested was synchronous, members of the group talked to each other through microphone and the average age was 23. We believe that in these conditions, the EAT might not be so necessary. The tool we present addresses younger students that work asynchronously and have little collaboration experience for academic purposes. Bakhtiar et al. [14] used the COPES framework [15] to develop and test their Socio Emotional Sampling Tool, but this is a scripting tool (not an awareness tool, see next section) and was not used freely by students who were instructed to do so at the beginning, middle and end of the collaboration process. The same happened with the S-Reg Tool [9] and the EmAtool [11]. We conclude that more research is needed on three aspects: a) to understand socio-emotional regulation during the whole process of collaboration, b) include hedonic affordances [16], and c) following Järvenoja and colleagues [11], we plan to test this prototype in other real learning scenarios; in informal settings without teacher supervision.

4.2 Description of the emotional and motivational affordances of the prototype

The application presented here (Figure 4.1 is the chat screen of it) is an asynchronous communication tool designed to be used during collaborative tasks by secondary school (13-16 year old) students. Each group has a set of activities (defined by the teacher) and for each activity a chat is created. Each chat is extended with the socio-emotional and motivational awareness tools that we present below.

Miller and Hadwin [8] presented the concept of awareness tools as complementary to scripting tools since those are considered less invasive to the natural flow of collaboration. Awareness tools can help students realise challenges that require action. Malmberg et al. [7] divided awareness in CSCL into cognitive and social group awareness. Our work focuses on the latest.

a) Members' avatars selection (signing-up and profile panels)

When students create their account in this prototype, they can choose an avatar from some predefined options (you can see one of the avatars at the top side of Figure 4.1 or 4.2). This feature has been included for two reasons: a) providing hedonic affordances to the group [16] and b) facilitating young students to express and share their emotions in the conversations of the group [17].

Figure 4.1: Chat panel

Figure 4.2: "My emotions" panel

Figure 4.3: Members' emotions

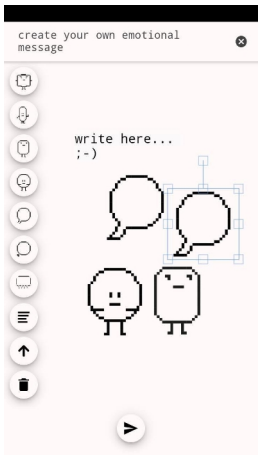

Figure 4.4: Group motivational message composer

b) Self- regulation: my emotions panel

This panel (Figure 4.2) presents a list of epistemic, achievement and social emotions [18], [19]. Each one of these emotions is described and can be measured in a likert scale (0-10) to facilitate each member to be aware of their felt emotions at any time during collaboration.

c) Co-regulation: members' reported emotions (hedonic)

When members of the group have expressed and shared their emotions using the previously presented "my emotions" panel, the rest of the group can see their report clicking on those users' avatars (Figure 4.3). If users report negative emotions or emotions with a negative valence [20] a red background with the number of negative emotions reported on the foreground is displayed (see the red badge at the top side of Figure 4.1) to let the rest of the group be aware that there are members of the group that could benefit from some socio-emotional co-regulation.

d) Socially-shared (and co-) regulation

For socially-shared regulation we present below two awareness tools:

- Emotional messages composer with avatars (Figure 4.4): In order to provide externalisation of emotions and hedonic features [16] to facilitate collaboration, this panel lets members share motivational and emotional messages with the group making use of the avatars selected by each member. The messages can be chosen from a predesigned set of visual emotional-motivational messages or members can design their own message using the tool provided.
- Anonymous messages: The socially-shared emotional regulation feature is the possibility to send anonymous messages to the group. This feature has been designed to support members that are shy or afraid to express their ideas, problems or emotions with the rest of the group at any time during collaboration.

4.3 Preliminary tests and future work

Previous versions of the current prototype were tested by two groups of students in order to base our design decisions on a user-centred design approach. Following that approach, the design of this new iteration was based on their feedback through a questionnaire and a face to face interview.

We are designing a new test with more groups that should answer our next research questions: Which are the most frequently reported emotions (by group members)? How often do the members check (or show interest in) other members' emotions? Do they take any actions? Does our application support the regulation of socio-emotional challenges? and if so, how?

We plan to test this prototype following a design based research approach with several iterations that should help us better understand what aspects of socio-emotional regulation are important in contexts without teacher supervision, and thus, improve the tool testing it during longer periods of time. Our ultimate goal is to check if our target students improve their regulatory skills during collaboration.

4.4 Acknowledgements

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5 HOW TO DESIGN FEATURES FOR PROMOTING SOCIAL AND EMOTIONAL INTERACTIONS DURING COMPUTER SUPPORTED COLLABORATIVE LEARNING

This chapter includes the following publication:

Velamazán, M., Santos, P. & Hernández-Leo, D. (2021). How to design features for promoting social and emotional interactions during computer supported collaborative learning. Accepted in HCI International 2024 Conference.

Promoting social presence, social interactions and group regulation is one of the most recent and active research lines in Computer Supported Collaborative Learning (CSCL). Students who engage in CSCL tasks often encounter socio-emotional challenges that are not well addressed. These challenges are more likely to arise when teachers are not monitoring the process. The goal of our study is to develop, implement and evaluate a prototype of a communication tool (called *me&co*) that provides UX/UI features to help teenage students deal with these challenges and maintain a productive atmosphere in their groups. Specifically, this paper addresses two gaps that are underexplored in the literature: 1) The regulation of learning in CSCL has mostly been examined in specific, research-defined moments: i.e., before, during or after collaboration. Therefore, we provide insights on how our prototype is used throughout the whole process of collaboration respecting its natural flow. 2) The regulation of learning has been investigated only in formal settings but we tested the prototype in situations where the teacher is not supervising the activity.

We adopt a Design Based Research (DBR) approach and, after examining previous CSCL tools that aimed at enhancing social and emotional awareness, we describe our design choices and the features implemented in our prototype. Then, we report the outcomes of two iterations of testing and redesigning. To assess the prototype, students (>=15 years old, n1=42, n2=64) completed a survey about their experience with the features, doing real tasks for homework in small groups.

The results show that students think the most useful features are the anonymous messages, the avatar selection and the visual messages composer. Students claim that when they already know each other quite well from class these features are not really necessary. In contrast, they report the features and affordances provided are useful and should be maintained for other users (who do not know each other previously). We propose several further research options to contribute with knowledge about how to design tools to support the emotional side of CSCL that inspires students to change their learning behaviour.

5.1 Introduction

As previous research has shown, the challenges that students may face during collaboration can be mainly categorised as: cognitive, motivational and socio-emotional [1], [2]. Most of the studies within the realm of Computer Supported Collaborative Learning (CSCL) primarily centre on the examination of cognitive challenges inherent in collaborative endeavours. However, it is imperative to underscore the notable gap in research that delves into the nuanced dynamics of how emotional, social, and motivational factors contribute to and shape specific challenges encountered during collaborative learning activities. Such challenges during collaboration appear more easily when teachers are not supervising the process and, in order to face them, students first need to be aware (and secondly learn) how to deal with these kinds of issues. Gilbert and Moore [3] and Isohätala et al. and Kreijns [2], [4] use the term social interaction for the socio-emotional and affective exchanges between learners in the task context.

The theory of the Social Regulation of Learning [5] has described three modes and three phases of regulation in collaborative learning [5], [6]. The modes are self-regulation, co-regulation (a student helps another student) and socially-shared regulation (that refers to the regulation of the group as such). The phases are planning, monitoring and reflection. In this paper we focus on the co- and socially-shared regulation modes and on the least studied monitoring phase. This theory tries to describe the interactions between the cognitive, the motivational and the social and emotional. In this paper we are focusing on the motivational and socio-emotional which are the least studied [7]. Pintrich [8] pointed out that some teachers expect students to learn regulation skills by just putting them to work together but regulation is difficult and must be learned [9]. Without the successful regulation of emotions, the cognitive side of learning can be ineffective[10], [11]. But in many cases students do not neither recognize nor activate any kind of control or regulation over these affective aspects since being aware of them requires learning and experience [12], [13]. Thus, a primary need is to be aware of them and this is the first goal of the tool that we have designed, tested and presented in this paper.

In this paper our goal is to design and prototype features with social and hedonic affordances. Then, collect data about what features are positively rated by students, their use and experience of it and if they find those features useful filling up the gaps found in existing tools concerning social interactions of group conversations and collaboration. We believe that these features would improve if their design was approached from a DBR perspective [14].

5.2 Theoretical background

In this section we present the different theories and research that we have used to design the *me&co* prototype.

Socio-emotional challenges refer to differences in participation (i.e. free riders), personalities and identities (i.e. low self-esteem, low esteem of someone else in the group), different interest in the topic [15] or communication [9], [16]. Motivational challenges can occur when members have different goals, different self-efficacy perceptions and different interests. These challenges should trigger the need to regulate socio-emotional aspects of collaboration [17], [18]. Researchers have found that if challenges are to be recognized, members need to be aware of their own and others socio-emotional states [6].

Social presence theory [19] explains communication media according to their potential to make "the other" present through socio-emotional cues. Social cohesion refers to the nature and quality of the emotional bonds of friendship such as liking, caring, and closeness among group members [20]. Shared identity may act as a stimulus to instigate the action of contributing information to an online chat. People may more readily contribute information under conditions where shared group identification is salient [21]. Avatars' representation liberates users from feeling exposed. It has been studied how it affects the behaviour of users in video games and social media [22]. The effect of avatars in classroom contexts has been also studied [23], [24] but not in informal and outside school settings as a collaboration facilitator [25].

Sharing emotions is one of the possibilities of face-to-face communication that technology mediated conversations lack and previous research has reported to improve regulation [26], [27]. Emojis appeared as a way to overcome this disadvantage. But there are no emojis for emotions during collaborative learning: researchers have described three categories of emotions during learning: social, epistemic and achievement emotions [28]. Emotion regulation is important for reducing negative responses and atmosphere in the group. Emotional valence is a measure of the positive or negative value that members perceive from the emotion. Low envy is perceived as good but low enjoyment is perceived as bad [29], [30].

Finally, Zschocke and colleagues [31] researched appraisals and motivation in group work context; the conclusion was that positive appraisals of the cognitive side is a significant factor for the activation of positive emotions. Positive socio-emotional interactions foster positive emotions [32]. In turn, negative socio-emotional interactions can provoke negative emotions [15] and this can lead to off-task behaviour and disengagement of joint learning collaboration [33].

a) CSCL and the socio-emotional side of learning

Kreijins and colleagues [2] took social presence theory as a starting point in order to identify the pitfalls for social interactions in CSCL and offered a model that included cognitive and socio-emotional processes. Later, they provided a framework for designing CSCL environments based upon technological, educational and social affordances [34]. A CSCL environment has certain features that enable and support social interac-

tion among learners. These features are called social affordances, and they are related to the social and contextual aspects of the learning situation.

Technology has changed and improved since then and their model was updated [35], [36] to include concepts like educability and hedonicity. Hedonicity, the concept we use in this paper, expresses the degree of enjoyment and positive experience that (online) collaborative learning tools provide. With this concept, they posit that the influence of the games and putting a fun spin on interaction will result in learning that is not only effective but also something to be enjoyed.

b) Existing CSCL tools for the socio-emotional side of learning

The concepts and models previously discussed have been widely utilized by numerous researchers since their publication. To begin with, Kirschner et al. implemented a widget for group awareness [34]. Miller and Hadwin [37] introduced an important distinction between scripting and awareness tools. Awareness tools are supposed to be less invasive and can help students detect the challenges they face. Our work focuses on group awareness tools because there are less existing tools of this kind. Other scholars, following the theory of regulation of learning, have also got inspiration from the findings presented above [4], [38], [39]. We have already reviewed most of these tools in a previous study [40]. As indicated, these tools tested socio-emotional aspects of collaboration in specific moments (before, after or in the middle of collaboration) or modes (self-, co- or socially-shared), not during the natural flow of collaboration. Moreover, since they did not apply a DBR methodology they did not integrate students in the process of design and did not find it necessary to get the opinion of students or to test if they found them useful. Now, we will offer here a brief overview of the main limitations of each tool (Table 5.1).

Table 5.1: Overview of tested theoretical constructs by previous research tools

Tool	Phase	Self-regulation	Co-regulation	Socially-shared regulation	Social identity/ presence	Self (re-) presentation
SEST	Evaluation	yes	no	no	no	no
Radar	Planning, evaluation	yes	no	yes	no	no
S-Reg	Monitoring (but interrupting collaboration)	no	yes	yes	no	no
EMA Tool	Planning, evaluation	yes	no	no	no	no
Collabucate	Monitoring	yes*	yes*	yes*	no	no
DREW + EAT	Monitoring	yes	yes	no	no	no

*No specific features were provided: Collabucate focuses on providing scripts for strategies to overcome challenges

Since we want to test our features in real contexts with complex teacher supervision during collaboration, we decided to follow Hoadley and Campos [14] suggestion; that the testing has to integrate a good design of the tool. This implies not only a good theoretical background to inspire the features but also a good graphic and interaction design so that students feel it is a sound alternative to their usual communication software. We had found out that previous authors [12] had reported that learners did not find the tools as useful as they could be [9]. Our primary goal was to create a tool with an intuitive graphical user interface and simple interaction. This tool integrates new social and emotional awareness features, along with cognitive and educational functionalities, into comprehensive communication software. It is designed to be effective in environments where teachers supervise teenagers with limited experience in asynchronous online collaboration for school tasks.

c) Research questions

Thus, our main research question for this study is:

Which features and affordances, according to students' opinions and experience, are adequate to facilitate students' participation and social, emotional and motivational awareness during online collaboration and support self-, co- and socially shared regulation?

This RQ has the following objectives that guided each of the iterations presented after the methodology:

- Determine how a digital tool can support learners to be aware and face the potential socio-emotional issues during their collaboration
- Following the conclusions of the previous point, how to implement and evaluate our fully functional prototype (*me&co*)?
- Do students find those features/affordances useful? Which are their favorite ones? Determine how learners perceive, use and experience the support provided.

5.3 Methods, participants and instruments

a) Methods

Design based research (DBR) is the main methodology followed in this research. As described by McKenney and Reeves [41] it consists of three iterative phases (analysis, design and evaluation). The reason for this choice was that although this methodology is still under continuous revision and improvement, there is enough consensus about its benefits for the learning sciences [14], [42].

User Centred Design is defined in an ISO norm (International Organization for Standardization [ISO], 2019) that states that human-centred design is a methodology in the development of interactive systems that prioritises the users, their needs, and requirements. It applies knowledge and techniques from human factors/ergonomics and usability to create systems that are not only usable but also useful. This approach boosts efficiency and effectiveness, enhances user satisfaction, promotes accessibility and sustainability, and improves human well-being. Moreover, it mitigates potential negative impacts on human health, safety, and performance that may arise from system usage. UCD consists of four general phases, which are: (1) specifying the context of use, (2) specifying user requirements, (3) designing solutions, and (4) evaluating the design [12]. Other authors like Sharp, Preece, and Rogers (Sharp et al., 2019) defined the UCD as a "user-centred approach" which has five basic principles. Furthermore, they outlined four basic phases of interaction design in which such principles could be applied. The phases consist of: (1) requirements discovery, (2) solution design, (3) prototyping, and (4) evaluation.

It is an iterative process in which final users are part of some or all the steps, and designers and tool developers obtain insights from their participation.

Different evidence-based strategies are typically used for UCD processes such as focus groups, co-creation sessions, associative object-based techniques or surveying (Dopp et al., 2019). We apply different techniques from UCD, like questionnaires, interviews and

paper prototyping to identify the final functionalities needed and how to organise them in a graphical interface (Design stage).

We explain our specific method in each of the following sections. But in general, we followed these steps for our DBR process. The main objective of the first iteration was to create a first prototype based on previous research trying to fill the gaps found and get students' opinions in order to improve it. In the second iteration, the objective was to present a refined version of the features and get new students' opinions and experiences for comparison with the first iteration.

b) Participants

Iteration 1. The first version of the prototype (more detail and images below) was tested with 42 students from two classes from a public high school in a town close to Seville (Valencina de la Concepción). The students were 16 years old from the first year of the Baccalaureate in Spanish Education System. IES Las Encinas, the name of their high school, is placed in a rural area from medium-low income level.

The researcher and the teacher created a collaborative activity for the students who were enrolled in a compulsory subject about Technology. The topic was basic computer networks and security. The goal of the task was to prepare a presentation about the different types of networks, the protocols and the devices. The task was assigned as homework and they used the tool for 5 days (outside school without teacher supervision) to organize and prepare the presentation.

The students were informed that they were expected to discuss and agree the content through the prototype of the collaborative tool. The groups (of 4) were also made by the teacher with students who did not usually work together in order to provoke more moments of socio-emotional challenges.

Iteration 2. This new version of the prototype (below more detail and images) was tested with 64 students from three classes from a public high school in a town close to Cádiz (Conil). The students were 16 years old from the first year of the Baccalaureate in Spanish Education System, IES Atalaya. It is a high school placed in a rural area during winter but touristic beach during summer from medium income level.

The researcher and the teacher created a collaborative activity for the students who were enrolled in a compulsory subject about philosophy. This time, trying to make the task more collaboration-focused and avoid dividing the task among members, the topic was preparing a debate about one of the themes proposed in the activity. The students were used to preparing debates since the teacher uses that type of task to make them practice and study philosophy. The theme selected had to be agreed upon by the members but from a list of topics provided by the teacher. After choosing one topic of discussion, they had to come up with arguments pro or against it. The groups were also made by students who did not usually work together in order to provoke more moments of socio-

emotional challenges. They had to deliver a document with all the best arguments agreed upon for the debate. The task was assigned as homework and they used the tool for five days (outside school without teacher supervision) to share and select their arguments for the debate.

All students signed the consent form about data privacy and ethics in research. Again, all students tested the same version of *me&co* and a brief introduction of the socio-emotional awareness features integrated in the app was provided by the main author.

c) Instruments

This article presents research that embodies two iterations. Both iterations imply the redesign of a first prototype that we present below. The objective of the iterations was to obtain a refined version of the prototype to be considered for implementation. Both iterations are interrelated.

The main instruments used were:

- The prototype to test (students had to solve a task for a real class)
- A post-task questionnaire asking about the experience of use of the features provided in the prototype
- Analysis of the chat conversations logs
- For each iteration, after evaluating the collected data from the questionnaire, we obtained a version of the prototype that would be used for the analysis of the next iteration. In the following sections we present the two instruments.

The me&co prototype

To design and implement the first prototype, we started by ideating the features and tools that could improve the previous research tools reviewed in the theoretical background. We wanted to give support for social presence, participation, regulation and motivation in order to facilitate addressing those socio-emotional challenges.

In table 5.2 we show the features designed and implemented in the *me&co* prototype with the research constructs that we try to facilitate.

Table 5.2: Features integrated in the prototype related to the theoretical background that supports them and the provided functionality description

Feature	Theory support	Functionality description
An Anonymous messages	Socially-shared and co- regulation. Promoting social interactions and participation.	We hypothesized that including the possibility of sending on-demand anonymous messages to the chat could facilitate and increase the participation of shy members and support facing socio-emotional challenges.
Avatar selection	Representation of the self, identity. SIDE model. Hedonic affordances and social affordances.	When students create their account in the prototype, they can choose an avatar from some predefined options.
Profile page	Self- and co- regulation. Social presence.	We designed a personal profile panel. The goal of this panel was to let users describe/present themselves to the rest of the group as collaborator students. The profile panel included a survey based on EMSR-Q to let members present to each other how they see themselves as collaborators.
My emotions panel	Self- and co-regulation and awareness of emotions	We designed a panel for each member with a list of emotions during collaborative learning. Students could select how much of the emotion they felt in a likert scale and the other members of the group could see how the rest of the members felt. We hypothesized that students could benefit from being more aware of emotions because that would help them self-regulate and co-regulate.
Visual messages composer	Socially-shared and co-regulation. Promoting motivation and hedonicity.	Students can visually create fun, motivational messages using the members' avatars together with other texts and graphics. Our aim was to provide some kind of hedonic support, a fun way of motivating the group and facilitating the socially-shared regulation of learning.

We then started to define the UX/UI and implement the features. In the following sections we present the features of the prototype and how they evolved across the two iterations.

Feature 1: Social presence and hedonicity: the representation of group members

Iteration 1: With the theory of social presence introduced in the background section in mind, we have tried to reinforce social presence, group cohesion and a sense of community through the design of a set of avatars (different but with common characteristics) that the users could choose as a profile picture (Fig. 5.1).

Figure 5.1: The avatars for members.

Students could choose their favourite avatar when they signed in *me&co*, our communication tool prototype. To promote social presence and group cohesion, these avatars were always visible during the whole collaboration. Their position in columns during the conversations was used to know who was writing each message (thanks also to the position of the icon of the type of message, see Figs. 4 and 5). That way, we hypothesised, the interface would also be seen as something more specifically designed for groups. In other similar communication tools, group conversations are presented with the same UI than those for a one-to-one conversation.

We used the analysis of the conversations and the answers to the questionnaire of this iteration 1 (see table 5.3 in the Results section for more information) to refine the design of the features and include new ones.

Iteration 2: In the second iteration, to improve the social presence and create a stronger emotional connection with the users we decided to show the name of the group and the avatars of all members (instead of just the user like in Fig. 2) of the selected group on the home page. The goal was to give more group cohesion and social presence to the group and the members from the start (Fig. 3).

The icon indicating the sender of the message was not understood by many students (Fig. 4) so we changed the graphic representation of the message bubble. In this iteration, it had a triangle pointing to the avatar which indicated what member had sent the message (Fig. 5). We placed the avatars at the bottom of the chat page so that the chat bubble pointed to them in a more hedonic, personal and emotional way (as if it was conversation between the avatars).

Figure 5.2: Iteration 1, only the avatar of the current student is shown in the tasks panel.

Figure 5.3: Iteration 2, the tasks panel shows the avatars of all the members of the group.

Figure 5.4: In iteration 1, the members were on top and the icon under the user avatar indicated the person sending the message.

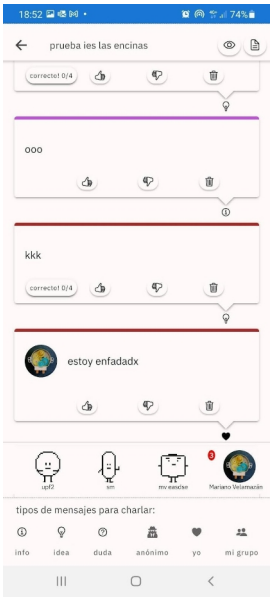

Figure 5.5: The chat bubbles point to the avatars at the bottom to show who is sending the message.

Feature 2: Facilitating participation and social interactions: the anonymous messages

Iteration 1: We hypothesised that including the possibility of eventually sending anonymous messages to the chat could facilitate and increase the participation of shy members and support facing socio-emotional challenges.

This is the feature that we designed and implemented in the prototype to test if it had the expected positive effects (Figs. 5.6 and 5.7) over students. In such messages, the other users could not see who sent those anonymous messages.

Iteration 2: To facilitate and promote anonymous participation to address socio-emotional challenges and regulation we included 6 ready made messages from common socio-emotional challenges during collaboration. The ready-made messages were taken from Alonso Tapia and colleagues' questionnaire EMSR-Q [43].

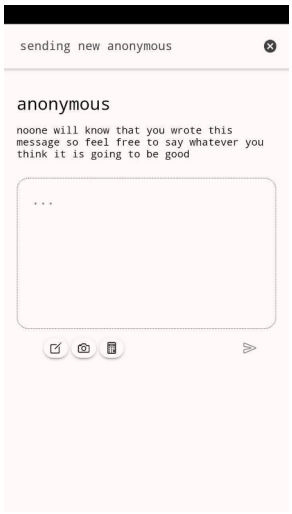

Figure 5.6: In iteration 1, the anonymous message feature just included an explanation of that type of message.

