Automatic Feedback on Collaborative Writing Tasks

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Abstract

Collaborative writing offers important educational benefits. However, not enough research has been done to analyze the collaborative writing process in-depth and investigate the effects of personalized feedback to strengthen group work and increase the quality of writing. For this reason, this PhD project will integrate social learning analytics in the online collaborative writing process in higher education to increase collaborative skills and provide effective feedback to students. The research will utilize a mixed methods sequential, exploratory methodology, beginning with a systematic literature review and the development of a prototype. A pilot test will refine the resulting tool, followed by an initial trial to identify emerging roles in the collaborative writing process. Feedback strategies will be designed based on the identified roles and user feedback. In a final phase, the focus will be on the long-term impact and evaluation of the tool on student writing skills.

Keywords

Computer Supported Collaborative Learning, Collaborative Writing, Social Learning Analytics, Emerging Roles, Automated Feedback

1. Motivation

Working with others is not only an important skill in one's own life but also an important core skill for future professionals [1, pp. 38–42], [2, p. 11]. In top industries such as oil and gas, care, personal services, wellbeing, electronics, automotive, aerospace, chemicals, advanced materials, education, and training, as well as non-governmental and membership organizations, the ability to collaborate and cooperate effectively is recognized as a key skill that is increasingly important for employees [1, p. 41]. To develop these skills, the European Commission claims in a 2018 recommendation on key competencies for lifelong learning that education plays a crucial role in promoting them [2, pp. 4, 15]. Fostering collaboration and developing strategies that lead to high quality in the pursuit of common goals in a collaborative setting therefore appear to be crucial tasks for higher education [3, p. 38], [4, p. 371].

With advancements in Web 2.0 technologies and the increasing use of cloud computing tools, collaborative online tools such as blogs, wikis, or Google Docs have become increasingly popular in teaching and learning environments [3, p. 38], [5, p. 74]. These technologies have also facilitated computer-supported collaborative learning (CSCL). This innovative field offers a variety of benefits for students. By utilizing methods of social interaction and technology, CSCL not only improves academic performance but also develops important skills for