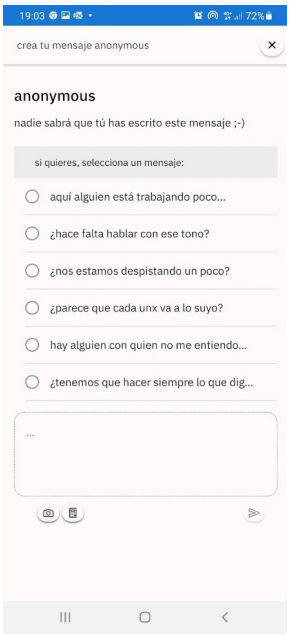

Figure 5.7: In iteration 2, the anonymous messages feature included ready-made sentences and an open-ended textfield.

Feature 3: Facilitating social and self awareness of emotions

Iteration 1: We designed a panel for each member with a list of emotions during collaborative learning. Students could select how much of the emotion they felt in a likert scale (Fig. 5.8) and the other members of the group could see how the rest of the members felt simply clicking on that user's avatar (Fig. 5.14).

Iteration 2: In Fig. 5.9 we show the second iteration of this panel simplifying the likert scale: only one slider that was enabled when an emotion was selected instead of having one slider per emotion which made the panel overloaded with UI components). We hypothesised that students could benefit from being more aware of emotions such as relief, enjoyment, curiosity and admiration to name a few because that would help them self-regulate and co-regulate their emotional mood during collaborative learning. The interface components work choosing one emotion and grading its value in a single scale component at the bottom of the panel.

The emotional valence [28] was expressed in our UI with a green or red thumbs up/down (Fig. 5.14) by the emotion value [44].

We also created a background colour for the emotion selection. So, when a user shares an emotion, the avatar of the user is sent with the background colour for the emotion in order to make it clearer and more emotional (Fig 5.9).

Figure 5.8: In the first iteration there was a list of emotions, a description of it and a likert scale per emotion to select their intensity.

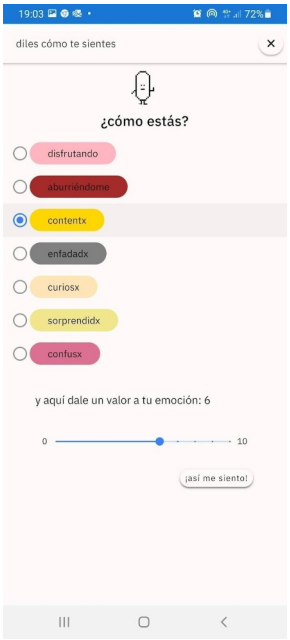

Figure 5.9: In iteration 2 the likert scale was only one and linked to the selected emotion. We also included a background colour to make identifying emotions easier.

Feature 4: Promoting motivation and hedonicity during collaborative learning

Iteration 1: We tried to support a positive group atmosphere through appraisals and motivation of members provided by a tool that also incorporated a creative and hedonic user experience. There were 4 ready made messages (Figs. 5.10 and 5.11) but we included the possibility of creating customised messages by clicking on the "pen" icon at the bottom of the panel (Fig. 5.10). Using the socio-emotional and motivational messages composer students can visually create fun messages using the members' avatars together with other texts and graphics (Figs. 5.12 and 5.13).

Iteration 2: In iteration 2 we placed the button for the "Motivational messages composer" in a more visible position (top-right, Fig. 5.11) because it was a feature really enjoyed (but not seen in iteration 1 by some students). In the Visual Messages Composer feature we provided a larger canvas for more complex custom messages (Fig. 5.13).

Figure 5.10: Iteration 1. Ready-made motivational messages feature.

Figure 5.11: In iteration2, the button "Motivational messages composer" in a more visible position (top-right).

With this feature, our aim was to provide some kind of hedonic support [36], a fun way of motivating the group and facilitating the socially-shared regulation of learning (because the default messages included all the members of the group, Fig. 5.11).

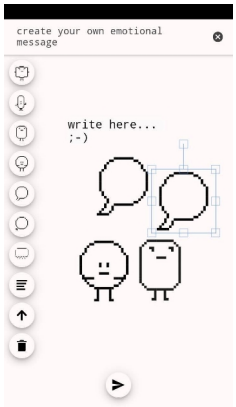

Figure 5.12: Iteration 1 Group motivational messages composer feature.

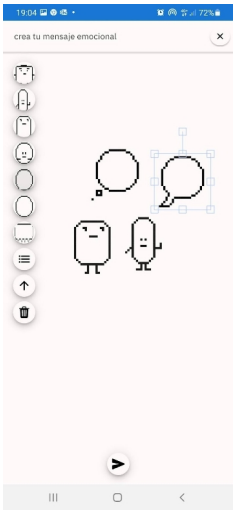

Figure 5.13: In iteration 2 we provided a larger canvas to allow more complex messages.

Feature 5: Improving social presence and regulation: the personal profile panel

Iteration 1: We also designed a personal profile panel. The goal of this panel was to let users describe/present themselves to the rest of the group as collaborator students. The profile panel included a survey based on EMSR-Q to let members present to each other how they see themselves as collaborators [43].

Iteration 2: To further promote participation with hedonic affordances, in the second iteration we improved the member's page layout to show the 'likes' of the messages (Fig. 5.15). We included a "thumbs up/down button" in every chat bubble to afford this functionality. This is a feature that a user requested in the previous version. We also allowed to show/hide the rest of the information about a member's profile to make it more usable and easy to read (Figs. 5.14 and 5.15) thanks to an "accordion" component.

The questionnaires and logs

Since the tools were new designs and different from previous research we could not find previous research questionnaires to use as a reference or a starting point. Thus, in both iterations, the questionnaire was designed by the authors. We created questions for each feature to:

- Students ratings of the features offered through a likert scale between 1 (not useful at all) and 5 (very useful)
- Their opinion (yes/no) if they would keep that feature in future iterations
- Suggestions to improve the features or possible new features to include in the *me&co* tool. These were open questions.
- A final open-ended question to know their general impression about the *me&co* tool through a likert scale (between 1, not useful and 5, very useful)

We also analysed the chat conversations looking for possible socio-emotional challenges to see their reactions.

5.4 Results

In this section we present the evaluation and results of the use of the tools (post task questionnaire). The following table summarises the results of the questionnaires of each iteration.

Table 5.3: Feature and ratings of students per iteration

Feature	Iteration 1 (%)		Iteration 2 (%)	
	Positive (>=4)	**Negative (<=2)**	**Positive (>=4)**	**Negative (<=2)**
Personal avatar selection	64.3	23.8	74.4	4.7
Personal public profile about you as a student	45.2	18.6	65.2	9.4
Anonymous messages	57.2	28.6	79.7	1.6
Sharing self emotions	31	40.4	60.9	17.2
Seeing other members' emotions	19	50	46	31.3
Motivational messages composer	30.5	42.8	64.1	12.5
General awareness of the socio-emotional challenges of the group	21.4	45.2	54.7	9.4

Since the first iteration was used mainly to improve the UX/UI of the prototype, we present now a brief overview of the results of the second iteration (sometimes in comparison to the results of the first iteration).

Personal avatar selection: Students are very positive (74.4% >= 4) about the possibility of choosing an avatar to represent themselves. Better results than in the first iteration (64.3%).

Personal public profile about you as a student: Learners are quite positive (65.6% >= 4) about presenting themselves with the questions about how they think they study and collaborate. This is a much better result than in our first iteration (45.2%), so the changes included had a positive effect.

Anonymous messages: Very positive opinions about the anonymous messages feature: 79.7% over four points (and much better than in the first iteration 57.2%).

Sharing self emotions feature: Being able to value/grade their own emotions is considered just slightly positive (60.9%) but much better than in the first iteration (31%).

Other members' emotions: But being able to see other members' emotions does not seem to be so useful for them since only 46% of students rated the feature over four. Moreover, 31.3% of students rated it below three.

Motivational messages composer: Students are quite positive (64.1%) about the feature that lets them send motivational, ready-made messages to the rest of the group. Again a much more positive result than in our first iteration (30.5%). A more positive result (67.2% >=4) for the possibility to create custom motivational messages themselves.

Awareness of the socio-emotional challenges of the group: To the general question about the app having made them be more aware of the socio-emotional challenges during collaboration they are much more positive than in our first iteration (54.7% vs. 21.4%).

Unfortunately, they reported that the specific features and affordances to facilitate socio-emotional awareness were not very used during collaboration. This was, according to their explanations, because they knew each other quite well from previous similar tasks and most of the groups concentrated on getting the task done.

5.5 Discussion

Through two DBR iterations, we have ideated, designed, refined and tested five features to promote social interactions and support social presence, hedonicity and self-, co- and socially shared regulation. Using this methodology, and the integration of a human centered approach through gathering students' opinions and experience using the app and integrating them in its design allowed us to show new results never studied before. Compared to the previous research tools we contribute with new knowledge from our tool because it integrates several features for several socio-emotional purposes into one tool that could be used during the natural flow of collaboration.

In general, students have reported that they understood the purpose and how to interact with the UI. Asked about their general experience they answered that they (58 out of 64 students) found the features useful and that they would keep them as part of *me&co*.

Best rated features: From the interaction with the interface, the anonymous messages composer (co- and socially shared regulation), the avatars (social presence) and the visual messages composer (hedonicity and socially-shared regulation) were the best rated by students (according to the students' answers to the questionnaire).

The anonymous messages: Surprisingly, even if they rated it high, the anonymous message tool does not seem to be very used; most students used their real names or the nicknames by which they are known in class. On one occasion, one student tried to start facing a challenge using the anonymous message feature and another answered asking why s/he was using the anonymous messages (instead of just saying it without hiding behind anonymity). Students explain that since they know each other, they do not need it.

The avatars: Choosing their avatars was really appreciated. In general, everything that involved avatars was enjoyed. Anyway, the purpose of this feature was mainly to esta-

blish a more emotional connection with students. Avatars were more a support to other features that could be used to address the socio-emotional challenges (like the anonymous messages or the sharing emotions panel).

The personal profile page: Most students took the time to fill up the data of this section and they said they would keep this feature in the *me&co* tool.

The visual messages composer: The ready made messages were used but with little explicit effect over the rest of the members, students created their own messages, some of them really original, but they did it for fun.

The self-emotions panel: This panel was hardly used. This can be explained because students said they prefer to work on their own, admit that in general they do not share their emotions easily with others and report they are aware of the emotions of the other members without any help. Adding that their main motivation when they work together is 1) to get a good grade and 2) to have fun together can also help to understand why students think that the feature for being aware of their emotions was the lowest rated.

This contradiction between rating the features high but not using them can be explained because students reported that they simply didn't need them. They claimed that they do not need the features because they know each other and they are already aware of their emotions and the challenges of collaboration.

It seems that the features that allow them to have fun (like the visual messages composer or the anonymous message feature) are preferred over those that are more 'introspective' (like the self-emotions tool). From their answers to the questionnaire, their second most important goal when collaborating is 'having fun' (right after 'getting a good grade'). For the self-emotions tool we think it was a good idea from students to include "stress" and "upset by the lack of work of others" in the list of available emotions. Regarding the avatars, many students asked for more characters, others wanted to have a tool to create them or to create avatars with gestures of the emotions or with personality traits. These can be ideas for future designers.

Another proposal we find interesting is their personal profile page as students and collaborators. Even though it was a long questionnaire, many students rated it quite high. It is again a feature connected to 'identity' (like the avatars) and it seems that students appreciate this type of information that makes them reflect about how they are.

5.6 Limitations

Gathering valuable insights from students is crucial, when applying a human-centered design approach, to comprehensively understand their needs and opinions before deploying an application in a genuine collaborative environment. While our study successfully obtained feedback on students' experiences with the tool's features, it is important to note that our experimental design was limited to a single task. Consequently, the data

collected may not provide a thorough understanding of the tool's broader impact on collaboration. Particularly in the initial iteration, students engaged with the tool, yet some features were utilized primarily for testing and enjoyment rather than fostering genuine collaborative interactions. This highlights the necessity of a more extensive exploration of student perspectives and utilization patterns before implementing the application in real collaborative settings.

5.7 Conclusion

This research is, to the best of our knowledge, the first to design and test a tool specifically tailored to facilitate socio-emotional aspects during the whole process of online collaboration. Moreover, in a real task, done during homework and thus, with very little teacher supervision. This is important because the existing tools have tested only specific moments of collaboration or specific modes or phases of socio-emotional interactions. In our opinion and other authors [14], using DBR in order to study the whole potential of the affordances developed, it was essential to involve students in the design process and to have a good design available any time, anywhere so that students could use the features when needed.

In general, as we have also introduced before, when the members of the group know each other from class, the vast majority of students claim they do not need such features. They hardly used the tools for practical purposes or real challenges. We have seen challenges in our analysis (that students also reported in the interviews) that were not addressed with the tool. Many students reported having members not working as much as the others but everyone accepted that situation. Research has described these challenges [12], [13], we have seen them and students admit they find them as well but, noticeably, when offered specific features to face them in a dedicated tool they do not even try to solve those issues (as we saw before when talking about the anonymous message tool, even though they claim they find the features useful -for other groups-). We hypothesize that if they use the features provided they may feel they are less 'mature' or a kind of 'hiding' or cowardly person in front of classmates they know. They have problems and challenges collaborating (like differences in commitment and effort put forth) but they do not face them; they do not want to 'complicate' things, they want to get the task done, get a good grade and have fun.

We also conjecture that, knowing that there was no teacher supervision, may have had a negative impact on the use of the app because they mostly used it for fun. In our analysis of the chats we learned that *me&co* did facilitate and promote social interactions but these were not supporting or improving their cognitive collaboration. At least in our experiments, most of these interactions were just about testing the tool in a fun way, not really as part of the collaboration to solve the task. From the Kreijns and Kirschner model [36], we hypothesized that social presence and learning outcomes affect each other but in our test, if this happened, it was not evident. Testing other conditions of anonymi-

ty, like anonymous to peers but not to the teacher, or testing the tool with students that do not know each other could also clarify if students would make a more productive use of the features provided.

On the positive side, as we presented, the average rate of the tool was high. They also explained that in other groups they have previously worked with, the features would have been useful (because they did not know each other so well). It seems that for these students, *me&co* was good to make them more aware of that side of collaboration.

5.8 Future research

As a future research line we propose to explore whether the features would be more useful in tests where students are unfamiliar with each other.

The design of the avatars could have potential benefits because students really enjoyed them. For example, it would be a good idea to link personality traits to the avatars so that they could define an avatar not only with an image but also with some kind of identity. The same goes for the anonymous messages and for new versions of the existing avatars adapted to graphically express emotions. The ambiguous results presented above encourage us to believe that these features could also be improved and tested in a different context: with students that do not know each other at all.

Finally, there were limitations that could also make the testing of *me&co* more contextually rich and realistic like the lack of notifications which made working on the tasks asynchronously quite difficult. As we also comment in the limitations section, longer experiments with more tasks and in depth interviews would be needed in order to get better data about the effect of our features during collaboration.

We have learned that future features or tools shouldn't just support awareness or script potential actions. Instead, they should also be focused on supporting discussions about challenges and conflicts in a more enjoyable and fun manner. This could include using chatbots or automatic agents to add an entertaining element to conversations.

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6 STUDENT PREFERENCES AND BEHAVIOUR IN ANONYMOUS COLLABORATIVE LEARNING

This chapter includes our following publication:

> Velamazán, M., Santos, P., Hernández-Leo, D., & Amarasinghe, I. (2022). Student preferences and behaviour in anonymous collaborative learning. In Weinberger, A. Chen, W., Hernández-Leo, D., & Chen, B. (Eds.), Proceedings of the 15th International Conference on Computer-Supported Collaborative Learning - CSCL 2022 (pp. 419-422). International Society of the Learning Sciences. https://repository.isls.org//handle/1/8323

Anonymity has been researched from different perspectives in Computer Supported Collaborative Learning (CSCL), e.g., peer assessment, writing, debating, etc. Although some negative implications have been found, positive findings are more abundant; for example, many students prefer anonymity because it facilitates more equal participation. However, little is known about what students prefer compared with what students do: Is their behaviour consistent with their reported preferences? In this chapter, we compare students' opinions and their actual technology-mediated conversations when collaborating in anonymous vs. identified mode. The results indicate a more unproductive atmosphere in anonymous mode. In future research, we propose new iterations of the modes of online collaboration to optimise the potential benefits of anonymity.

6.1 Introduction

The effect of anonymity in groups has been studied in different disciplines and from different perspectives. Research about anonymity has been applied to better understand the processes of deindividuation (Social Identity model of Deindividuation Effects, or SIDE theory), brainstorming, decision-making, and social influence in groups. According to several studies, anonymity can have both negative and positive effects (Howard et al., 2010; Postmes et al., 2001; Roberts & Rajah-Kanagasabai, 2013). On the negative side, it can channel anti-normative or anti-social behaviour. On the positive side, it can increase group cohesiveness and attraction towards the group if a common group identity is salient. Furthermore, studies on anonymity from the learning sciences and computer-supported collaborative learning (CSCL) fields have arrived at similar conclusions: In anonymous mode, quiet students might find a voice (Chester & Gwynne, 1998). Voting and debating (Ainsworth et al., 2011), peer assessment (Rotsaert et al., 2018), writing (P Woodrich & Fan, 2017), and giving feedback (Howard et al., 2010) are some of the contexts in which anonymity has a positive effect on equity (gender, status, race) and the quantity and quality of participation. However, anonymity also has some disad-

vantages. For example, despite boosting participation, many students have reported that they tend to avoid making anonymous contributions (Hoadley, 2002), or that anonymity allows for jokes, insults, or an unproductive group atmosphere (O'Sullivan & Flanagin, 2003).

Some of these studies have surveyed students' perspectives, for example, by comparing their behaviour online with their behaviour in face-to-face classes (Chester & Gwynne, 1998) and asking them about their perceived problems during collaboration (Le et al., 2018) or their experience with peer assessments in anonymous vs. identified mode (Vanderhoven et al., 2015). Roberts and Rajah-Kanagasabai (2013) asked students to rate their preferences regarding posting in anonymous vs. identified posting on discussion boards; however, the boards provided were simulations, so students did not actually collaborate, and their real behaviour could not be measured. Thus, there is a lack of research focusing on understanding students' reported preferences and experiences compared with their actual behaviour when engaging in anonymous and identified collaborative tasks online.

In this study, we focused on first-year engineering students, and we used the Pyramid-App (Manathunga & Hernández-Leo, 2018), a tool that facilitates the implementation of the Pyramid pattern (Hernández-Leo et al., 2006) to shape a collaboration structure that promotes the participation of all students. Our goal was to obtain preliminary findings from students' reported behaviour and their opinions about anonymous and identified collaboration and to compare this data with quantitative data from the Pyramid-App logs. This manuscript aims to contribute knowledge about why students prefer anonymity or identified mode and if this is related to their behaviour, thus a factor in the quality of their collaboration. The following research question guided this study: How did the anonymous vs. identified modes of the tool (Pyramid-App) affect the students' collaboration in terms of the quantity and quality of their participation?

6.2 Methods

We used descriptive statistics to analyse the answer to a questionnaire and content analysis to examine the logs of the collaboration tool. Bothe are described in the Instruments section.

One class of engineering university students (n = 74) participated in four lectures of the Introduction to Information and Communication Technologies course, which is commonly offered in several engineering programmes, at a public brick-and-mortar university. Each teacher proposed a discussion exercise related to the topic covered during the lecture. Of the 74 students, 40 were male and 34 were female. The students participated in a face-to-face classroom setting using the Pyramid pattern. After the four lectures, the post-activity questionnaire (described below) was answered by 63 students (33 males and 30 females).

In the first phase of the Pyramid pattern during each lecture, the students were divided into groups of five to six people. The students logged in to the Pyramid-App using one of the two available modes: anonymous or identified. In anonymous mode, members' names are not displayed at any time. Instead, generic identifiers are provided (e.g., user1, user2, etc.). All members logged in using the same mode as instructed by the teacher. During the four lectures, the students logged in twice in anonymous mode (for two of the activities) and twice in identified mode (for the remaining two activities).

The following instruments were used in the experiment: 1) System logs were used to check the amount and quality of participation; any blank messages sent to the chat, as well as messages that were not understandable, were deleted. 2) A post-activity questionnaire was given to the students after they had completed the four collaborative activities. The questions asked about students' preferences concerning their experiences and behaviours when in anonymous vs. identified mode. There were two groups of questions: cognitive and social-emotional (Barron, 2003). The cognitive-related questions asked if the students had posted more/equal/less a) ideas/proposals, b) feedback/answers, and c) questions/doubts. The questions about social-emotional interactions asked if they had posted more/equal/less d) humour/jokes, e) criticism/complaints, and f) spam messages in anonymous mode. Spam is a very context-dependent category (see Discussion), but we define it here as a purposefully off-topic comment.

After initial instructions on using the Pyramid-App for collaboration were given and a trial activity was done, each group of students completed four activities with four different teachers on four different days. The Pyramid pattern comprises various sequential phases that script collaboration through a combination of individual and collaborative participation (increasingly larger groups integrating previous subgroups) until consensus is reached in the final phase. The duration of each collaborative activity was defined by the teacher using the tool. In three of the activities, the two collaborative phases lasted five minutes each, while the remaining activity took 14 minutes (seven minutes each phase).

6.3 Analysis and results

We first analysed the answers to the post-activity questionnaire to gain a general understanding of the topic from the students' perspectives. The majority (59%) preferred to collaborate in anonymous mode. The most frequently given reason was a feeling of safety that made contributing easier, followed by having more fun. Some students referred to the safety of their behaviour not having 'consequences', while others referred to having the 'freedom' to express their opinions. Among students who preferred identified mode (18.8%), their main reason for the choice was a more productive and serious collaboration. One student reported that they wanted to know with whom they were talking. The group of students who did not have a preference of anonymous or identified mode (29.9%) stated they worked as much and behaved the same in either mode. Four

students reflected on how the content of an activity may cause them to change their behaviour in one mode or the other. For example, one student reported that if they were addressing 'controversial' topics, anonymous mode might be more appropriate.

When asked if they shared more/equal/less a) ideas, b) feedback, c) questions, d) useless jokes, and e) complaints in anonymous mode, most students reported positive effects of anonymity in their collaboration (see Table 6.1). They said they shared more ideas (47%), gave more feedback (44%), asked more questions (36%), did not make more useless jokes (46%), and did not complain or criticise more than in identified mode (60%).

Table 6.1: The distribution of more/equal/less ideas, feedback, questions, jokes, wasted time, and complaints in anonymous mode (as reported by the students)

		more	**equal**	**less**
		%	**%**	**%**
Content/ cognitive	Ideas	47.6	46.1	6.3
	Feedback	44.4	49.2	6.4
	Questions	36.5	52.4	11.1
Social-emotional	Criticism/complaints	19.1	60.3	20.6
	Humour or jokes	46	46.1	7.9
	Spam	19	54	27

We then analysed and compared the content of the logs of the students' actual conversations during collaboration with their reported behaviours. To begin, we compared the amount of participation between anonymous and identified chats, counting the number of messages in each. We filtered out the blank and meaningless messages. The data show that students did not participate more in anonymous mode. Indeed, there was no significant difference concerning the amount of participation: the two identified chats had 468 (see discussion for an explanation for this significantly higher number) and 234 messages, respectively, while the two anonymous chats had 245 and 289 messages.

To compare the actual behaviour during the chats with the behaviour reported in the questionnaire, we conducted a content analysis of all the messages. We clustered messages in the same categories used for the questions of the questionnaire, with the first category encompassing the content and the cognitive aspects of collaboration and the second category including the social-emotional aspects of collaboration. The first category contained the following sub-categories: a) ideas and/or proposals, b) questions and/or doubts, and c) feedback/opinions related to a or b. The second category contained the following sub-categories: d) support of the team, e) regulation of behaviour, f) humour and/or jokes, and g) wasting time (spam). The sub-category of 'criticism/complaints'

that was present in the questionnaire did not produce any results, so we created a more general category about group regulation and warnings about behaviour.

The results of the analysis (see Table 6.2) show that, despite what the students reported, there were fewer ideas, less feedback, and fewer questions in anonymous mode. In addition, there were fewer messages supporting the team, fewer messages regulating behaviour, and less humour and fewer jokes. There was a significant increase in spam in the anonymous chats (after blank and meaningless messages were deleted). Therefore, we can conclude that the quality of collaboration was lower in anonymous mode.

Table 6.2: Results of content analysis of messages

		Identified chat 1	**Identified chat 2**	**Anonymous chat 3**	**Anonymous chat 4**
Content/ cognitive	Ideas	44	21	24	14
	Feedback	99	76	90	65
	Questions	17	7	4	5
Social-emotional	Team support	23	14	9	11
	Regulating behaviour	7	5	0	7
	Humour	34	18	20	1
	Spam	18	5	10	67

Students who reported negative experiences during collaboration were those who preferred to work in identified mode. Their main reason for preferring identified mode was that the others did not take it seriously, and their behaviour made these students put extra effort into completing the activity.

6.4 Discussion and future work

The majority of the students preferred to collaborate anonymously, and they justified their opinions with solid reasons. However, the overall behaviour of the group in anonymous mode was less productive in terms of the quality of participation. Concerning quantity, the students posted more messages in anonymous mode, but the majority of these were coded as spam. The first activity had an unusual amount of higher participation but the total number of coded messages is very similar to the rest; many messages were about welcoming each other and saying hello to each other (maybe because it was the first time those students used the Pyramid-app).

An issue for discussion is the questions of the activities. As some students answered in the questionnaire, ‘maybe the topic was not controversial enough’. Different topics of discussion may change the behaviour of many students.

Since the Pyramid-App offers a shared text editor with which to compose answers collaboratively, the chat conversations were essentially feedback on and questions about individual answers, but they did not introduce ideas or proposals because we think these were made by editing the answers straight ahead in the collaborative editor.

The clustering of the social-emotional messages was especially difficult because the distinctions between the sub-categories varied within the flow of the conversations. For example, sometimes we considered a message to be a joke, but when it was repeated several times during the conversation, it became spam. At other times, messages were a mix of content and social-emotional messages, for example, mixing feedback with humour or a joke.

The Pyramid-App, like many previous research tools, provides only one mode of anonymity for all members of a group. What if students were logged in in identified mode by default but could choose to post specific, individual messages in anonymous mode? We hypothesise that this could be a good way to optimise the potential benefits of anonymous mode while maintaining the advantages of identified mode. Another way to fine-tune anonymity could be to provide some kind of mechanism to exclude spamming.

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7 USER ANONYMITY VERSUS IDENTIFICATION IN COMPUTER-SUPPORTED COLLABORATIVE LEARNING: COMPARING LEARNERS' PREFERENCES AND BEHAVIOURS

This chapter presents the following publication:

Velamazán, M., Santos, P., Hernández-Leo, D., & Vicent, L. (2023). User anonymity versus identification in computer-supported collaborative learning: Comparing learners' preferences and behaviours. Computers & Education, 104848. https://doi.org/10.1016/j.compedu.2023.104848

Previous research on the effect of anonymity on computer-supported collaborative learning has reported mostly positive results, as well as some negative results. Scholars have indicated that anonymity can promote more participation among members; however, it can also promote off-task behaviour and spam. Although the concept has been investigated in different contexts (peer assessment, writing, debating, etc.) and from different perspectives (for example, social psychology, computer mediated communication), students' preferences and whether these preferences align with students' actual behaviour during collaborative learning remain uncertain. In this study, we compared students' opinions with their technology-mediated conversations when they collaborated while anonymized versus while identified. Our results were derived from a survey and content analysis of conversation logs that included 186 university students. These findings suggest that anonymity promotes a less productive atmosphere, though students seem to prefer it. We present our findings about how anonymity affects the quantity and quality of collaboration, a group's work balance, and spam messages' role, among other factors. Moreover, we contribute new knowledge about the social component of the social identity model of deindividuation effects (SIDE). Finally, we propose new features for computer-supported collaborative learning tools that could help optimise anonymity to maximise its potential benefits.

7.1 Introduction

For over 20 years, researchers have focused on fostering social interactions among group members during computer-supported collaborative learning (CSCL). Studies have shown that simply providing collaboration tools is insufficient (Järvelä & Hadwin, 2013; Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). The sociability, social space, and social presence constructs have been used to compensate for CSCL environments' tendency to concentrate only on the cognitive side of learning (Kreijns et al., 2013; Hernández-Sellés et al. 2019). In contrast, anonymity in CSCL systems could be perceived as the opposite of social presence. The lack of body language, facial expressions,

and tone of voice, among other factors, challenges the social side of online learning collaboration. These challenges are exacerbated by the antisocial and anti-normative behaviour that anonymity enables (O'Sullivan & Flanagin, 2003).

Nevertheless, anonymity can be useful in CSCL contexts. Previous research has found that it can help increase participation—especially for low-status individuals, social minorities, and shy students—by creating a safe, reprisal-free participation environment (Christopherson, 2007). Hoadley and Linn (2000) included a feature in their SpeakEasy learning environment that allowed anonymous contributions "to establish a collaborative, safe environment, not a competitive environment" (p. 840). In their study, students (eighth graders) could choose to show their faces or remain anonymous in an asynchronous setting. The results showed that anonymity increased participation. Meanwhile, Howard et al. (2010) reported that "students who were anonymous were approximately five times more likely to provide substantively critical feedback than were those whose identities were known to their recipients." Anonymity has also been shown to offer benefits in other contexts, such as voting and debating (Ainsworth et al., 2011), peer assessment (Kobayashi, 2020; Lin, 2018; Panadero et al., 2023; Rotsaert et al., 2018; van den Bos & Tan, 2019; Vanderhoven et al., 2015), blended learning that mixes real and online identities (Miyazoe & Anderson, 2011), writing (Woodrich & Fan, 2017), sharing knowledge in a community of inquiry (Bagustari et al., 2019), and giving feedback (Howard et al., 2010; Panadero & Alqassab, 2019). However, little is known about students' collaboration (and what students think about collaborative learning) when they are anonymous versus identified in CSCL environments.

Studies in several contexts that use different supporting tools are needed to explain this phenomenon and how to improve conditions to optimise effective collaboration. In the study presented in this paper, we aimed to better understand how anonymity affected students in a real educational context in order to optimise the positive aspects of anonymity and minimise its negative effects in the design of future CSCL environments. Comparing anonymous and identified login modes in this context is important for several reasons. First, previous studies have reported positive and negative effects in different settings, but they have not analysed collaboration in real educational settings. Second, we aimed to test anonymity's effect on the amount of participation and quality of collaboration to determine, third, whether anonymity affected other aspects—such as social and emotional interactions among students. Finally, we sought to determine whether students' preferences for identification or anonymity aligned with their behaviour.

a) Theoretical background

Studies of anonymity began in social psychology. Spears, Postmes, Sassenberg, and Christopherson presented different literature reviews on such studies' development (Christoferson, 2007; Sassenberg & Postmes, 2002; Spears, 2017). The first studies in this field followed deindividuation theory. This theory states that, within a group, members

are not seen as individuals (Christoferson, 2007). These investigations pointed out the lack of social presence and social cues in computer-mediated communication (CMC). CMC was viewed as an impersonal medium that reduced attraction to a group while decreasing socio-emotional interactions and regulatory processes, leading to unproductive behaviour (Christopherson, 2007).

New theories appeared to explain how anonymity affects behaviour in computer-mediated systems in more detail, including the equalisation hypothesis and the social identity model of deindividuation effects (SIDE; Christopherson, 2007). The equalisation hypothesis (Dubrovsky et al., 1991) posits that computer-mediated systems can promote more equal participation due to a lack of social cues, such as signs of physical appearance, gender, race, age, physical disabilities, and attractiveness. Lower-status students could also benefit from this lack of social cues (Postmes & Spears, 2002).

The SIDE model developed deindividuation theory, focusing on the situational factors of anonymity. More precisely, for the SIDE model, "what matters is how group members (and self) are visually represented online" (Spears & Postmes, 2015). For example, Lee (2004) investigated how visual representations of members affected depersonalization and conformity in CMC groups. Wodzicki et al. (2011) examined how the sharing of information among proselfs (people with a salient identity and interest in their own gains) could be increased without decreasing the participation of prosocials (people who care more about the group's gains) in an online setting. Meanwhile, Hara et al. (2018), proposed a multilevel de-anonymization concept to optimise anonymity effects in a discussion system. They presented different levels of attribution and anonymity in discussions. However, these experiments were conducted in simulated or hypothetical contexts instead of real educational situations.

The SIDE model includes both cognitive and strategic components. From a cognitive point of view, the model (Spears, 2017) distinguishes between (a) the self's anonymity to a group and (b) the group's anonymity to the self. SIDE predicted that, when all members are anonymous, (a) group salience will increase, and members will identify more with the group. However, if just one member is anonymous to the group, (b) this person will identify with himself or herself more than with the group. From a strategic perspective, the same authors theorised that members would also use anonymity to meet their goals and needs. For example, Flanagin et al. (2002) reported that women tend to preserve their anonymity during discussions, while members may also use anonymity to have fun, distract, or behave antisocially, such as via the free-rider effect (Aggarwal & O'Brien, 2008).

Adaptive structuration theory (AST) is another theory that can help explain this strategic use of technology (Christopherson, 2007). AST proposed that people will use technology in two possible ways: (a) according to the purposes for which the technology was designed or (b) for other uses that emerge as people interact with the technology. This

strategic side of technology use seems crucial to explain whether anonymity leads to productive or unproductive behaviour in CSCL groups.

Concerning students' behaviour in CSCL environments, van Aalst (2009) analysed conversations and distinguished between knowledge sharing, creation, and construction before developing a coding scheme that included "ideas," "questions," "information," and "community." Järvenoja et al. (2017) used several subcategories to code socio-emotional interactions, such as "motivation", positive emotions (including "humour" and "laughter"), support or "encouraging another group member," and challenges (such as "off-task behaviour" and "reactions to address challenges" or regulating group behaviour). Consequently, we decided to code students' conversations that had been shared in a CSCL tool and adapt the categories presented above in our analysis.

Concerning students' opinions, several scholars have investigated students' online behaviour by (a) comparing it to their behaviour in face-to-face classes (Chester & Gwynne, 1998), (b) identifying problems that students encounter during collaboration (Le et al., 2018), and (c) asking students about their experiences. An example of this third category involved an assessment of other classmates in identified versus anonymized contexts (Vanderhoven et al., 2015). Davis (2007) studied whether the task type (in a "next-generation classroom network") affected the use of anonymity and whether students' statements about the use and utility of anonymity matched their actions. She concluded that students had different uses and purposes for anonymity, depending on the type of task, but she did not analyse conversations during students' collaboration. Roberts and Rajah-Kanagasabai, (Roberts & Rajah-Kanagasabai, 2013) surveyed students' preferences in rating anonymous versus identified postings on discussion boards. Students reported being more likely to post on a discussion board if they could log in anonymously. However, these students did not really collaborate because the boards had been set up by the researchers, so the students' authentic or natural behaviour could not be observed.

Thus, a gap has persisted in the literature since several studies have tried to optimise anonymity, but none have analysed students' collaboration (by quantity and quality) in a real educational context using both login modes (i.e., anonymous and identified). In our study, we also added two axes of comparison: (a) between students' behaviour during collaboration when anonymized versus identified and (b) between students' reported preferences and behaviours in these two contexts and their actual behaviour during collaboration. A group works well if its social interactions are rich, productive, and respectful within a positive atmosphere, and as previous researchers have observed, these conditions do not arise spontaneously (Muñoz-Carril et al., 2021). Problematic patterns, such as ineffective communication and unequal participation (Strauß & Rummel, 2021), frustrate students and can lead them to reduce their participation. A favourable attitude toward CSCL, as well as perceived usefulness and enjoyment, influence students' perceived learning (Muñoz-Carril et al., 2021). Some scholars are already trying to identify ways in which different levels of anonymity and its representation can foster positive interactions while avoiding the well-known drawbacks of anonymity (Wodzicki et al.,

2011; Hara et al., 2018). To advance this previous research, we compared students' preferences with their actual behaviour when they collaborated using different login modes, collecting valuable knowledge to design features and tools adapted to students' preferences and needs. For example, in this study, we sought to better understand how off-topic conversations influence collaboration, under what conditions students work more and better, and whether the negative aspects of anonymity can be minimised.

Therefore, this study's significance lies in its relevance, originality, methodological soundness, and potential impact. First, this study presents findings that can inform strategies to improve conditions that may foster fruitful social interactions. Moreover, the study is novel in that it collected data from a real educational context and compared two conditions. Methodologically, the scale of this study's data collection is remarkable, involving 186 students, and this study applied mixed methods. Finally, the contributed knowledge has practical implications since it can inform designers of CSCL environments about how to support identified or anonymized collaboration. Moreover, our findings may help educators select and configure such environments (see Section 7.4.d).

b) Research questions

We posed the following research questions (RQs).

- RQ1: What are students' preferences and reported behaviours related to collaborating in anonymous versus identified contexts?
- RQ2: How does a CSCL tool's anonymous versus identified mode affect students' collaboration in terms of the amount and quality of their participation? This RQ was addressed by answering the following supporting questions:
    - How many messages were shared in each login mode?
    - What were the messages' types and qualities in each mode? How did productive and unproductive messages compare in each mode?
    - How did group size affect these modes?
- RQ3: To what extent do students' reports align with their actual behaviour?

7.2 Material and methods

a) Participants

Three classes of first-year students (n1 = 74, n2 = 56, and n3 = 56) participated in four lectures of an Introduction to Information and Communication Technologies course common to several engineering programs at a public brick-and-mortar university. Students were informed about the research purposes (analysing their conversations) and the treat-

ment of their data privacy (anonymized), and they consented to participate. The Pyramid App checkbox was used to accept or reject participation in the study.

b) Learning tasks

For each lecture, four different teachers proposed a discussion exercise related to the topic that had been covered during that session. The topics, generally, concerned ethics in professional or academic settings. We wanted to use real tasks from the different participating teachers; thus, different task types we involved, but we had no control over them. The discussions proposed for each task were as follows.

- Task 1: "What is considered plagiarism, and why is it important to know it in university?"
- Task 2: "What surprised you most about what you learned in the content covered in the previous three class sessions? Why?"
- Task 3: "Read the given case study carefully and identify two ethical principles that have been committed in the particular case."
- Task 4: "Considering the data on the screen, you have to define a user profile oriented toward financial risk with the most relevant characteristics that are possible to obtain from those events. Choose the four characteristics you believe are more important, explain how you would generate them, and argue why those are related to financial risk."

The experimental setting

The students worked on the tasks described in the previous subsection face-to-face in a classroom setting using a CSCL tool (PyramidApp) that integrated the pyramid pattern (Manathunga & Hernández-Leo, 2018). This pattern shapes a collaborative structure that promotes all students' participation. The pyramid pattern comprised various sequential phases that scripted collaboration through a combination of individual and group participation (increasingly larger groups integrating the previous subgroups) until consensus was reached in the final phase. In this paper, we use "class" to refer to the whole class group and "group" to refer to smaller units created by Anonymized Tool.

All the students in the class were informed about the characteristics of the anonymous and identified modes, and they logged into Anonymized Tool using one of the two available modes. For all group members, the tool only allowed logging in in either the anonymous or identified mode. Therefore, all members logged in using the same mode, as instructed by their teacher. In the anonymous mode, the students' names were never displayed or known even to the teacher, although the teacher could monitor, see, and comment on the students' collaborative messages (and define the timing of each phase of a task). Students were informed about this ability. Instead of students' proper names, ge-

neric identifiers were provided (i.e., User 1, User 2, etc.). These identifiers were persistent across all phases of a task but reset for every task. Each lecture started by presenting some guidelines on using Anonymized Tool for collaboration and a trial task. Then, each class completed the four tasks with four different teachers on four different days. During the four lectures, all students logged in at least once anonymously and at least one other time in the identified mode. The sequence of login modes per class or task is depicted in Table 7.1.

Table 7.1: Sequence of login modes per class and task

	Task 1	**Task 2**	**Task 3**	**Task 4**
Class 1	identified	identified	anonymous	anonymous
Class 2	anonymous	identified	anonymous	anonymous
Class 3	anonymous	identified	identified	identified

Ultimately, six sessions took place anonymously and six sessions took place in the identified mode. The first class worked in English (not their mother tongue), while the other two classes worked in Spanish and Catalan (languages in which they were fluent).

c) Procedure

Following the pyramid pattern, each task comprised five phases. First, students provided individual responses to the task. Then, they were randomly assigned (by the CSCL tool) to small groups of five to six people. In these small groups, individual proposals were shared among group members. This second phase involved students individually rating each other member's proposals. This rating was expressed through a component that had been built into the tool, and the grades were shared among the group members. They could not see each member's individual rating, only a final average of all the ratings. The third phase was collaborative, and the group had to improve upon the individual proposals by creating a common solution. During the fourth phase, the tool combined the existing small groups into larger groups. It automatically promoted solutions for each small group, so these solutions were available to members of the newly created groups. The new, large groups then rated each group's proposal. Finally, during the fifth phase, the new groups again collaborated to improve upon the previous solutions. During each phase, collaboration took place through a chat feature and a shared text editor to improve the solutions.

Although all tasks shared the previously described structure, their durations were defined by the teachers through the tool as follows.

- Task 1: Six minutes for individual answer submission + three minutes for the first ratings + five minutes for the first improvement + three minutes for the se-

cond ratings + five minutes for the second improvement; thus, the collaborative phases lasted five + five minutes

- Task 2: Six minutes for answer submission + two minutes for the first ratings + five minutes for the first improvement + two minutes for the second ratings + five minutes for the second improvement; thus, again, the collaborative phases lasted five + five minutes
- Task 3: Twelve minutes for answer submission + six minutes for the first ratings + five minutes for the first improvement + six minutes for the second ratings + five minutes for the second improvement; once more, the collaborative phases analysed lasted five + five minutes each

Task 4: Eleven minutes for answer submission + three minutes for the first ratings + seven minutes for the first improvement + four minutes for the second ratings + seven minutes for the second improvement; thus, this final task involved longer collaborative phases of seven + seven minutes

d) Instruments

After the four tasks had been completed, a questionnaire was administered to the students. They were informed about the study's research purposes and the anonymization of their personal data. From Class 1, 64 students consented to complete the questionnaire, versus 40 and 48 from classes 2 and 3, respectively. The survey questions asked about students' preferences concerning the login modes and their experience and behaviour across the two anonymity conditions. One question (Table 7.2) asked whether they had posted more or fewer messages of the following types: (a) cognitive or content-based and (b) relational or emotional (Barron, 2003; Hod & Ben-Zvi, 2018). This question's goal was to later explain and compare students' behaviour reported in the questionnaire with their real behaviour during collaborative conversations in the anonymous versus identified chat modes. As Table 7.2 shows, the first group of cognitive-related questions asked whether, in the anonymous mode, students had posted more, an equal amount of, or fewer (a) ideas or proposals, (b) feedback or answers, and (c) questions or doubts. The second group of questions concerned socio-emotional interactions and asked whether students had posted more, an equal amount of, or fewer messages in the anonymous mode about (d) humour or jokes, (e) criticism or complaints, and (f) spam messages.

This study's selection of cognitive categories (see Table 7.2) was based on a simplification of the work by van Aalst (2009) presented in our literature review. The categories selected to cluster social and emotional messages (Table 7.2) were inductive categories from our previous research and based on a simplification of the work by Järvenoja et al. (2017) that was also presented in our literature review. As Table 7.3 shows, these categories from previous studies were slightly modified later, during analysis, to align them with the data we collected from actual conversations.

Table 7.2: Questions in the post-task questionnaire

	Cognitive posts	**Socio-emotional posts**
When working in the anonymous mode, did you provide more/ equal/less…	Ideas? Feedback? Questions/doubts?	humour/jokes? Complaining/criticizing other members? Wasting time?
Why do you think you did so?		
Anonymous versus identified, which login mode do you prefer to collaborate? Why?		
Did you experience any socio-emotional difficulty/challenges during your collaboration?		
If so, can you give us an example?		

To answer RQ2, we used the system logs from Anonymized Tool to check the extent of participation and its quality. These logs included a reference to the user (the email for the identified mode or a generic identifier, such as "user33," for the anonymous mode), the chat room, the phase of the conversation as structured by the pyramid pattern, and a timestamp to order the messages chronologically.

e) Coding criteria

To code the logged messages, we first deleted empty and meaningless messages. This decision was difficult since deleting data that had been part of the examined collaboration experience was challenging; students had complained about so many blank messages during their collaboration because it made reading the chat much more difficult. We decided to delete these blank messages because they appeared only in one class (Class 1) and only in the final exercise (Task 4); therefore, they did not represent a general behaviour. The number of blank or empty messages and other unproductive messages (such as random letters) was particularly large and irregular for Task 4 of Class 1 compared to the other tasks of that same class. In this particular setting, students were observed to be particularly tired and unfocused. Additionally, any kind of welcome message ("hi" etc.) or farewell messages were not coded. If a member's sentence was divided across several chat messages, these expressions were coded as a single message. If a message's meaning could not be inferred, the message was not coded.

Also notably, we decided that the chat utterances could be assigned only one category because, otherwise, our analysis of the conversations and comparison with the questionnaire responses would have been far too complex. Of course, many sentences could ha-

ve been coded into more than one category, but most were short and clear. In any case in which utterances could be coded into more than one category, we chose the most suitable option—the category that best suited the message's main purpose.

We coded messages in the same categories (see Table 7.3) that had been used for the questionnaire questions. As we explained in the instruments section (section 7.2.e), the first group of questions concerned the content or cognitive side of collaboration. This large set of questions included the following categories: (a) ideas or proposals, (b) questions or doubts, and (c) feedback or opinions concerning these ideas, proposals, questions, or doubts. The second group (addressing the socio-emotional side of collaboration) was altered slightly because the category of "criticism or complaints" that had been used in the questionnaire did not correlate with a significant number of messages in the observed conversations. Based on an initial analysis of the conversations, we created a new but related category that included motivation and regulation. Therefore, the coding of the social and emotional messages included the categories (d) team support, (e) behaviour regulation, (f) humour or jokes, and (g) wasting time or spam messages.

Table 7.3: Coding categories and subcategories for chat messages

Category	Subcategory	Reference
Cognitive and content-related	Ideas or proposals	Adapted from the work of van Aalst (2009)
	Feedback or answers	
	Questions or doubts	
Social and emotional	Team support	Adapted from the works of Järvenoja (2017) and Näykki (2014)
	behaviour regulation	
	humour and jokes	
	Wasting time or spam	

Now, we describe the different cognitive and content-related categories used in this study's coding process:

- Ideas or proposals: These messages demonstrated any kind of initiative to solve or improve a task, push forward, or iterate. When a message proposed something that had been proposed before, it was coded as feedback showing agreement. Sometimes ideas or proposals were implicit.
- Feedback or answers: This category included messages that reflected any type of agreement with another message, typically an idea or proposal. They could be short ("yes," "ok," the thumbs-up emoji, etc.) or long. If a message seemed to express an idea but just confirmed a previous idea, it was considered feedback.

Further, this category included messages that explained an answer to a question or doubt.

- Questions or doubts: These messages required any kind of clarification or pointed to a lack of information, precision, or understanding. Some ideas or proposals—especially those that were polite—were sometimes formulated as questions ("Shall we start with the most voted?") but coded as an idea or proposal. Of course, if a question was open (requiring an answer beyond yes or no), then it was coded as a question, such as, "What do you want to do?"

Our criteria for coding the socio-emotional categories were:

- Humour or jokes: These messages tried to make other students laugh but did not disturb or distract from the topic of a conversation. Laughs ("hahahaha," "ggg," etc.) were considered humour messages. They normally created a convivial atmosphere or relaxed tense situations. Sometimes, these messages could be negative but fun, such as, "It's a mess hahahah."
- Motivation and behaviour regulation: This category included messages that encouraged a team to maintain a good atmosphere (motivation) and messages about group regulation in the sense of warnings about behaviour (when students tried to redirect from a challenging situation to a productive one). Time management and praise of other members' suggestions were also considered part of this category.
- Spam messages: This category was very controversial because it was heavily context-dependent, but we defined it as purposefully off-topic comments that were aimed neither to complete a task nor maintain a good group atmosphere. These messages could make other members feel uncomfortable, tired, distracted, or offended. Spam messages could include humour or jokes repeated so many times that they became tiring or distracting.

Inter-rater agreement

A first pass at coding was performed by two coders (the main author and an assistant) for over 30% of the data set, which is considered reliable (Armstrong et al., 2020). After the coders agreed on the main differences in their coding, inter-rater agreement with a Cohen's Kappa of 0.89 was achieved, which is considered "almost perfect agreement" (Landis & Koch, 1977). With this clear common understanding of the criteria, the main author then coded the rest of the data set.

7.3 Results

a) Students' opinions and preferences about anonymity versus identification

To answer RQ1, we started by using descriptive statistics to analyse the answers to the post-task questionnaire in order to obtain a general perspective on students' opinions. The majority of the students (48.8%) preferred to collaborate in the anonymous login mode. Their most frequent reason for this preference can be summarised as a feeling of safety from judgement by other students or teachers. This feeling made their contributions easier. The second-most-frequent reason was increased fun. Some answers suggested safety from expected academic "consequences" of their behaviour, while others referred to the "freedom" to express their opinions.

By contrast, 18.8% of students preferred the identified login mode. Their main reason for this choice was that they found collaboration more productive and serious. The group of students who preferred neither the anonymous nor the identified mode (36.9%) justified their answer by indicating that they had worked as much and behaved as well in both modes.

When asked whether, in the anonymous mode, they shared more, an equal amount of, or fewer (a) ideas, (b) feedback, (c) questions, (d) useless jokes, and (e) complaints or criticism, most students also reported that anonymity had positively affected their collaboration (see Table 7.4). Generally, most students claimed that they behaved equally in either mode. A detailed analysis of their answers revealed that they said they shared more ideas (33.7%), gave more feedback (30.4%), asked more questions (27%), and made more jokes (31.8%) in the anonymous mode. Only 21.8% and 15.9% of students admitted to having wasted more time and criticised peers more, respectively, in the anonymous mode.

Table 7.4: Distribution of students' reported expressions of ideas, feedback, questions, jokes, wasted time, and complaints in the anonymous login mode

		More (%)	Equal (%)	Fewer (%)
Content and cognitive side	Ideas	33.65	53.24	13.11
	Feedback	30.42	56.28	13.30
	Questions	27	59.22	13.77
Social and emotional side	Criticism or complaints	15.9	60.78	23.32
	humour or jokes	31.84	50.49	17.67
	Spam or wasting time	21.8	58.22	19.98

b) Analysis of conversation logs

We addressed RQ2 by content-analysing the CSCL tool logs of students' real conversations in their collaborative chats.

First, we determined the number of students who had not participated at all in the tasks' collaborative phases (the chats) although they had logged into Anonymized Tool. We added the total number of students who had logged into the tool for all four lectures in each of the three classes. We then compared this outcome with the total number of unique students who had participated in the chats at least once. The totals were very similar since counting the three classes during the four lectures revealed that 71 of 368 students in the anonymous mode and 70 of 365 students in the identified mode did not participate at all.

Second, we compared the number of messages posted by students who had participated in the anonymous versus identified login modes. We realised that students participated 20% more in the anonymous mode. The non-anonymized chat logs contained 468 (this outlier can be explained by the novelty of using the tool), 234, 155, 139, 144, and 251 messages, respectively, for each of the six sessions (1,390 in total). Meanwhile, the anonymized chat logs contained 245, 289, 314, 187, 288, and 355 messages, respectively (1,678 in total).

The results of our content analysis of the system logs (Figure 7.1) showed that—despite students' reports—no significant difference arose between the number of messages related to cognitive or socio-emotional content in the identified mode versus the anonymous mode. However, a slight increase in feedback, questions, and behaviour regulation was observed in the anonymous mode. By contrast, spam messages increased in the

anonymous chats (after blank messages and meaningless messages were deleted). The reason for the increase in the number of messages mentioned in the previous paragraph was due to the increase in the number of spam messages. To ensure that this increase was statistically significant, we conducted a hypothesis test, which is a common validation technique for experiments that compare the behaviour of a group in different contexts. In this case, we obtained a p-value of 0.011, which allowed us to conclude that spam messages increased in the anonymous mode.

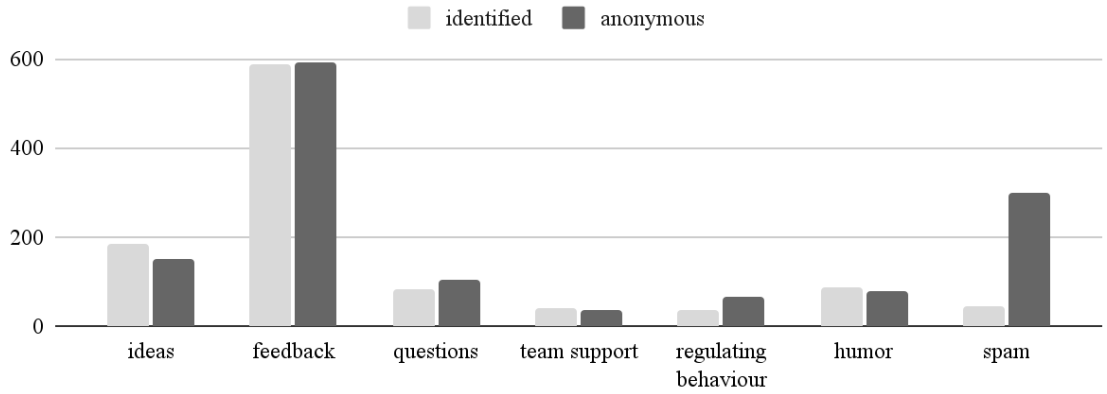


Figure 7.1: Number of messages by type in the identified and anonymous login modes

Notably, the number of spam messages grew from a total of 109 in the first phase of the collaborative task to 235 in the second phase of the pyramid pattern (presented in section 7.2.c) that structured the collaborative task when groups included more members. Parallel increases were also evident when we compared classes (Figure 7.2), modes (Figure 7.3), and tasks (Figure 7.4).

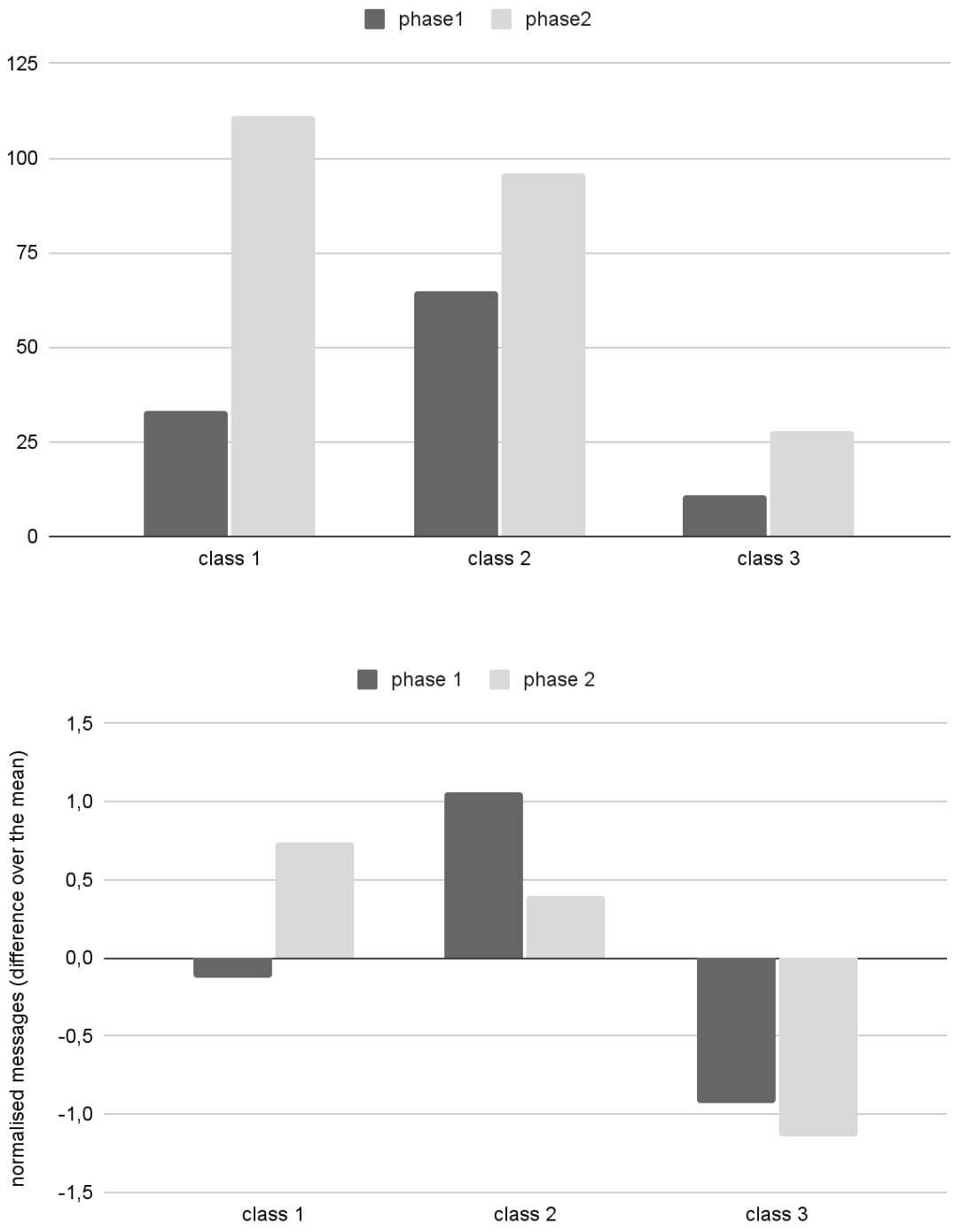


Figure 7.2: Number of spam messages in Phase 1 (dark gray) and Phase 2 (light gray) of the pyramid pattern for classes 1, 2, and 3 (the upper graph) and for the normalised data (the bottom graph)

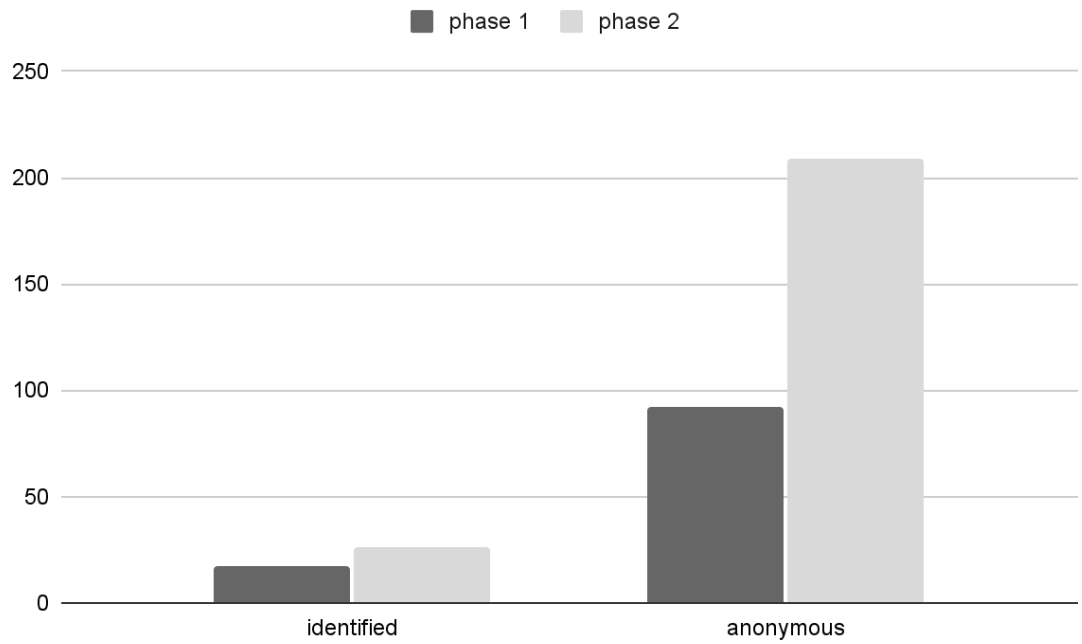


Figure 7.3: Number of spam messages in phases 1 and 2 of the pyramid pattern by login mode

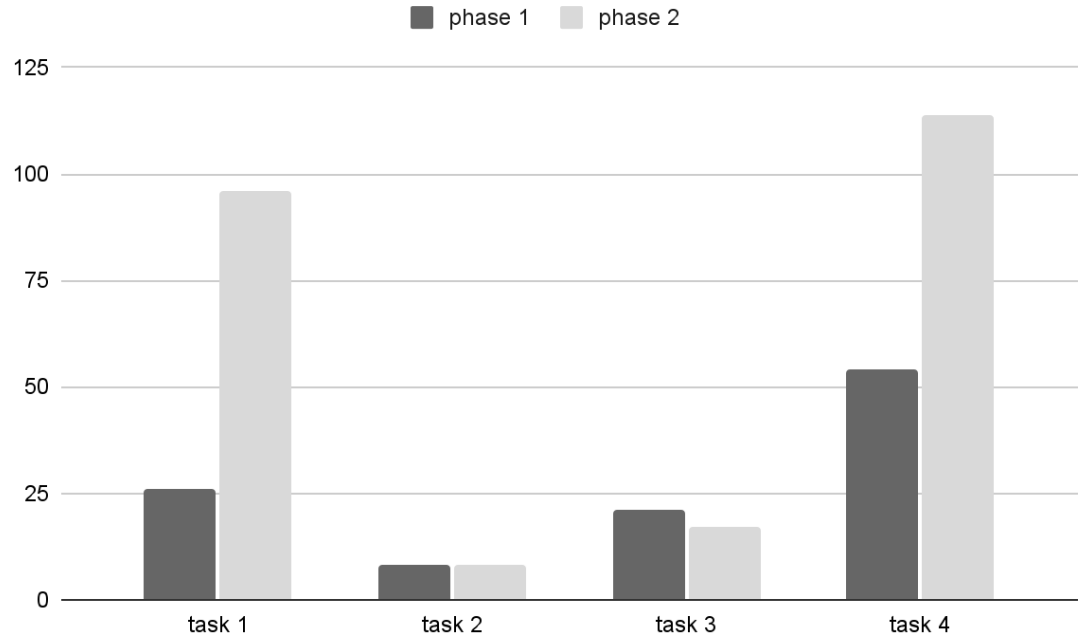


Figure 7.4: Number of spam messages in phases 1 and 2 of the pyramid pattern by task

Task 2 included the same number of spam messages in both phases, but this finding was attributed to all teams having participated in the identified login mode.

Another interesting result concerned the number of messages per user in the different modes. We wondered if individuals write more messages in the anonymous mode or the

identified mode. We analysed and separately compared the messages from the four tasks for each of the three classes (Figure 7.5.), and we observed that fewer messages were posted in the identified mode. However, these fewer messages were more balanced—that is, the numbers of users who wrote the most of these messages and of users who wrote the fewest messages differed less. Further, in the anonymous mode, fewer students sent more messages.

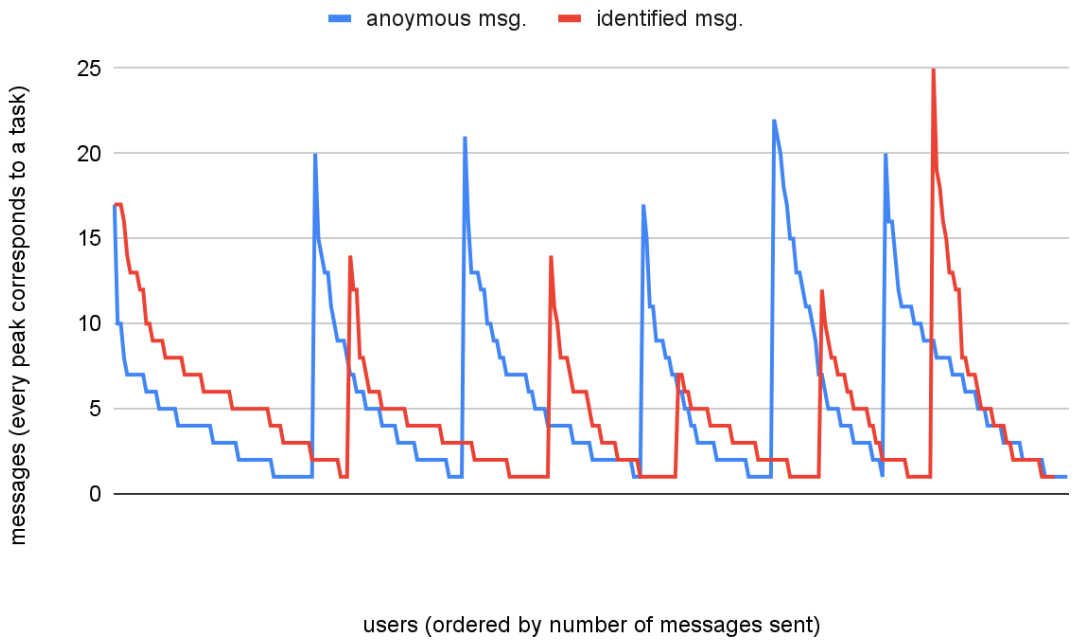


Figure 7.5: Number of messages posted per user in the identified login mode versus the anonymous login mode; the sawtooth pattern corresponds to each task, (six in the identified mode and six in the anonymous mode).

We were curious about the quality of the messages that had been posted. Figure 7.6 shows the results of an analysis of the different message types' details. The number of ideas proposed in the identified login mode (red) versus the anonymous login mode (blue) are depicted for all the classes. As shown in the graph, the identified mode involved more students (48 vs. 36) and more per-student and total messages (168 vs. 117) than the anonymous mode.

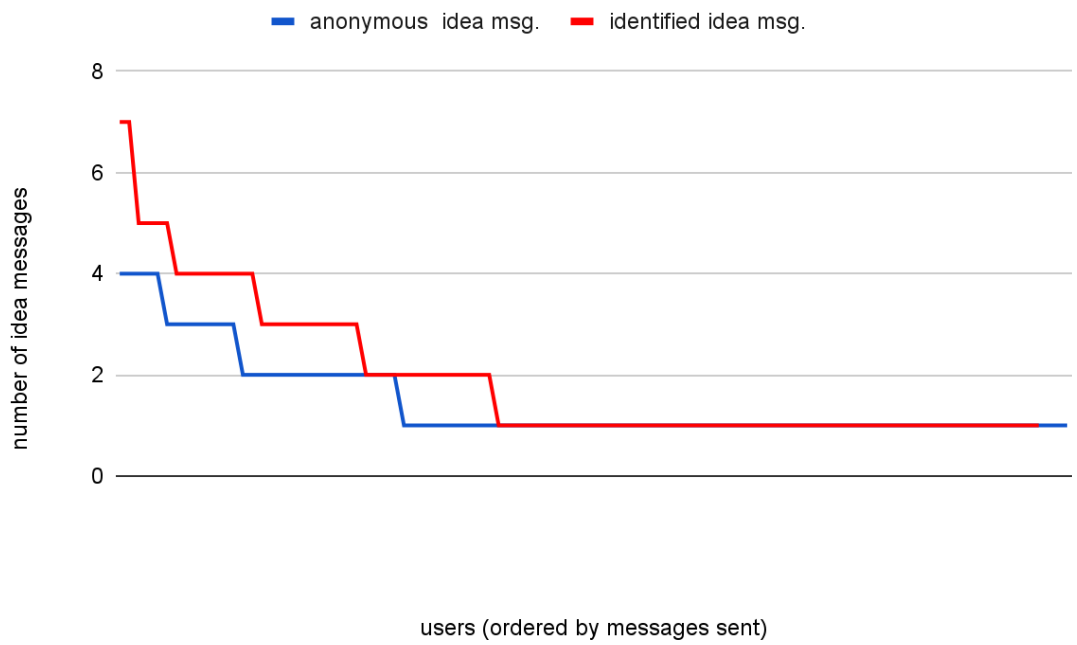


Figure 7.6: Number of idea messages shared per user in the identified login mode (red) versus the anonymous login mode (blue); users' names and identifiers have been hidden for privacy reasons

We also analysed how many spam messages had been sent per student in the anonymous mode versus the identified mode. Figure 7.7 shows that the number of spam messages was much larger in the anonymous mode (blue) and that the distribution was less equilibrated in the anonymous mode. Thus, only a few students sent a relatively large number of spam messages.

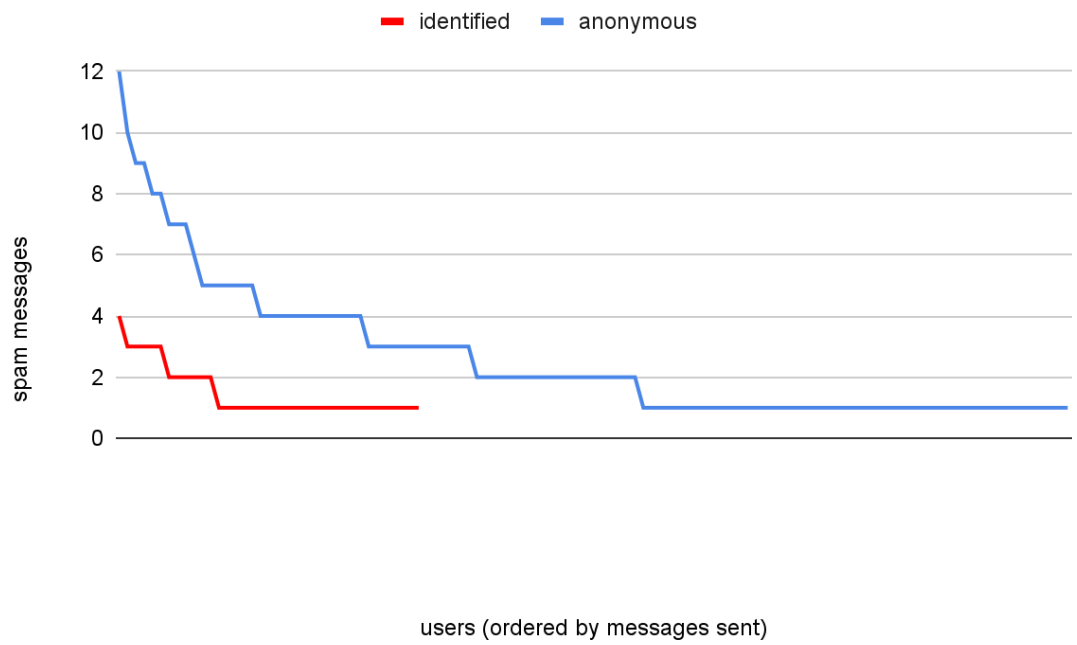


Figure 7.7: Number of spam messages per user in the identified login mode versus the anonymous login mode; users' names and identifiers have been hidden for privacy reasons

c) Comparing students' opinions and behaviours

To answer RQ3, we first analysed the classes and how students' chats had affected their experiences of collaboration and their answers to our questionnaire. Generally, through all classes and tasks and as Figure 7.8 indicates, cognitive activity (the blue palette) was much more abundant than social and emotional activity (the orange palette). We explored whether a class's language could affect its number of messages. Class 1 worked in English (which was not these students' mother tongue), while the other two classes used Spanish (Class 2) and Catalan (Class 3). Most students were Catalan or Spanish native speakers, and they switched languages as needed. The class that worked in English, which could have decreased the number of messages posted, did not significantly differ in the extent of its participation.

To check for the possible influences of the class's language or login modes on participation quantities, we conducted a single-factor analysis of variance (ANOVA) test. This test compared the messages that had been sent by the three classes. The result was a p-value of 0.29, which indicates that language cannot be confirmed as a factor that influenced participation quantities. We also applied another single-factor ANOVA test to check whether a task's teacher significantly influenced the number of messages posted by each class. As we explained before (sections 7.2.b and 7.2.c), all classes completed each task with the same teacher. The result, a p-value of 0, showed that at least one task significantly affected the amount of participation. Then, we performed several hypothesis tests among the classes and found that the differences between the tasks-teachers 1

and 4 affected the participation quantity among students. The final task-teacher, in the anonymous login mode context, triggered an especially large number of spam messages (even after the blank messages were deleted).

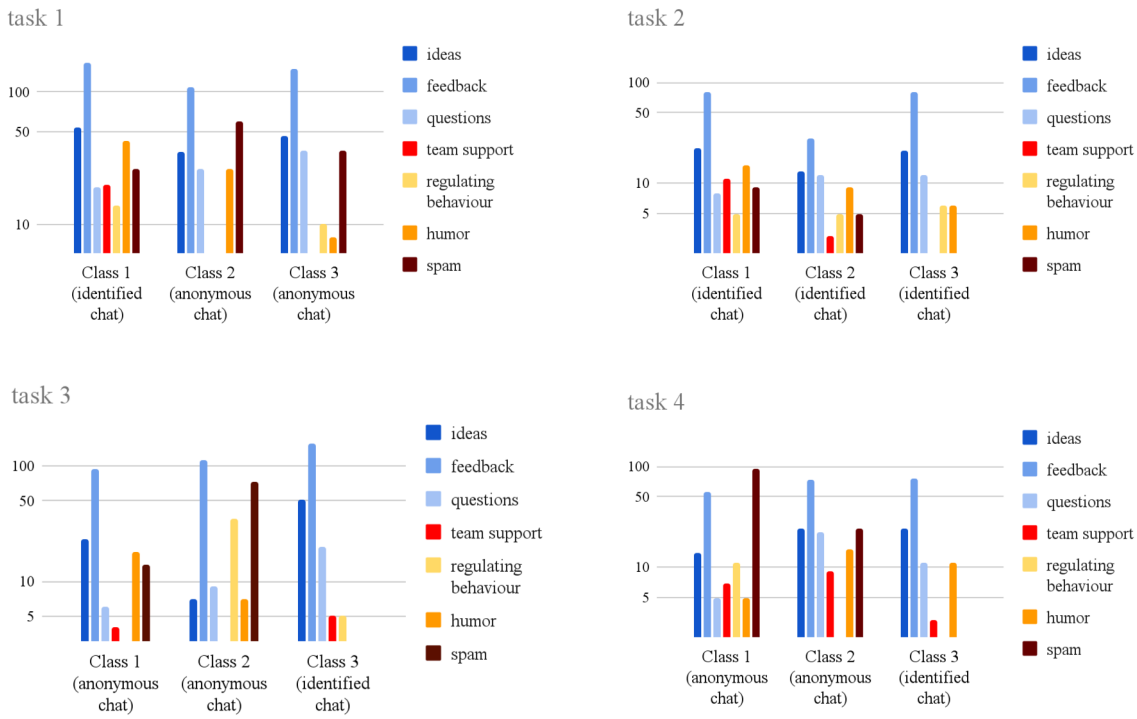


Figure 7.8: Number of messages by class and task; cognitive messages appear in blue shades, and social-emotional messages appear in orange shades

Based on the classes' answers to the post-task questionnaire, we observed (Figure 7.9) that in all classes, the majority of students preferred the anonymous mode (59.4%, 41.0%, and 46.0%, respectively) over the identified mode (18.8%, 17.9%, and 6.0%). Classes 1 and 2 included the most students who preferred the identified mode (light gray in Figure 7.9). This finding can be explained by the fact that classes 1 and 2 also experienced the most spam messages (in total, 144 and 161, respectively; see Figure 7.2). Both classes also showed high percentages (59.4% and 41%, respectively) of students who preferred the anonymous mode. Therefore, classes 1 and 2 were more polarised than Class 3. We hypothesise that the classes with the most spam were more polarised because the people who did not send spam messages preferred the identified login mode because they suffered from the distractions provoked by spam messages, while the students who sent all the spam messages probably preferred the anonymous mode. The majority of Class 3 (46%) preferred the anonymous mode or was indifferent (48%), perhaps because their collaboration was a bit more focused (at least, they posted fewer spam messages).

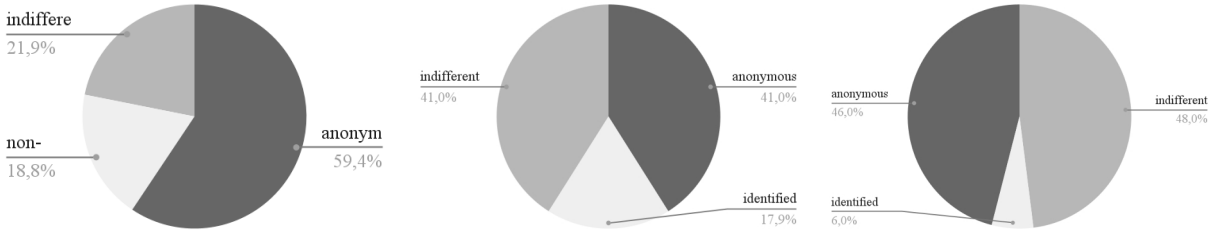


Figure 7.9: Preferences by login mode; legend: anonymous (dark), indifferent (grey), and identified (light) by classes 1 (left), 2 (centre), and 3 (right)

Next, we analysed the students' feedback (from the questionnaire) about this possible explanation. In Figure 7.10, we show the results of our analysis using the answers to questions about students' impressions concerning how their behaviour changed between the identified and anonymous login modes. Classes 2 and 3 provided very similar answers, and most of the time, the students reported equal behaviour in both modes. Class 3 reported more ideas and fewer jokes than Class 2. Class 1 members reported that they had sent many more ideas, feedback messages, questions, and jokes and an equal number of spam messages and criticism, whereas (as we already observed) this class had sent more spam messages than its members reported. Seemingly, spammers do not admit to their behaviour.

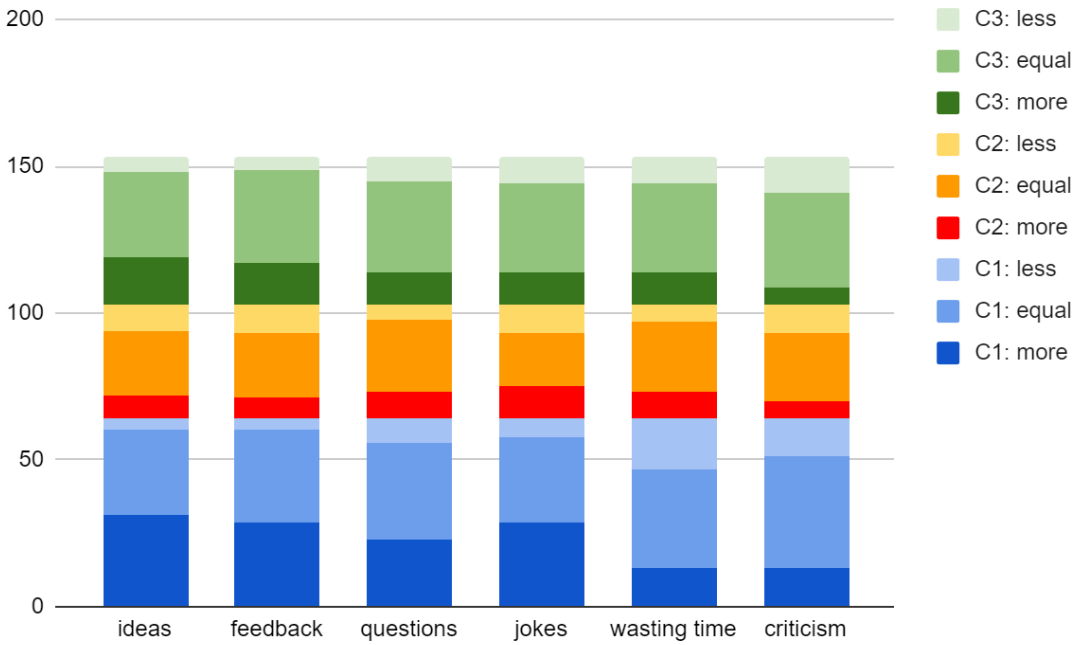
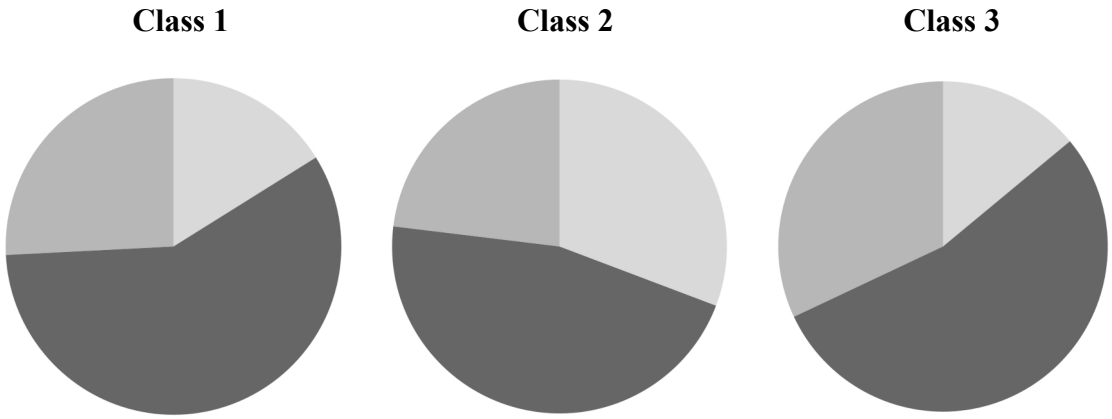


Figure 7.10: Behaviour reported in the post-task questionnaire concerning contributions by message type and class; legend: Class 1 in blue shades, Class 2 in orange shades, and Class 3 in green shades; more in darker shades, less in lighter shades

This hypothesised lack of honesty in spammers' disclosing their behaviour also seems present in Figure 7.11, which shows that the majority of Class 1 indicated that they had not experienced any situation that made them feel especially good or bad, or that they did not know how to answer this question, or that it was not really important. This question was multiple-choice, with options to select "yes," "no," "I do not know or I think it was not important," or "other," the latter of which required text input. This question was followed by an open question that asked students who had answered "yes" to the previous question whether they wanted to describe the situation. This question included examples to illustrate what could have made them feel "especially well or bad." Surprisingly, Class 1's answers to this question were very similar to Class 3's, the group with the least spam and time-wasting messages. When students indicated that they had experienced challenging situations during group collaboration (light grey in Figure 7.11), most of them explained that many people did not work well, or that some group members' behaviour even made others' work more difficult. We could not draw solid conclusions about these results; see the discussion and limitations (sections 7.4 and 7.6) below for possible explanations.

Figure 7.11: Students' answers to the question, "During your tasks/activities, did you experience any challenge that made you feel especially well or bad? (For example, some people worked much more/better than you expected or, on the contrary, didn't work as much as you expected, the group had higher goals than you expected, or your goals were higher than the rest of the members')"; legend: "yes" (light), "no" (dark), "I do not know or I think it wasn't important" (middle shade)



7.4 Discussion

a) What preferences and behaviours related to collaborating in anonymous versus identified login modes did students report?

As we had expected, we observed that the majority of students, after completing the post-task questionnaire, preferred to work in the anonymous collaboration mode. They presented solid reasons supporting this preference: the freedom to express their ideas without consequences from other members or teachers and increased fun. This result is

consistent with previous research (Miyazoe & Anderson, 2011; Roberts & Rajah-Kanagasabai, 2013; Vanderhoven et al., 2015). The students who preferred the anonymous mode thought they contributed more cognitive messages (ideas, feedback, etc.) and better socio-emotional messages (regulating group behaviour, motivation, support, etc.). At the same time, these students claimed they sent fewer spam messages. This finding is consistent with previous research (Panadero et al., 2023). We discuss in the following sections (7.4.c) how these claims do not align with students' usual behaviour.

b) How does the anonymous login mode of the CSCL tool affect students' collaboration in terms of the quantity and quality of their participation versus the identified mode?

Concerning the number of active participants, we did not observe a significant difference; the numbers of students who did not participate were similar for both login modes. In contrast, slightly more messages were sent in the anonymous mode (around 20% higher: 1,390 messages in the identified mode vs. 1,678 in the anonymous mode), mainly due to an increase in the number of spam messages (37 spam messages in the identified mode vs. 311 in the anonymous mode). Generally, according to the type of message sent (i.e., ideas and questions), we can conclude that the quality of collaboration (from a cognitive point of view) was lower in the anonymous mode. We also observed that the number of spam messages increased when the groups became larger during a task's later phases. This finding may have arisen because, when students' accountability is diluted, they have a weaker sense of group cohesiveness. This perspective aligns with a variation of the well-known social loafing effect (Latané et al., 1979), and it is consistent with the first studies on anonymity in CMC (Draft & Legel, 1984) and the notion (from deindividuation theory) that anonymity results in a lack of self-regulation (Spears 2017; Postmes & Spears, 2002).

c) To what extent did students' reports align with their actual behaviour?

The question concerning the extent to which students' reports aligned with their actual behaviour focused on triangulating subjective preferences and actual (objective) actions. Generally, students' statements about anonymity did not align with their actions. Specifically, students did not admit when they had sent more spam messages. In the anonymous mode, a significant number of users seemed to avoid productive participation (Lea et al., 2001, 2007). Consequently, the productive work fell to fewer people. This trend is among the most problematic patterns identified by Strauß and Rummel (2021). Moreover, this finding is consistent with the opinion reported in the post-task questionnaire by the (smaller) group of students who preferred the identified login mode. Overall, our results suggest that students preferred the anonymous mode (or were indifferent to the choice of modes) as long as too many spammers did not participate.

In contrast, as figs. 7.10 and 7.11 show, in the post-task questionnaire, the class with the most spam messages also reported balanced opinions and positive experiences in the anonymous mode. We argue that students considered more factors beyond the observed unproductive behaviour. For example, they may have viewed what we considered unproductive spam messages as a fun approach to social interaction. We recognize that what we call "spam messages" (from a cognitive point of view) need not necessarily be negative and unproductive (from a socio-emotional point of view) since these messages are highly context-dependent (O'Sullivan & Flanagin, 2003). In this regard, recall that fewer than 19% of the students preferred the identified mode after completing all the tasks. Several recent studies have investigated the connection between learning and humour (Vogler et al., 2019). Moreover, the allowance of non-task-related social interaction has been proposed to promote sociability (Abedin et al., 2011), which is known to flourish in non-task-related contexts (Northrup, 2001). Perceived social enjoyment (Muñoz-Carril et al. 2021; Martin & Rimm-Kaufman, 2015) is among the main factors that students find positively influence their perceived learning. Emotional support among members has revealed itself as a solid foundation for positive collaboration (Hernández-Sellés et al., 2019). According to the SIDE model, anonymity involves both cognitive and strategic sides, and based on our study, we posit that it also affords a component of social and emotional enjoyment. As we have shown, in the anonymous login mode, a socio-emotional behaviour emerged (more jokes and more "spam," but also more fun and cohesion among members) that was less likely in the identified mode. This finding is consistent with the observation by Bagustari et al. (2019) that "anonymity has high influence on the aspect of social presence in sharing while anonymity has low influence on the cognitive aspect" (p. 1). This behaviour occurs even without a visual representation of the group or individual members (Kobayashi, 2019).

We regard our deletion of an enormous amount of blank and meaningless messages as a consequence related to AST, combined with a strategic component of SIDE theory (Spears, 2017), since the students made strategic use of the tool that the designers did not intend (sending blank messages to fool teachers and the system by pretending they were participating).

We did not observe a clear pattern regarding group regulatory processes, as deindividuation theory has suggested (Spears, 2017). In both login modes, some messages were aimed at regulating group behaviour and maintaining a good atmosphere, but they were not numerically significant. The number of group-regulation messages increased in the anonymous mode, and we hypothesise that this result was due to the increase in spam messages; the more spam, the more regulation needed. As noted earlier (section 7.4.b), from a cognitive point of view, the quality of the conversations and collaboration was lower in the anonymous mode, and many messages annoyed some users. Sometimes, the annoyed students tried to warn spammers and redirect the conversation. This increase in regulation was not positive, but at the same time, it provided opportunities to further train regulation skills; as Hadwin et al. (2017) have summarised, "challenges pro-

voke opportunities for regulation" (p. 20). The SIDE model also helps explain the distinction between the self's anonymity to a group and the group's anonymity to the self (Spears, 2017).

d) 7.4.4 Implications for future research and practice

For future research, our results suggest that partial anonymity is a condition worth studying. The tension between students' preferences and actual behaviour in the current study indicates that more complex or double-faceted perspectives on student identification must be studied. The first option would be to explore the effects of a student's anonymity to other students but not to their teacher, or vice versa. Alternatively, further research could also explore how technological functions can help avoid unproductive and off-topic messages when participants are anonymous. Our research suggests the following options: (a) a feature to temporarily block unproductive members or (b) a tool to allow participants to rate other group members' messages (i.e., if a message were considered inappropriate or constructive). Like the findings of Hara et al. (2018), our results indicate the need to study an adaptation to the CSCL context of the "anonymity of the self to the group". Scenarios of this kind include students logging into the identified mode by default but having the ability to post certain messages at certain moments anonymously before returning to the identified mode. In alignment with the SIDE model (Spears & Postmes, 2015), we suggest that future research investigate how those different levels of anonymity would be graphically represented in a user interface. Finally, further research should examine gender's effect and the temporal dimension of students' behaviour when contributing off-topic messages. Understanding the temporal pattern (e.g., the concentration of spam messages before or after completing a task) would provide further insights into understanding off-topic behaviour and the design of computer supports to facilitate fruitful conditions for social interaction.

Concerning implications for practice, our research clarifies that applying full anonymity to a CSCL situation does not produce optimal conditions for collaboration despite most students' preferring this login mode. Educators may consider implementing scenarios that allow a level of anonymity between students but identify the students to their teachers (e.g., using codes—instead of names—whose correlations with specific students only teachers know). Under this condition, students would have a safe environment and freedom to share their ideas and difficulties. Additionally, knowing that teachers could trace their messages, students would be prevented from engaging in disturbing spam behaviour. Alternatively, the time available for an activity could be limited to avoid unproductive comments when students have finished a task. This recommendation could be implemented by setting a time limit or monitoring students' progress (e.g., in an analytics dashboard) or asking students to indicate when an activity is completed. Consistent with previous research (Stahl, 2014), we suggest that groups (especially in the anonymous mode) should be small, with four to five members. If a collaborative activity includes different phases to allow students to discuss and refine their answers through

various iterations in increasingly large groups (such as when applying the pyramid collaborative learning flow pattern), these phases should be minimised when using the anonymous mode. When a solution is difficult to improve upon, students stop trying to improve it. Our results show that only a few students are responsible for most spam. Detecting these students early in an activity could help teachers intervene and regulate this situation. More effort could be put, by future researchers, to understand these active disturbers to moderate groups even better.

7.5 Conclusion

The results of this empirical study show that CSCL researchers are still far from able to promote social interaction that optimises the benefits of anonymity claimed by theory and students' preferences. Our study offers new evidence based on an examination of anonymity in a scripted CSCL context from a real classroom situation. A primary conclusion is that studying anonymity is complex, and several perspectives (subjective and objective data) and theories are needed to comprehensively understand the human experience in this context (and how to improve it). Most students prefer the anonymous login mode for the reasons described by the equalisation hypothesis (section 7.1.a). However, we have shown that, due to a minority's misbehaviour (as predicted by deindividuation theory), the remaining students become distracted and must do more work to complete a task. In our study, communication was more productive when students were not anonymous. Students' fooling the system and their teachers while anonymous by sending blank messages, giving the impression that they were participating (a strategic use, according to the SIDE model, that was not predicted or intended by the tool's designers, according to AST) could account for the blank messages we observed in one classes' final tasks.

Continuing to work toward understanding why and how to support different types of login modes is important because most students prefer the anonymous mode even when they experience misbehaviour by whom we have called spammers. Our study and related works (O'Sullivan & Flanagin, 2003) suggest that anonymity allows socio-emotional interaction that, according to their responses, most students enjoyed. We refer to this enjoyment as the social component of SIDE theory.

Further, in light of our results, we have also proposed new experimental avenues to test the design of CSCL systems that facilitate some of the benefits we have identified while minimising the drawbacks. In a learning context, this facilitation includes extending the distinction between the anonymity of the self to a group and the anonymity of the group to the self—for example, permitting students' anonymity among themselves but identifying them to their teachers.

7.6 Limitations

Our study faced some limitations. For instance, Cohen's kappa measures the agreement between coders when they classify items into mutually exclusive categories, but the messages in our study's chat logs were not binary (that is, not mutually exclusive). Therefore, a message could have been assigned more than one category—for example, as both feedback and humour. As we explained when presenting our coding criteria (section 7.2.e), we decided to categorise such mixed messages based on what we understood as their main purpose, but this approach constituted a limitation in our analysis.

Moreover, although the same total number of tasks were completed in the identified and anonymous login modes, Task 2 was only conducted in the identified mode. We wanted an opportunity to check whether we could find any behavioural differences in a task that all groups had performed using the identified mode. Indeed, we found clear evidence that, in the identified mode, students from all classes sent fewer spam messages (see Figure 7.4).

Finally, students' opinions and preferences are subjective, which is important to consider. This paper advances previous research (Davis, 2007; Le et al., 2018; Miyazoe & Anderson, 2011; Vanderhoven et al., 2015) by comparing students' opinions with their behaviour in scripted, synchronous CSCL classroom activities. Studies in several contexts that use different supporting tools are needed to explain these phenomena and how to improve conditions to optimise effective collaboration.

7.7 Acknowledgments

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8 OPTIMISING ANONYMITY IN CSCL: COMPARING COLLABORATION BETWEEN IDENTIFIED AND ANONYMOUS-TO-PEERS LOGIN MODES

This chapter includes the following publication:

Velamazán, M., Santos, P., Sánchez-Reina, J. R. & Hernández-Leo, D. (2023). Optimising anonymity in CSCL: comparing collaboration between identified and anonymous-to-peers login modes. *Under review.*

Most research on anonymity in computer-supported collaborative learning, which has reported both positive and negative outcomes, largely focuses on a fully anonymous login mode. In this context, further research is necessary to optimise the potential benefits of this 'login mode' to promote participation and social interaction. This study tests a subtle variation in this mode by which messages remain anonymous to peers (APM) but not to the teacher. We designed a quasi-experimental study with an analysis of the conversations and preferences of first-year university students (N = 109), conducted by employing content analysis of the log data and a post-task questionnaire . We conclude that APM is more productive in terms of participation and discussion oriented to content than in a completely anonymous mode. Additionally, a content analysis of the discussion messages focused on 'off task' messages, have been performed aiming to enhance comprehension of their nature, impact on social interactions, and the patterns associated with their use. The outcome of this analysis has resulted in a first attempt at a taxonomy.

8.1 Introduction

In this section we analyse different studies about anonymity in CSCL, theories and models describing the effect of anonymity in groups, other studies that have taken into account students' opinion about the anonymous login mode and finally, previous research about promoting social interactions and the role of off-task conversations.

a) Anonymity in CSCL

Promoting social interactions and social presence are key to successful collaboration, although they do not necessarily happen naturally (Järvelä & Hadwin, 2013; Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). A group works well if its social interactions are rich, productive and respectful within a positive atmosphere. However, as previous researchers have observed, these conditions do not arise spontaneously (Muñoz-Carril et al., 2021). Problematic patterns, such as ineffective communication and unequal participation (Strauß & Rummel, 2021), frustrate students and may compel them to reduce their participation. In this context, a favourable attitude towards CSCL, as well as its

perceived usefulness and enjoyment, can influence students' perceived learning (Muñoz-Carril et al., 2021).

Anonymity can facilitate positive social interactions in CSCL because it encourages increased participation across contexts. This is particularly beneficial for individuals who may feel marginalised or intimidated by others (Christopherson, 2007). For example, Hoadley and Linn (2000) designed a learning environment called SpeakEasy, which allows students (eighth graders) to post anonymously or along with their identities in an asynchronous mode. They found that anonymity increased participation and created a collaborative – not competitive – atmosphere (p. 840). Similarly, Howard et al. (2010) found that anonymous students were more likely to offer critical feedback than identified students. Barr (2017) employed the clicker approach to study and understand the effect of anonymity on college students class engagement and participation. The study was conducted by comparing the number of times each student participated in class discussion via clicker or hand raising. It registered a significant difference with 97.9% of students responding when using clickers, while only 9.1% responded via hand-raising. Other studies have also reported the benefits of anonymity in different tasks, such as voting and debating (Ainsworth et al., 2011), peer assessment (Kobayashi, 2020; Lin, 2018; Panadero et al., 2023; Rotsaert et al., 2018; van den Bos & Tan, 2019; Vanderhoven et al., 2015), blended learning with a combination of real and online identities (Miyazoe & Anderson, 2011), writing (Woodrich & Fan, 2017), knowledge sharing in a community of inquiry (Bagustari et al., 2019) and feedback provision (Howard et al., 2010; Panadero & Alqassab, 2019). In contrast to these findings, other authors (O'Sullivan & Flanagin, 2003) have reported that anonymity in CSCL systems may also have a negative impact on social presence, which is the opposite of what it is meant to achieve. Online learning collaboration must have a social dimension, but this is hindered by the absence of non-verbal cues, such as body language, facial expressions and tone of voice (Spears & Lea, 1992). Moreover, anonymity can encourage behaviours that are antisocial and violate norms (O'Sullivan & Flanagin, 2003). In addition, many groups often develop unproductive patterns of collaboration, such as social loafing – that is, the tendency to put less effort into group work compared to working alone (Aggarwal & O'Brien, 2008) – and unequal participation (Strauß & Rummel, 2021). These findings show that the effects of anonymity on students' collaboration and perceptions of collaborative learning in CSCL environments are still unclear. This makes it necessary to delve deeper into the broader theories of anonymity that have tried to describe its influence on human behaviour.

b) General theories about anonymity

Several authors have traced the evolution of research on anonymity (Christoferson, 2007; Sassenberg & Postmes, 2002; Spears, 2017), which started off in the field of social psychology. The initial studies were based on deindividuation theory, which suggests that the members of a group lose their individual identity (Christoferson, 2007).

These studies emphasised the absence of social presence and social cues in computer-mediated communication (CMC), which was considered a medium that reduced group attraction, socio-emotional interactions and regulatory processes, resulting in unproductive behaviour (Christopherson, 2007).

Later theories, such as the equalisation hypothesis and the social identity model of deindividuation effects (SIDE; Christopherson, 2007), provide a more nuanced account of how anonymity influences behaviour in computer-mediated systems. The equalisation hypothesis (Dubrovsky et al., 1991) argues that computer-mediated systems can foster more egalitarian participation due to the lack of social cues, such as indicators of physical appearance, gender, race, age, physical disabilities and attractiveness, in such an environment. This could also benefit students with a lower social status (Postmes & Spears, 2002).

The SIDE model has two components: cognitive and strategic. The strategic aspect relates to the ways in which people use anonymity to achieve their goals and needs. For instance, Flanagin et al. (2002) found that women tend to hide their identity during discussions, while Aggarwal and O'Brien (2008) noted that some people use anonymity to have fun, disrupt or act in antisocial ways, such as indulging in free-riding. Meanwhile, the cognitive aspect (Spears, 2017) of the SIDE model differentiates between how anonymous a person is to a group and how anonymous a group is to a person. The SIDE model presumes that when everyone is anonymous, people think more about the group and feel more connected to it. However, if only one person is anonymous to the group, people will think more about themselves and feel less connected to the group. Consequently, according to the SIDE model, group members will focus on the common goal and avoid personal interests if they are either all identifiable or anonymous to each other (Spears & Lea, 1992).

In a previous study (Velamazán et al., 2023), we compared students' opinions and conversations in 'fully anonymous' and 'identified' login modes in a real educational context to find that although the students consistently preferred working in the anonymous mode, a large number of unproductive messages (random letters, off-topic conversations, etc.) were exchanged in conditions of full anonymity. Interestingly, we also observed that some of these unproductive messages had a positive social component since they promoted social interaction. Nonetheless, a CSCL environment comprises a third actor – the teacher – who can help complement the distinction between anonymity of the self to the group and from the group to the self (as noted by the SIDE model). This forms the context of the primary gap in the literature that this paper seeks to address by testing a distinct condition of anonymity in which all members are anonymous to peers (APM), but not to the teacher. In this research, we hypothesise that anonymity can be fine-tuned to promote participation and social interactions in a real educational context. Notably, the context in this quasi-experiment is the same as that in the previous study (the same subject, classrooms, teachers, students profiles and tasks), except that the stu-

dents differ. Moreover, in the current study another aspect that we changed for the current experiment was tracking individual students in both login modes.

Another theory that can explain this strategic use of technology is the adaptive structuration theory (AST) (Christopherson, 2007), which proposes that people can use technology in two ways: (a) as intended by the designers or (b) for other purposes that emerge from people's interactions with the technology. It is imperative to account for this strategic aspect of technology use to appropriately understand whether anonymity leads to positive or negative outcomes in CSCL groups.

c) Students' opinions about anonymity

Regarding students' opinions about anonymity, some researchers have explored the ways in which students assess their peers in identified or anonymous settings (Vanderhoven et al., 2015). Davis (2007) investigated the influence of task type (in a "next-generation classroom network") on the use of anonymity, as well as whether students' claims about the role and value of anonymity matched their actions, to find that students had different uses and goals for anonymity depending on the type of task. However, she did not analyse the conversations that took place during the students' collaboration. Roberts and Rajah-Kanagasabai (2013) surveyed students' preferences in rating anonymous or identified posts on discussion boards, where the students reported being more likely to post on a discussion board if they could log in anonymously. However, since the boards had been constructed by the researchers, the students did not engage in actual collaboration, as a result of which their natural or authentic behaviour could not be observed. Yep et al. (2023) made an experiment using ClubHouse and the majority of students reported a positive preference for anonymity. Notably, some scholars are already trying to identify the ways in which different levels of anonymity and their representations can foster positive interactions while avoiding the prominent drawbacks of anonymity (Wodzicki et al., 2011; Hara et al., 2018). Therefore, the third research gap that this study addresses pertains to recording students' opinions about their behaviour during CSCL tasks and their reasons for choosing their preferred login mode – aspects that researchers have yet to investigate. This analysis is complemented by verifying whether there is consistency in the students' reported and actual behaviours during their collaborative conversations. Moreover, we extend the prior research on this topic by contrasting students' preferences with their real behaviours when using different login modes, thus obtaining valuable information for creating features and tools suited to students' preferences and needs. For instance, this study aims to comprehend the effect of collaboration on off-topic conversations, the conditions that enhance students' work quality and quantity, and the techniques to reduce the negative aspects of anonymity. As a conclusion, the main objective in this paper is to evaluate (including students' opinions) the influence of conversational/interaction modalities (Identified, IDM vs Anonymized, APM) in a Computer-Supported Collaborative Learning environment.

d) Social interactions

Previous studies have indicated that social interactions in computer-supported collaborative learning (CSCL) environments facilitate more effective participation and learning outcomes (Avry et al., 2020; Borge et al., 2019), while emotional support among members forms a solid foundation for positive collaboration (Hernández-Sellés et al., 2019). Social interactions among group members have been broadly categorised as cognitive and socio-emotional or relational (Barron, 2003; Hod & Ben-Zvi, 2018). Notably, Barron warned about issues that may arise at both levels of interaction, emphasising that within the relational space, 'problematic relational issues did arise, often when one or more members did not display a strong intent to collaborate' (p. 311).

Other authors have categorised interactions more broadly as on-task or off-task. The former refers to knowledge-related actions, such as proposing ideas, asking questions and giving feedback (van Aalst, 2009), while the latter includes actions that are not directed at the epistemic facet of learning tasks, such as greetings, group support and friend-making (Abedin, 2011; Abedin et al., 2011, 2012).

However, the literature offers scarce information about the diverse forms of possible off-task interactions. For instance, Abedin (2011) studied the patterns of off-task interactions, while Vogler et al. (2019) examined the role of humour in CSCL contexts. Moreover, CSCL environments and processes can pose challenges for students who lack self-regulation and self-directed learning skills (Yilmaz et al., 2020). In this context, Muñoz Carril et al. (2021) found that motivation, task engagement, intra-group support and a sense of belonging are the key factors that explain success in task completion and perceived learning satisfaction. Tan and Chen (2022) studied different types of peer feedback in CSCL contexts to conclude that, in particular, affective and supportive feedback facilitated further improvement in the CSCL tasks they analysed. Notably, non-task behaviour can manifest in many ways, from talking about family and friends (Abedin et al., 2011) to 'flaming' (Flanagin et al., 2002, 2014; O'Sullivan & Flanagin, 2003), 'trolling' or 'cyber-bullying' (Jane, 2015). In a previous paper (anonymised) we also observed an important amount of off-task messages. As a result, we consider there is a need to attain a deeper understanding of the influence of off-task messages during collaboration, since there is a major difference between sending a greeting or a motivational message and sending a message containing random letters to deceive the system through fake collaborative participation. Therefore, this is a goal that emerged from these previous studies: to enhance the available understanding of these interactions and propose appropriate categories to classify off-task messages. To the best of our knowledge, this represents a gap in the CSCL literature that this study attempts to address.

e) Research questions

Upon examining the literature presented in the introduction section, we identified the gap that the anonymity to peers –but not to the teacher– (APM) mode has not been su-

fficiently researched and, therefore, we focus this study on its influence on students' behaviour, and on considering students' opinions about it.

More precisely, the present study addressed the following specific research questions:

RQ1: How does anonymity to peers but not to the teacher (APM) benefit group collaboration and participation in the setting of the CSCL activities?

To respond to this question, we hypothesised that group discussions conducted under the Anonymized to Peers Modality (APM) would report higher levels of participation and task productivity compared to the groups interacting under the Identified to Peers Modality (IDM). The hypothesis is supported by Miyazoe and Anderson (2011) who reported that the use of anonymity in online writing tasks increased participation, particularly for students who are reluctant to participate in conventional classroom environments.

We complement the analysis of group interactions with the same analysis but referred to individual students' interactions because this way we obtain precise information about potential findings regarding strong differences in behaviour among individual students. Thus, we formulate the following research question:

RQ2: Which form of online interaction – Anonymous to Peers or Identified to Peers – reports higher levels of collaboration and participation among individual students?

To respond to this question, we hypothesised that in the setting of the APM students would report higher levels of participation and task productivity. This hypothesis tries to complement the criteria provided in the aforementioned study (Miyazoe & Anderson, 2011) with the analysis of individual students' rates of participation, discussion productivity and discussion orientation in authentic tasks.

RQ3. Which modality of collaboration (APM or IDM) would students adopt after conducting a series of tasks within the CSCL platform?

To respond to this question, the study hypothesised that after interacting with both forms of collaboration, students would perceive APM as a more productive mode of collaboration. The hypothesis is supported in the findings provided by Roberts and Rajah-Kanagasabai (2013) who found that students post significantly less on discussion boards requiring identification.

RQ4: When are off-task messages most frequent, and what purposes do they serve?

The negative side of anonymity that we are trying to optimise in this paper is basically, unproductive, off-task messages. We observed that not all off-task messages are disturbing and unproductive depending on the moment of use and the intention of them. For example, off-task messages that are interchanged to meet or make plans after the task is finished should not be considered disturbing. To answer this question we will analyse the conversations of the students who sent the biggest amount of off-task messages tr-

ying to find patterns of when these messages are produced and what is the purpose of those messages.

8.2 Materials and methods

a) Study design and sample

The present study aimed to analyse the implications of anonymous interactions in the setting of a CSCL platform. We designed a quasi-experimental study where participants utilised the PyramidApp CSCL environment during regular classroom sessions. The study was structured as a within-subject design, with each participant testing two forms of online interaction: Anonymized to Peers and Identified modalities (ADM and IDM). The study took place during four lessons in the "Introduction to Information and Communication Technologies" course within the Engineering degree program at a Public University in Spain. The sample comprised a total of 109 students who participated in the experiment in separate groups, naturally formed as class sections (T1, N= 58; T2, N= 25; T3, N= 26). The participants' age ranged from 18 to 24 years old, with the sample distributed as N = 76 (69.72%) male, N = 31 (28.4%) female students and N = 2 (1.83%) prefer not to respond to the gender question.

As part of the study design, we collected the data generated in four online activities, also known as Tasks in the context of the PyramidApp CSCL environment. The learning tasks were not specifically designed for this study, but part of an ordinary teaching practice. This decision contributed to collecting students' authentic/genuine data and online behaviour. The tasks were led by four different professors. While one professor led two of the tasks, the other two were led by two different teachers. Figure 8.1 exhibits the study design, including the distribution of the online tasks and discussion group formation.

Notably, this study uses the term 'class' to refer to the whole class group, while the term 'group' is used to refer to the smaller units created by the PyramidApp CSCL environment.

The students signed a consent checkbox that included information on how their private data would be used (anonymised and used only for research purposes) and the research purposes of the study (to obtain knowledge about their behaviour during a collaboration activity in which online tasks would be conducted in different login modes). Furthermore, the PyramidApp CSCL environment provided another checkbox pertaining to the acceptance criteria to participate in the experiment.

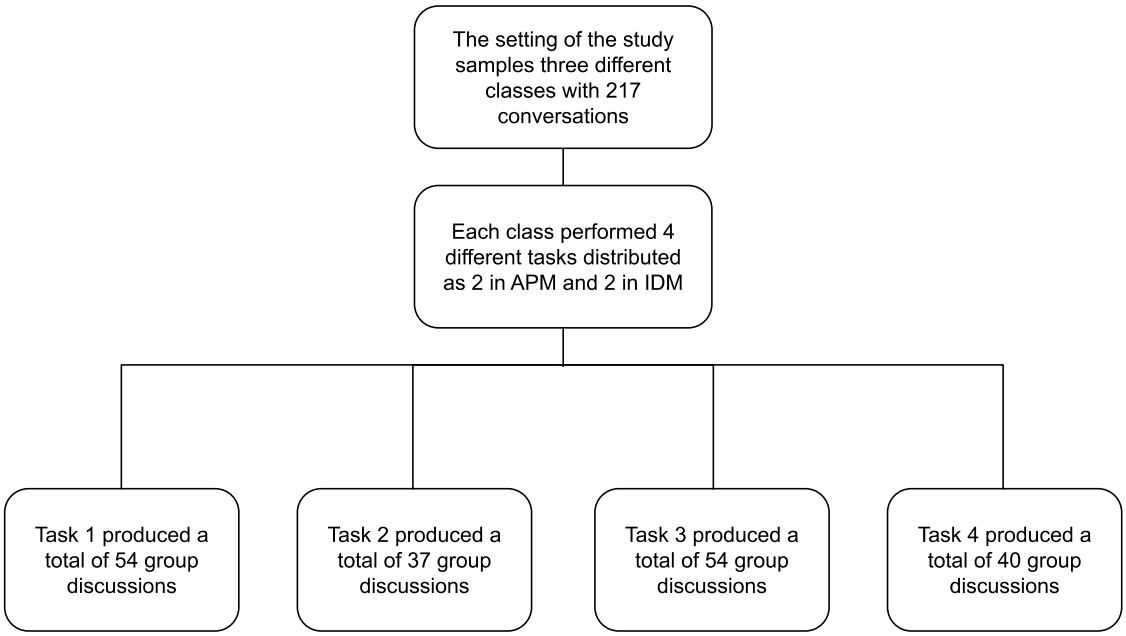

Figure 8.1: The diagram displays the structure of the study design, observing the distribution of the tasks and the participation modality.

b) Procedure

The PyramidApp CSCL environment is an online platform that allows teachers to create and conduct tasks following the collaborative learning flow pattern (CLFP) (Manathunga & Hernández-Leo, 2018). The tool comprises two components: an authoring tool for teachers to design pyramid activities and an enactment tool for students to participate in online discussions. Through the students' interface, participants can submit their individual answers, rate their peers' responses, and initiate discussions in small chat groups (Figure 8.2).

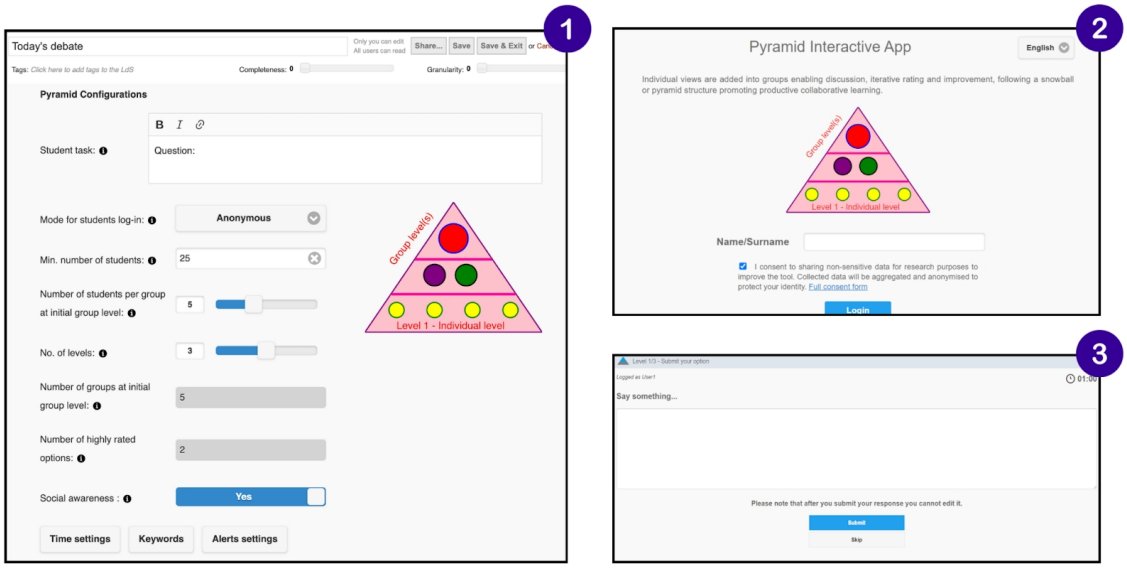

Figure 8.2: PyramidApp CSCL environment: Teachers' Design and Students' Submission Interfaces. This figure displays screenshots from the interfaces. Image 1 displays the authoring tool for teachers. Images 2 and 3 show the login and submission screens for students.

The PyramidApp promotes collaboration through the development of reflection and discussion. It combines the individual contributions of students answering an initial triggering question and the collaborative work of the class to improve the provided answers until reaching a consensus or proposing a new collaborative answer. One particular feature of the PyramidApp environment is the separation of participant students in the task in small discussion groups similar to chat rooms (Figure 8.3). Each of the chat rooms provides a group of students with a list of suggested responses for them to discuss the most complete answer or provide a better quality answer. To achieve this goal, students are invited to discuss the different contributions during a set of time and (re)elaborate their final decision in a text editor. In the context of the present study, 185 chat rooms were considered units of observation and they were distributed in Anonymized and Identified chat modalities (ADM and IDM).

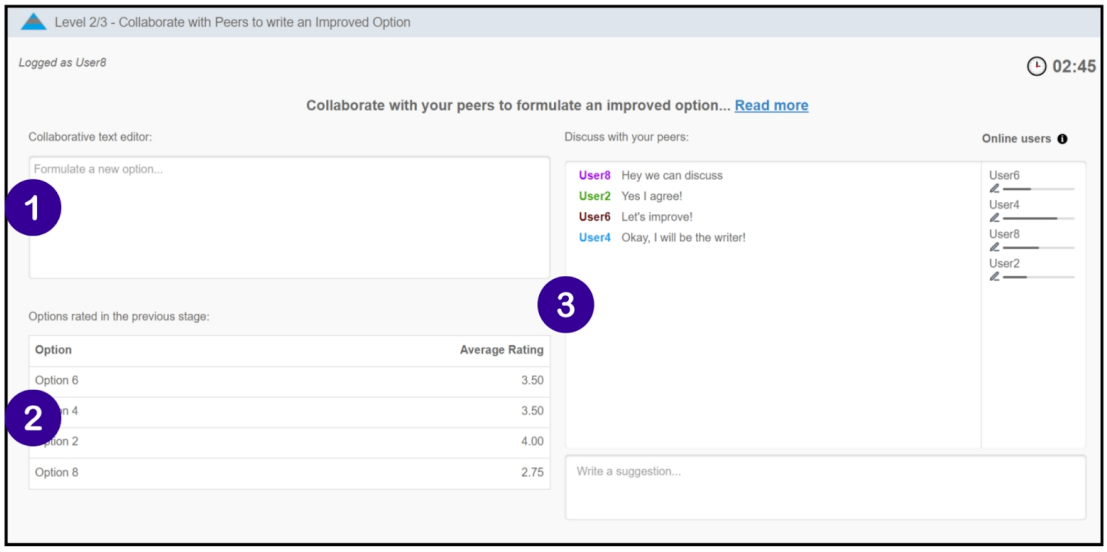

Figure 8.3: PyramidApp CSCL environment: Group Discussion (Chat Room) Interface. This figure displays screenshots from the chatroom in the setting of the CSCL environment. The interface features (1) a collaborative text editor; (2) a list of initial submissions for the group to discuss and create or improve a collaborative answer; (3) a chatroom to discuss with members of the class who have been allocated randomly.

The teachers provided the students with information about the two available login modes and which of them had to be chosen for each session and task. This information was explicitly provided to the students to ensure clarity regarding the difference between the two login conditions. While the IDM displayed the name of the students to the rest of the members of the group, the APM showed a user number, the details of which were known only to the teachers.

The students were informed that the teachers could track the authors of the different messages. Notably, the user numbers remained the same throughout the tasks and lectures. The tool created the groups randomly, but the teachers decided on the number of members to be included in each group (4–6). To familiarise the students with the CSCL tool, a trial task was conducted after providing them with a brief explanation of the system. The four tasks were completed on four non-consecutive days, with all students working in both modes during the course of the tasks. In practice, each group used a language based on the team members' preferences. Six tasks were performed in the IDM and six in the APM.

To avoid interference with class dynamics and ensure sufficient experience in using both login modes, the sequence of login modes was established making sure that all students in each class had the same number of login modes.

The students first provided an individual answer to the task, after which the tool created the groups. Following this, the individual proposals were rated by the rest of the members using a feature offered by the CSCL tool. The members, each of whom was now part of a group, had to collaborate to try to improve the first individual's answers by arriving at a new consensus solution. Therefore, through the system, the students could

discuss their answers in view of the aggregated rating and work together to write an improved answer to the task. Ultimately, the following tasks were proposed:

- Task 1 (Teacher 1): 'Education is a key aspect of social development and a great engine for levelling inequalities, especially by providing ample opportunities for collective development (culturally, socially, developing democracy, etc.). Studies indicate that quality and inclusive education is a critical factor in the development of a prosperous and diverse society. As engineering students, you may have ideas about how technology will evolve in the future. Imagine that, in the future, your job is to advise the Commissioner of Education of the European Union. How do you think technological evolution can improve our society through education? Do you think AI can harm it in any way? Indicate a maximum of three positive and three negative aspects.'
- Task 2 (Teacher 2): 'What surprised you most about what you learned in the content covered in the previous three class sessions? Why?'
- Task 3 (Teacher 1): 'What is considered plagiarism and why is it important to know about it in university?'
- Task 4 (Teacher 3): 'Read the given case study carefully and identify two ethical principles that can be observed in the particular case'.

The duration of each collaborative task, as defined by each teacher, was as follows: Task 1: 11 minutes, Task 2: 4 minutes, Task 3: 7 minutes and Task 4: 11 minutes. The average was 8.25 minutes.

c) Instruments and measurement

The study approach combined the measurement of objective and subjective measures to provide a better understanding of the implications of anonymity within CSCL activities. The objective measurements (for answering RQ1 and RQ2) were obtained from the data logs of the CSCL environment and were useful in understanding group and individual interactions in the group discussions (Chat Rooms). The subjective measurements involved a questionnaire (for RQ3) to capture perceptions of students' behaviour (both their own and their peers') when interacting under the anonymous modality. The process for data extraction and dataset creation will be explained in the forthcoming section. For RQ4 we looked for the most active students sending off-task messages and analysed their conversations to do a content analysis of them and obtain patterns that would describe a proposal for a taxonomy of off-task messages.

The conversation logs

The variables and indicators for each measurement are described as follows:

Measurement of Group Interaction: In order to analyse the implications of APM and IDM in group interaction three variables were proposed and measured according to prior research:

- *Communication Production*: Building on previous studies in the context of CSCL (Amichai-Hamburger et al., 2016), this variable was defined as students' participation in the group discussion. It was observed through students' interactions within the chat room and quantified as the number of computed messages. The average number of computed messages in overall group discussions was M = $18.07_{messages}$, with a standard deviation of SD = 12.58.
- *Productivity in Discussion*: According to Pellegrino (2017), the aims of learning are mainly directed at cognitive goals; motivational goals; and social goals. They state that the cognitive goals are task and/or subject matter oriented (e.g., cognitive process, knowledge, skills); the motivational goals include attitudes, beliefs, self-efficacy, and so on; and the social dimension includes peer interactions, team support, and so forth. Thus, this variable distinguishes the total messages produced in the group discussion from instances oriented towards collaboration; messages focused on the task and aimed at achieving the outcome. The measurement of the variable included the quantification of messages proposing ideas, providing feedback, adding clarifications, and offering support and motivation to members of the group to complete the task. The average number of messages classified as productive in the group discussion was M = $14.85_{messages}$, with a standard deviation of SD = 10.18.
- *Orientation of the Discussion*: We followed Strijbos (2011) recommendations based on what he calls Group Experience. Strijbos observed that when evaluating CSCL processes, it's particularly interesting to notice that the process encompasses not just cognitive aspects, but also social and motivational elements. Thus, this variable classified the messages produced in the chat discussions into two categories: Oriented to Content (OC) and Oriented to Socialization (CS). The orientation of the messages was determined through content analysis conducted by the first authors, following the coding criteria specified in section 8.2.d. The average number of OC messages in the group discussion was M = $13.86_{messages}$ (SD = 9.40), while the average number of CS messages was M = $4.20_{messages}$ (SD = 5.55).

We also analyse individual students' interactions because doing so provides us with information about possible significant differences in behaviour among individual students. Therefore we also analysed:

Measurement of Students' Interaction: To assess the performance of students in both login modes, we conducted an analysis of the data generated by students in each modality (APM and IDM). To discern differences between APM and IDM, we analysed the aforementioned variables within the context of individual practice.

- *Communication Production*: This variable registered the number of messages produced by the individual students in each of the conversation modalities. The average number of messages produced by each student was M = 10.42 $_{messages}$ (SD = 6.59) in the APM and M = 9.15 (SD = 5.68) in the IDM.
- *Productivity in Discussion*: Similar to the analysis of group discussion, the variable extracted from the total number of messages, the number interventions oriented to collaborate in the task and its outcome. The average number of messages produced by each student and oriented to the task was M = 9.27 $_{messages}$ (SD = 6.02) in the APM and M = 7.88 $_{messages}$ (SD = 4.91) in the IDM.
- *Orientation to Discussion*: The interventions produced by each student, classified according to the coding criteria (section 8.2.d), reported an average number M = 7.80 (SD = 5.16) for Oriented to Content messages in the APM and M = 6.80 $_{messages}$ (SD = 4.05) in the IDM. Regarding Oriented to Socialization messages, students reported an average of M = 2.63 $_{messages}$ (SD = 3.27) in the APM and M = 2.33 $_{messages}$ (SD = 2.62) in the IDM.

The questionnaire

Upon completion of all tasks, an ad-hoc post-questionnaire was answered by 109 students. We chose to include as few questions as possible to avoid tiring the students, which would have discouraged them from providing answers. Furthermore, we tried to use clear language and provided sufficient examples and descriptions to ensure that the students had properly understood the questions.

The questions were designed based on related literature to answer the research questions. Since the aim was to compare the students' answers to the questionnaire with their behaviour, as observed from the chat logs, previous research was consulted to code the cognitive and socio-emotional messages (Van Aalst, 2009; Järvenoja et al., 2017). More details regarding this categorisation are provided in the next section.

After selecting their gender from the "male", "female" and "prefer not to specify" options (see question one in Table 8.1), the second question asked the students about their preferred login modes in order to start answering RQ3. This question was accompanied by a brief explanation that reminded the students of the differences between the modes, after which the students had to select one item from a list of radio buttons. The third question enquired about the students' personal behaviour in the APM compared to the IDM – whether they had posted more, an equal number or fewer messages related to the cognitive and socio-emotional categories. Notably, the subdivisions in Questions 3 and 5 are based on previous works by Van Aalst (2009) for the cognitive categories and by Järvenoja et al. (2017) for the socio-emotional categories. Question 4 was also designed in accordance with the analysis conducted by Järvenoja et al. (2017) to identify reasons for the students' behaviour and emotional states. Question 5 asked the students the same

question as Question 3, but regarding the behaviour of their team members (as opposed to their personal behaviour).

Table 8.1: Post-task questionnaire questions

1. Please tell us your gender.	Male/female/prefer not to specify	
2. Anonymous to peers versus identified – Which login mode do you prefer for collaboration activities?	Anonymous to peers/Identified/Indifferent	
2.1 Why?	Open text field	
NOTE FOR THE READER, students did not see these categories	Cognitive posts	Socio-emotional posts
3*. When working in anonymous mode, did you share more/equal/less…	Ideas? Feedback? Questions/ doubts?	Humour/jokes? Wasting time? Regulating group behaviour?
4. With regard to the cases in which you worked differently, why do you think you did so?	Open text field	
5*. In general, do you think THE OTHER members of your group participated differently when they were in anonymous mode compared to their peers? Specifically, answer if you think they shared more, less or the same...	Ideas? Feedback? Questions/ doubts?	Humour/jokes? Wasting time? Regulating group behaviour?
6. During your tasks/activities, did you experience any unusual situations that made you feel especially good or bad? (For example, some people worked much harder/better than you expected or, on the contrary, they did not work as much as you expected; the group had higher goals than you expected or your goals were higher than the rest of the members on the team.)	Yes / No / I do not know or I think it was not important /another (open text field)	
7. If so, can you give us an example?	Open text field	

Footnote*: These questions were a matrix of radio buttons. The rows were dedicated to the different types of messages (Idea, humour, etc.) while the columns contained the amount (more, equal, less). In each corresponding cell of this table there was a radio button for students to select if they thought they had sent more/equal/less types of messages.

In order to know the students' perception and experience (to complement Strijbos' view of Group Experience) during both login modes, we defined the following variables:

Measurement of Students' Behavioural Perception: Due to the novelty of this login mode, we could not find previous validated questionnaires. Thus, to measure students' perception of anonymized collaboration and preference on interaction modality, an ad-hoc questionnaire was designed. The measurement involved the data of participants who tried both modalities of participation (APM and IDM) and who successfully completed a self-report questionnaire. The measured variables included:

- Preference on Login Modality Interaction (question 2): This variable measured the preferred modality among the participants to conduct the CSCL activity. It included three categories and the results reported 38.4% of participants preferring the APM, 22,2% opting for the IDM, and 39.4% choosing either way.
- Students' perception of their own behaviour in the Anonymized Modality (question 3): This variable included the measurement of students' perceptions of their performance while completing the CSCL tasks. Similar to the analysis of the messages produced, the variable was categorised considering assessment of their personal contributions in the chat room and saw the Oriented to Content and Oriented to Socialization categories. The measurement included a list of 8 items (See Table 8.1) measured in a 3-point likert scale (1 Less - 2 Equal - 3 More).
- Students' perception of peers' behaviour in the Anonymized Modality (question 5): Similar to the previous variable, this variable was measured according to students' perceptions but registered the perceived peers' interaction. It therefore involved the same measurement system. The reported preferences and the obtained values can be seen in Table 8.2.

Table 8.2: Report of students' perceptions of their own and peer behaviour when interacting with APM

When working in anonymous mode, did you share more/equal/less…?	Mean	SD	When working in anonymous mode do you think your peers shared more, equal or less …?	Mean	SD
SP. Ideas and proposals	2.17	.475	PA. Ideas and proposals	2.12	.643
SP. Feedback and Answers	2.12	.540	PA. Feedback and Answers	2.08	.680
SP. Questions and Doubts	2.12	5.76	PA. Questions and Doubts	2.01	.692
SP. Jokes	1.98	.589	PA. Jokes	2.05	.734
SP. Regulation of Group Behavior	2.00	.495	PA. Regulation of Group Behavior	1.94	.603
SP. Off-tasks Messages	1.84	.548	PA. Off-tasks Messages	1.93	.718

Footnote: The table displays the items for the measurement of the self-perceived behaviour (SP) and the Peer Assessment (PA) when interacting in the APM. The values of scale have been converted and reported as the mean values.

d) Coding criteria

A research assistant and the main author conducted a first round of analysis on 25% of the messages, following the process recommended by Armstrong et al. (2020). After a few discussions on disagreements and misunderstandings between the two, a second round of analysis was carried out, ultimately achieving Cohen's kappa inter-rater agreement of 0.85.

As explained below, the distinct categories were adopted from previous studies conducted by Van Aalst (2009) for the cognitive categories and by Järvenoja et al. (2017) for the socio-emotional categories. Moreover, in the previous study a few changes were implemented to the original categories, as explained below, and those same categories were retained in this study for comparison.

Content/cognitive categories

To analyse students' behaviour, the system logs from the PyramidApp CSCL environment were counted (to check the amount of participation) and the messages were classified (to study the quality of participation) according to the categories noted above. The categories to code the conversations (and to compare them with the students' opinions about their behaviour) were filtered according to previous research. In Vân Aalst's (2009) analysis of how students' dialogues relate to their behaviour in CSCL contexts, the researcher developed a detailed description of the asynchronous computer-mediated discourse required for the knowledge-creation model proposed by Bereiter and Scarda-

malia. Consequently, three modes of discourse were identified: knowledge sharing, knowledge construction and knowledge creation. Furthermore, Vân Aalst (2009) proposed a coding scheme for examining asynchronous discourse, building on previous schemes that focused on the socio-cognitive aspects of online discourse as well as CSCL based on prior work on rating scales related to levels of questioning and explanations. The researcher argued that the main codes – 'ideas', 'questions', 'information' and 'community' – could be used as the general framework for coding to enable comparisons across studies on CSCL. The current study adopted the first three codes, while the 'community' code was specified under the socio-emotional category.

Thus, the coding criteria can be described as follows:

- Ideas/proposals: a message that represents any kind of initiative to solve, push forward, iterate or offer a solution to improve or solve a task, or that displays some kind of planning or a strategy to continue a task. Ideas/proposals may sometimes be implicit. The following message from a user can be considered a typical example of an idea/proposal: "We can add the homeschooling topic that the other opinions suggest"
- Feedback/answers: messages that refer to any type of dis/agreement with another message, typically an idea or a proposal. If a message appears to be an idea, but is actually just the confirmation of a previous idea, it is considered feedback. Furthermore, messages that explain something and answer a question or doubt can be considered feedback. For instance, the following message is feedback: "OK, I'll add it"
- Questions/doubts: messages that request any kind of clarification, ask for an opinion or point to a lack of information, precision or any kind of misunderstanding. In this context, it should be noted that some ideas/proposals, especially polite ones, may sometimes be formulated as a question, but should be coded as an idea/proposal. Furthermore, an open question should be coded as a question. The following is an example of a message coded as a question/doubt: "Do you agree?"

Socio-emotional categories

For the socio-emotional categories, this study drew on the analysis conducted by Järvenoja et al. (2017), where interactions were coded as socio-emotional when they involved talking about feelings or motivation (for example, expressing how students felt about the task, praised themselves or discussed the value and progress of a task) or exhibited a significant positive or negative emotion (for example, laughing, cheering, expressing frustration, making jokes or reacting emotionally to an outcome) that elicited a response from another group member. The researchers further explained that a socio-emotional interaction segment could also include motivation or emotion regulation, which refers to a suggestion of a challenge, such as low ability or negative emotion, or a clear challen-

ge, such as being distracted from the task, followed by a response trying to address the challenge. Therefore, motivation regulation was coded as a socio-emotional interaction segment when the group members' conversation contained utterances aimed at increasing motivation in the group. Following Järvenoja et al. (2017), this study selected some of their subcategories to code socio-emotional interactions. For example, the 'motivation' and support subcategory inspired the 'support' category in this study, while the 'positive emotions' segment was coded 'humour'. Furthermore, Järvenoja et al. (2017) coded challenges such as 'off-task behaviour', which relates to the 'off-task' category in this study. Finally, this study also included the researchers' 'regulating group behaviour' category as 'regulation of behaviour' (to also include self-regulation in the analysis). Therefore, the subcategories considered in this study are as follows:

- Humour/jokes: messages that try to make others laugh but do not disturb or distract from the content of the topic of conversation. They usually create a better atmosphere and/or ease tense situations, although such messages can sometimes be negative but fun. In general, these were messages in which students made explicit that they were laughing ("Hahahaha") or in which they were commenting something referring to the task but in a humorous way ("we can not perfect perfection").
- Support motivation: messages in support of the team that uphold a good atmosphere (motivation) and provide very positive feedback (not just 'ok'). For example: "great men"
- Regulation of group behaviour: messages about group regulation and time management or those that praise other members' suggestions. The following is an example of support/motivation/regulation: "bro, 3 minutes".
- Off-task messages: comments that are not particularly aimed at fulfilling a task or maintaining a good atmosphere in the group. Notably, greetings were not considered part of this off-task category. For instance: "I send you poems written by my hand"
- Greetings: this includes all kinds of hello, good bye, welcome or farewell messages.

Furthermore, the following kinds of messages were not coded:

- Messages about errors and mistakes in the CSCL system. For example, a message replying to a user complaining about not being able to write using the tool was not coded.
- If the meaning of a message cannot be inferred. For example, if a message was probably a typing error or an error related to sending a message before finishing a sentence, such as in "ª" or "ñe".

- In general, we coded each message because the majority of them were meaningful utterances, but if one sentence was broken into several messages it was coded as one message.

e) Data analysis

Once the data collection was completed, we proceeded to the creation of two datasets. The first dataset condensed the collected data logs from the CSCL environment and registered the group chat conversations as the minimal units of analysis. This resulted in 217 conversations (See Figure 8.1). To include a chat conversation as part of the analysis, it was necessary to meet as criteria of analysis: a) the implication of at least two conversational agents (participant students) and b) the exchanges of messages between the agents. The second dataset compiled the data reported by students in the questionnaire and the logs of individual interactions extracted from the CSCL environment. An alphanumeric code reported in the questionnaire and the CSCL task allowed the unification of both anonymous and identified data. After the data merging and its verification (e.g, students completing both the tasks and questionnaire), the sample of analysis was set in 109 students.

The data analysis strategy involved a two step analysis for the hypothesis testing. The first stage of analysis involved a descriptive statistical review of the variables for the groups APM and IDM. We calculated and compared percentages, averages, and standard deviations for both APM and identified conditions. The analysis also incorporated normality tests to examine the distribution of variables. The second stage employed parametric statistical analyses for hypothesis testing: independent t-tests to evaluate the relationship between participation and collaboration in APM and IDM groups; paired t-tests to compare the performance of individual students when interacting with APM and IDM. Moreover several chi square tests aided to evaluate students' perception of online behaviour when interacting with the anonymous modality.

8.3 Results

This section presents the results of the study, arranged in terms of each of the research questions.

a) Participation and Collaboration in Group Discussions (RQ1)

Overall findings indicate that group discussions that interacted with APM reported higher levels of participation and collaboration (Figure 8.4). Concerning the Communication Production within the groups, the results showed that the APM had higher values ($M = 20.38$, $SD = 15.63$) compared to the IDM groups ($M = 15.69$, $SD = 7.75$). An independent t-test revealed significant differences in both modalities of interaction ($t(135.69) = 2.58$, $p = .005$) with a small effect size ($d = 0.38$). When observing the Pro-

ductivity in Discussion, the analysis showed a similar pattern, reporting statistically significant differences in the mean values of APM (M = 16.69, SD = 12.59) and IDM (M = 12.99, SD = 6.42) conditions; t(137.85) = 2.52, p = .007, d = 0.37. Regarding the Conversation Focus, Orientated to Content interventions in the APM groups reported higher values (M = 15.59, SD = 11.6) than the IDM groups (M = 12.08, SD = 5.94), and statistically significant differences were observed (t(138.14) = 2.59, p = .005, d = 0.38). Compared to Oriented to Content interventions, the focus on Socialization reported smaller mean values. In this vein, although the APM group had higher values compared to the IDM groups, there was no statistically significant difference (t(147.69) = 1.42, p = .079, d = 0.21).

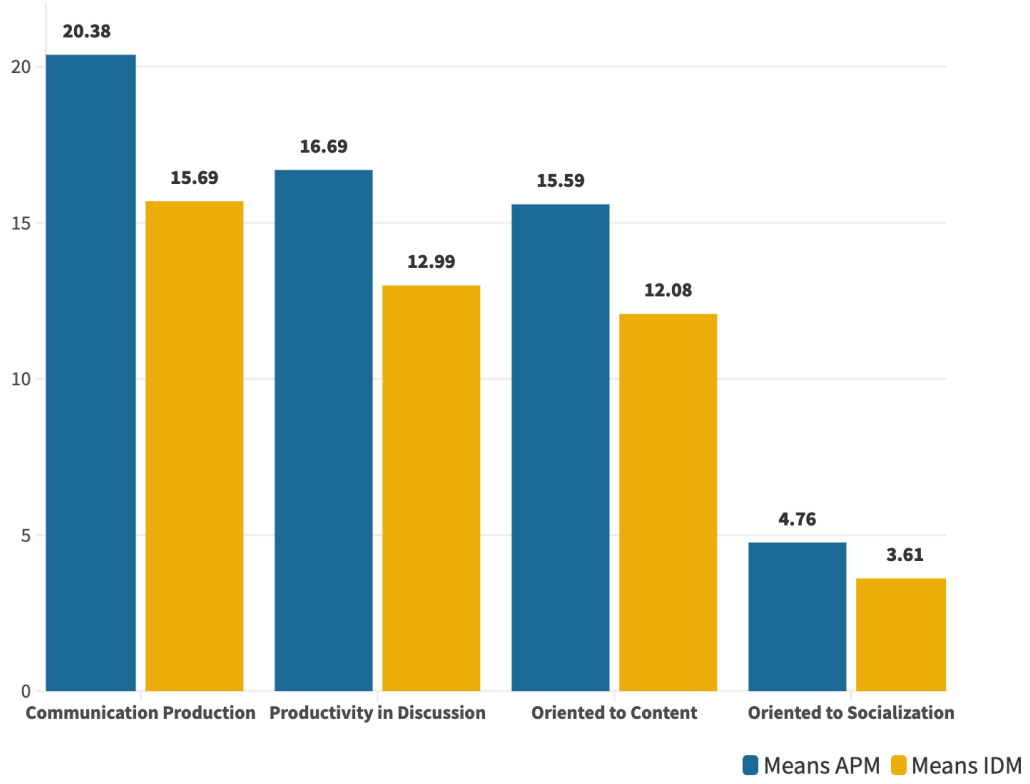

Figure 8.4: Mean values for participation and collaboration in group discussions observed by interaction modality.

A detailed analysis of the focus of interventions revealed that APM groups showed significantly higher engagement in categories such as Sharing Ideas & Proposal, Offering Feedback, Solving Question, and Group Regulation. The differences in mean values were supported by statistically significant t-tests in these categories, indicating a meaningful distinction between APM and IDM groups in these aspects. Other categories, including Giving Support, Making Jokes, Sending Off-Tasks Messages, and Greetings, did not show significant differences between the two groups. Table 8.3 summarises the statistical analysis for these intervention categories.

Table 8.3: Intervention categories in group discussions.

	APM		IDM				
	Mean	**SD**	**Mean**	**SD**	**t**	**p value**	**d**
OC. Sharing Ideas & Proposals	3.78	3.49	3.02	2.12	1.79	0.038	0.26
OC. Offering Feedback	9.42	7.22	7.39	4.03	2.358	0.01	0.35
OC. Solving Questions & Doubts	2.38	2.32	1.66	1.43	2.528	0.006	0.37
OS. Giving Support	0.17	0.564	0.11	0.43	0.82	0.207	0.12
OS. Making Jokes	0.4	1.11	0.54	1.04	-0.916	0.181	0.14
OS. Regulating Group Behavior	0.53	1.28	0.26	0.68	1.797	0.037	0.26
OS. Sending Off-tasks Messages	1.23	4.58	0.42	1.75	1.595	0.057	0.23
OS. Greeting	2.44	3.15	2.28	2.23	0.405	0.343	0.06

b) Students' Participation and Collaboration: Anonymous vs Identified Modality (RQ2)

Concerning the assessment of students' participation and collaboration in APM and IDM tasks, the analysis showed that when logged in as anonymous, students consistently reported higher mean values in Communication Production, Productivity in Discussion, and interventions Oriented to Content. As observed in Table 8.4, these differences were statistically significant. Similarly, although students logged in as anonymous reported higher mean value in Oriented to Socialization interactions (APM: M = 2.63 SD = 3.28; IDM: M = 2.33, SD = 2.62) no statistically significant difference between the two modes was observed.

When observing in detail the types of interventions performed by students (Table 8.5), the descriptive analysis revealed differences in Oriented to Content interactions between groups, with APM reporting higher mean values. However, there were no statistically significant differences. Regarding Oriented to Socialization interventions, only two types of interventions showed significant differences, with APM groups reporting lower mean values in Making Jokes and higher mean values in Sending Off-tasks Messages. Other interventions did not exhibit statistically significant differences.

Table 8.4: Students' participation and collaboration: APM vs IDM.

	Media	Mean	SD	t	gl	p value one-tailed
Communication Production	APM	10.42	6.60	1.83	98	0.035
	IDM	9.15	5.69			
Productivity in Discussion	APM	9.27	6.02	2.195	98	0.015
	IDM	7.88	4.92			
Oriented to Content	APM	7.8	5.17	2.063	98	0.021
	IDM	6.82	4.05			
Oriented to Socialization	APM	2.63	3.28	0.717	98	0.238
	IDM	2.33	2.62			

Table 8.5: Intervention categories observed by students' interactions: ADM vs IDM.

	Media	Mean	SD	t	gl	p value
OC. Sharing Ideas & Proposals	APM	1.92	1.90	0.937	96	0.176
	IDM	1.74	1.67			
OC. Offering Feedback	APM	4.75	3.36	1.335	96	0.092
	IDM	4.28	2.60			
OC. Solving Questions & Doubts	APM	1.11	1.31	1.087	96	0.14
	IDM	0.94	1.27			
OS. Making Jokes	APM	0.15	0.46	-3.196	96	<.001
	IDM	0.47	0.90			
OS. Giving Support	APM	0.09	0.33	0.207	96	0.418
	IDM	0.08	0.34			
OS. Regulating Group Behavior	APM	0.22	0.65	0.35	96	0.364
	IDM	0.19	0.53			
OS. Sending Off-Tasks Messages	APM	0.93	2.50	2.016	96	0.023
	IDM	0.34	1.29			
OS. Greeting	APM	1.14	1.28	-1.098	96	0.137
	IDM	1.3	1.33			

c) Students' perception of online behaviour

The analysis of students' perceptions showed that the APM modality was preferred over the IDM modality (N = 38, 38.4%; N = 22, 22%, respectively). Interestingly, over a third of the participants agreed to prefer either mode of participation (N = 39, 39.4%).

Table 8.6 summarises the statistical analysis for students' perception of online behaviour (Self-Assessment and Peer Assessment) according to their preferred login modality. A significant number of students who preferred anonymous login reported that the APM had impacted on their online interactions such as sharing ideas and offering feedback. A chi square analysis confirmed statistically significant differences. When observing the impact of the interaction modality in socialisation categories, the analysis showed that students preferring the APM perceived higher levels of affectance in social behaviours such as Making Jokes and Regulating Group Behavior. However, there were no statistically significant differences.

Table 8.6: Students' and peers' reported behaviour in APM vs. IDM

	APM	**IDM**	**Either**
Perception of Self Behaviour	**N (%)**	**N (%)**	**N (%)**
Sharing Ideas and Proposals**	16 (40.0)	1 (4.3)	5 (12.5)
Offering Feedback and Answers*	14 (35.0)	1 (4.3)	7 (175)
Solving Questions and Doubts	13 (32.5)	1 (4.3)	10 (25.0)
Making Jokes	8 (20.0)	4 (17.4)	4 (10.0)
Regulating Group Behavior	9 (22.5)	2 (8.7)	2 (5.0)
Sending Off-tasks Messages	3 (7.5)	2 (8.7)	3 (7.5)
Perception of Peers' Behaviour			
Sharing Ideas and Proposals**	14 (35.0)	5 (21.7)	11 (27.5)
Offering Feedback and Answers*	15 (37.5)	3 (13.0)	10 (25.0)
Solving Questions and Doubts*	18 (45.0)	3 (13.0)	6 (15.0)
Making Jokes	11 (27.5)	6 (26.1)	13 (32.5)
Regulating Group Behavior	6 (15.0)	3 (13.0)	6 (15.0)
Sending Off-Tasks Messages	10 (25.0)	3 (13.0)	10 (25.0)

Footnote: Percentages reported for the category "More". Differences tested with Chi-squared test.

* p value < .010; ** p value < .001

Concerning students' assessment of peer online behaviour, students preferring the APM tended to report higher perceptions of their peers sharing ideas, offering feedback, and

solving questions in the Anonymous modality. A chi-square test revealed statistically significant differences. The levels of perception of students making jokes, regulating the group, or engaging in off-tasks activities did not show any significant differences among the different groups (Figure 8.5).

Figure 8.5: Students' perception of online behaviour. Assessment of self (SP) and peer (PA) behaviour

d) Patterns and purposes of off-task messages in the APM (RQ4)

To achieve an in-depth understanding of the behaviour of students who posted off-task messages, a content analysis of their conversations and their reported opinions was conducted by employing a selection of the most active students who sent off-task messages in anonymous mode.

Patterns of use

To begin with, a clear pattern is that the most frequently occurring off-task messages were greetings and other messages related to welcoming each other that were exchanged at the beginning of the conversations, even under time constraints with regard to task performance. The students dedicated part of their limited discussion time to greeting each other, even in the APM. In total, 255 greetings were sent in the IDM and 195 in the APM. In fact, this was the most frequently occurring type of socio-emotional message recorded in the conversations.

A second prominent pattern was observed with regard to sending these messages when the task had been completed or at least when the time for the conversation was coming

to an end. Among the 46 conversations with at least one off-task message, 32 featured at least one such message around the end of the task (69.56%). The following exemplifies a typical conversation that concluded with a multitude of off-task messages after task completion:

IDM_user_RC: Where are you in class?
IDM_user_RC: xd
IDM_user_RC: since we are done
IDM_user_RC: at the back
IDM_user_MR: second row in front of the screen second from the left

Types of off-task messages

User APM_user_09. Normative off-task messages

Although this user (the most active off-task student in the APM) reported being indifferent to working in either login mode, he portrayed a different behaviour in reality. While he claimed that his behaviour was exactly the same in both modes, he participated in both discussions and off-task messages because both seemed to be accepted by the group, representing a type of messaging that could be called normative. One such conversation is presented below:

APM_user_81	what else do we put
APM_user_09	the 1.6 also not?
APM_user_81	come on
APM_user_81	I withdraw from this war
APM_user_09	sex
APM_user_10	saa
APM_user_09	Keep in mind you have few seconds left to for

User APM_user_56. Humour/fun off-task messages

Before the group members engaged in trolling in the chat, they participated in a discussion about the potential consequences of their intentions and whether the teacher could track them. However, without much deliberation, the students presumed that the teacher could not track their behaviour and hence started engaging in a kind of humorous messaging:

APM_user_30	Who knows what the teacher can see
APM_user_56	if the teacher sees this we are F
APM_user_79	She doesn’t see it, trust me
APM_user_30	Otherwise she would have many messages xD
APM_user_56	that spam there
APM_user_30	Exactly
APM_user_30	She doesn’t know the number either
APM_user_56	I wanted to make a New Year’s countdown
APM_user_56	F
APM_user_01	we put some section of another and that’s it
APM_user_56	haha
APM_user_56	10
APM_user_01	8

APM_user_01	7 [continues countdown until 0]

User APM_user_56. trolling off-task messages

Furthermore, this same user seemed to disturb and even ruin conversations, signifying an example of trolling-related off-task messages, as noted below:

APM_user_79	Eyy
APM_user_52	Holo
APM_user_79	ma friends
APM_user_79	how are you doing
APM_user_13	Hello
APM_user_79	I'm the best
APM_user_79	benzema ballon d'or
APM_user_13	I like the one that talks about the moore law
APM_user_79	Alexia Putellas have 2 balloons d'or
APM_user_79	yes I like
APM_user_79	I like the last
APM_user_30	Hi
APM_user_79	[folk, romantic song] Fui a la orilla del rio y vi que estabas mu sola vi que te habías vi que crecían amapolas en lo alto de tu pecho tu pecho hecho en la gloria

User APM_user_66. Socialising off-task messages

The following conversation exemplifies off-task messages in the IDM. Since the users knew each other, it seems that they engaged in off-task messages to socialise, meet outside of school and make plans.

IDM_user_AM	are you in class albert
IDM_user_JG	joan would you roll a joint? uwu
IDM_user_JC	
IDM_user_TF	I have written a lot
IDM_user_TF	jofre I also want [joint]
IDM_user_RM	share with us jofre
IDM_user_JG	dj pills has good material
IDM_user_RM	bye

Class 2. Task 2. Identified mode - Faking participation off-task messages

In an effort to promote participation, the PyramidApp CSCL environment was equipped with a widget structured like a bar that displayed the amount of contribution made by each user to the conversation. However, this tool initiated a few off-task messages among some users who tried to deceive the system (and the teacher) by faking participation:

IDM_user_MC then
IDM_user_MC we
IDM_user_MC leave it
IDM_user_MC like that
IDM_user_MC ?
IDM_user_GB Why
IDM_user_GB do
IDM_user_GB you speak
IDM_user_GB like this?
IDM_user_SR hahahaha
IDM_user_EG I would say yes, otherwise what would you want to put?
IDM_user_MC because
IDM_user_MC like this
IDM_user_MC I fill up
IDM_user_MC the bar
IDM_user_MC faster
IDM_user_GB XD

On examining all the categories identified from the off-task conversations, it was inferred that some of these messages were content related (humour, socialising and trolling) while others were context related (normative, faking participation and greetings). Based on the above findings, these newly identified dimensions were added to further refine the categories. The following table 8.7 summarises the different categories of off-task messages identified in this study.

Table 8.7: Final categories of the off-task messages

Content related	Fun/humour	Making jokes that are not related to the task
	Socialising	Knowing each other, meeting outside, making plans
	Trolling	Disturbing collaboration
Context related	Normative	Off-task messages that are accepted by the group, leading to members joining off-task conversations
	Fake participation	Deceiving the CSCL system and the teacher
	Greetings	Saying hello or goodbye to the group

8.4 Discussion

In this study, we have compared the effects of APM and IDM in group behaviour. In general, it has been observed that the APM is more positive than the IDM mode but we will discuss this statement in the following sessions.

a) RQ1: How do anonymized peer interactions benefit group collaboration and participation in the setting of the CSCL activities?

As observed from the results (see section 8.3.a, figure 8.4), in APM there is a significant increase not only in terms of Communication Production but also in the Productivity in Discussion messages exchanged. Group messages sharing ideas and proposals, providing answers and feedback and asking questions and doubts were significantly higher in the APM. This is consistent with previous research that reports positive results of anonymity in perceived learning and attitude towards the system (Lin, 2018) and in different contexts like peer feedback or writing (Miyazoe & Anderson, 2011; Rotsaert et al., 2018). Notably, the increase in the number of messages Oriented to Socialization in this mode was also higher although not significant compared to the IDM mode. This finding suggests that the collaboration was not only more productive in terms of cognitive messages but also concerning socio-emotional messages.

More precisely, concerning the types of messages sent (see section 8.3.a, table 8.3), the results show a significantly higher engagement (in APM vs. IDM) in categories such as sharing Ideas and Proposals, Offering Feedback and Answers, Solving Doubts and Questions, and Group Regulation that can be considered productive types of messages all of them oriented to content. The participation rate of the rest of the types of messages, except making jokes, were also higher in APM but not significantly. Thus we can conclude that the APM mode is more effective when considered from a group perspective.

This improvement can be explained by the APM condition, in which the teacher (an external, authoritative figure over the group) was used to affect group behaviour. It can be argued that the presence of the teacher promoted participation and reduced the number of off-task messages compared to the fully anonymous login mode. This role of the teacher is a revision of Rotsaert and colleagues (2018). In their paper, the students were anonymous while giving feedback but the teacher could monitor their messages.

In order to have a more solid ground to affirm that APM is a more productive login mode, we complement our findings with the analysis of individual students' behaviour in the following section.

b) RQ2: Which form of online interaction – Anonymous to Peers or Identified to Peers – reports higher levels of collaboration and participation among individual students?

When focusing on individual students regarding the Communication Production, Productivity in Discussion and Oriented to Content messages (see section 8.3.b, table 8.4), significantly more participation was observed in the APM condition. The increase in the Oriented to Socialisation messages in APM was not significant.

Concerning the types of messages sent, from the perspective of individual students, we saw significant differences in the increase of jokes and off-task messages in APM (see section 8.3.b, table 8.5). It is surprising that from the group's perspective, off-task messages increased but not significantly while in the analysis of individual students' behaviour off-task messages were significantly higher in APM. This can be explained because many of these types of messages were sent by only a few, but very active trolling students. This is consistent with the findings of our previous study. It can be argued, following Siemon's et al. (2019), that when people are anonymous, they may be more likely to take advantage of others' efforts (social loafing, free-rider, etc.), but this drawback is offset by the advantage of reducing the fear of being judged, which leads to more group participation and diversity of views.

Thus, in conclusion, not only did groups participate more and were more oriented to content in the APM, but from the perspective of individual students, APM also promoted more productive messages (cognitive and socio-emotional) across the four tasks in this mode.

c) RQ3: Which modality of collaboration (APM or IDM) would students adopt after conducting a series of tasks within the CSCL platform?

Most students' preferred login mode was the APM (see section 8.3.c). These students found that the APM facilitated participation and offered a safe environment to share ideas without being judged.

Notably, in the current study, a third of the students claimed that they were indifferent to working in either mode –a factor that may be attributed to the APM being perceived by students as quite similar to the IDM in this study. According to these students, the APM served to neutralise misbehaviour, and thus it did not differ considerably from the IDM. We argue that this is a positive result concerning our RQs 1 and 2 because if students are indifferent to APM or IDM means that the negative consequences of anonymity have been minimised.

Overall, compared to the full-anonymity mode of the previous study, students do not feel the presence of the teacher as something negative. In contrast, they keep preferring being anonymous to their peers.

Concerning their opinion about their own behaviour, as presented in Table 8.6, the students considered themselves to be more productive in the APM. Furthermore, they also think that their peers' behaviour was more productive in APM. So they feel more comfortable in that mode and have a positive view of their self-efficacy and their group's efficacy.

Finally, since the students participated more, sent more messages oriented to content, socialised more (see sections 8.3.a and 8.3.b) and considered APM to be a better login

mode (see sections 8.3.c), it can be argued that this mode has the ability to encourage better collaboration.

d) RQ4: When are off-task messages most frequent, and what purposes do they serve?

Our analysis found some conversations in which students expressed feeling the pressure of being monitored by the teachers (see the conversations of user APM_user_56 in section Types of off-task messages). Such cases can be explained because when students are aware of the teacher being able to track what they do and say, their behaviour during collaboration may be fun but not disturbing. This is consistent with Kreijn's (2003) statement: "These [non-task] conversations show an abundant exchange of socio-emotional and affective information contributing to impression formation, creation of social relationships, group cohesion and a sense of community." (p. 344). During the analysis of the conversations, it emerged that off-task messages cannot always be considered low-quality. For example, off-task humour after task completion should not be considered low quality, especially if students indulge in such conversations to make plans or meet outside the class. This same perspective applies to greetings. Thus, drawing on these observations, this study proposed some patterns and categories to better describe these off-task messages.

Although off-task messages can happen any time, many of them appear at the beginning (mostly greetings) or after the task is done.

Regarding the categories of off-task messages proposed in the results section 8.4 (Table 8.7), the importance of the fun/humour type of message must be emphasised. This study differentiated between on-task humour (related to the task) and off-task related humour. Humour was a common factor noticed in all the classes, tasks and genders. Moreover, if on-task and off-task humour messages were considered together, it would emerge as the most frequent type of message. In addition, such messages improve social interactions and facilitate a good atmosphere in groups. Among the conversations investigated in this study, several examples of chats that utilised funny comments combined with cognitively productive messages were identified. Even though the students did not explicitly mention humour/fun as part of their collaboration, evidence of such messages could be clearly located in their conversations – a finding that is consistent with previous research (Vogler et al., 2019). Moreover, for students, having fun while learning is integral, with recent works on CSCL experimenting with agents that offer different types of sense of humour (Ceha et al., 2021) or those that use memes (Tao et al., 2022).

Furthermore, this study identified the practice of faking participation, by which students send messages simply to reach a certain level on the 'participation bar', which makes it seem like they were actually engaging in productive discussion with a clear intention. This aspect was revealed in conversations where students messaged that they were breaking their sentences into different messages to boost their 'participation bar'. This

behaviour is a clear example of the strategic use of anonymity, as described by the SIDE model (Spears, 2017) and AST theory (DeSanctis & Poole, 1994).

In addition, examples of the socialising type of messages, which constitute students checking whether they had met before and making plans to meet outside of class, were also noted in the conversations. As mentioned in the introductory section, when students are enquired about what they miss in CSCL systems, they especially mention the lack of opportunities to engage in socialisation (Stodel et al., 2006). Interestingly, most of the socialising messages were exchanged in the APM, a possible explanation for which is that this mode prevented the students from identifying each other, thus driving them to exchange more off-task socialising messages to get to know each other.

The other types of off-task messages (trolling and normative) are related. We have seen conversations in which one user starts sending trolling messages and other members join. These messages disturb collaboration and should be avoided.

The taxonomy presented in this study aims to act as a first proposal to better understand off-task behaviour in CSCL environments.

8.5 Limitations

This study was conducted within an authentic educational setting, seamlessly integrated into regular classroom activities. While this approach offers a more naturalistic environment for our research, it comes with certain limitations. Specifically, by embedding our experiments within students' existing curriculum rather than designing tasks solely for research purposes, we acknowledge a trade-off between realism and control. In contrast to a controlled laboratory setting, this method affords less direct oversight from researchers, potentially impacting the breadth and diversity of tasks assigned. Moreover, variations in time constraints, determined by teachers, may have influenced observed behaviours such as off-task messaging frequency.

Furthermore, we chose to administer a single post-task questionnaire to minimise disruption and mitigate student fatigue. However, this decision relies on students' accurate recall of their prior task engagement, introducing a potential limitation. Additionally, our questionnaire development process lacked the utilisation of a pre-existing, validated research instrument. This was due to a dearth of documented opinions and preferences from students in similar contexts. As a result, our study was constrained by the absence of a validated question set, limiting our ability to leverage established instruments for data collection.

Our interest in documenting students' opinions and preferences also implies the limitation of predicating a part of the results on self-reports, which pose some well-known validity issues with regard to research (for example, students being dishonest in their comments, not remembering events accurately or not identifying a notable difference be-

tween login modes). To compensate for this lack of validity, this study conducted an analysis and a comparison of the logs of chat conversations. The sequence of the APM and identified login modes was made so that we had the same amount of tasks for each mode but this meant that tasks had different amounts of login modes.

For the coding criteria for the chat messages we have relied on two different authors that have coded cognitive chats and socio-emotional conversations respectively. We have used parts of both trying to synthesise them but further iterations (including more data from experiments and validating with more studies) should be done to refine the coding criteria.

8.6 Conclusion and further research

Addressing the first two research questions proposed in this study, the analysis results concluded that students' participation behaviour in APM is more productive in terms of Communication Production and Productivity in Discussion messages.

Although not statistically significant, groups also produced more Oriented to Socialization messages, thus implying a better group atmosphere. Since the amount of off-task messages was not statistically significant we can conclude that the APM is a better choice for small groups that have to collaborate for a short period of time and whose members do not know each other.

Furthermore, this study observed that the APM is more productive than full anonymity, which is usually afforded in most CSCL systems. The APM encourages participation, especially among shy students, and promotes social interactions that do not culminate in trolling messages as often as in the full anonymity mode. After analysing the results we hypothesised that only a few students are responsible for a considerably high amount of off-task messages meaning that there is a kind of type of student that is an active troller or "disturber". Thus, we suggest that further research try to find ways to identify and control these active disturbers.

Concerning the third research question, the study results are supported by the students' opinions and preferences, as expressed in the post-task questionnaire, where they expressed their preference for the APM over the IDM. Thus, APM optimises the best side of anonymity minimising the drawbacks.

The SIDE model predicts that for the members of a group to strive towards achieving group goals (not individual interests), its members should either be fully anonymous or fully identifiable. However, this assumption might not be so clearly applicable in an educational context. Continuing to work toward understanding why and how to support different types of login modes is important because most students prefer the anonymous mode even when they experience misbehaviour by whom we have called spammers (Velamazán et al., 2023). This is what we call the social component of the SIDE model.

Furthermore, humour and group support often featured mixed among the cognitive messages, representing a significant factor in understanding collaborative learning. In this context, Tan and Chen (2022) emphasised that affective and supportive feedback especially helps improve collaboration. Vogler et al. (2019) also suggested that humour is an important variable in socially shared and co-created text in online discussions. Drawing on this context, more studies based on humour, group motivation and support should be conducted to explore the various other contexts in which these categories can be tested.

To address the fourth research question, we began by categorising what has generally been called off-task messages to attain a better understanding of their diverse nature and effects. Some of them ("humour" and "getting to know each other") had positive implications for group cohesion and atmosphere, especially after task completion. This study identified a common pattern in the moments during which off-task messages are usually sent, such as at the beginning of a conversation as a greeting and then at the end, once the task is finished.

Drawing on the findings of this study, it is recommended that CSCL system designers and developers should consider implementing the APM, since it is more efficient than "fully" anonymous login. Another line of study could be to test other conditions of anonymity by, for example, letting students individually choose their preferred login mode for every task. It could also be interesting to test the possibility of automatically detecting off-task messages pertaining to the "fake participation" and "trolling" types by performing a combination of sentiment and semantic analyses in real time. This potential detection mechanism, which could be especially useful when dealing with a large number of groups, could be used by teachers to double-check whether the detection is correct or if the group requires some kind of supervision.

With regard to teachers, we recommend paying more attention to the messages exchanged in the groups, especially during the last minutes of the scheduled time, because, as already observed, that is when most unproductive behaviour is initiated. Depending on the students' needs, these minutes could be used for something more productive. Alternatively, when sufficient time is available, these minutes could be left for students to socialise by employing the CSCL environment (we did not observe any extremely disturbing/unrespectful insults or flaming activities after the students finished the task). Another recommendation for teachers is to use the categories proposed in this study as instruments to evaluate the process of collaboration in groups.

The anonymous login mode in CSCL is an extremely complex phenomenon that depends on several aspects. This is probably the reason, as noted in the Introduction section, for the contradictory results that research on this topic has yielded so far. Another important distinction is that when people collaborate in groups without clear guidelines and for a short time, like in this study, being anonymous can be useful. However, for teams (as opposed to groups) that have specific rules and a structure and that collaborate over long periods of time, anonymity can be detrimental. To work together effectively

in the long term, people need to be aware of each other, have empathy and trust, which are not achieved overnight. These key elements are missing when collaborators can hide their identities and avoid accountability behind anonymity (Siemon's et al., 2019). In this regard, the findings of this study contribute with new insights concerning the use of APM mode, considering the goal of promoting social interactions, whose presence in CSCL environments is considered a positive characteristic (Muñoz-Carril et al., 2021; Yilmaz et al., 2020; Kreijns et al., 2022).

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8.8 Declaration of interest and generative AI and AI-assisted technologies in the writing process

The authors report there are no competing interests to declare.

In preparing this study, the authors used Copilot – the artificial intelligence agent integrated into the Microsoft Edge browser – to paraphrase some of the texts from a previous research (from its introduction/literature section). We also used this tool to paraphrase another section of text written by one colleague in the research group to describe the CSCL environment.

After using this tool/service (Copilot by Microsoft Edge), the authors reviewed and edited the content as required. The authors take full responsibility for the content of the publication.

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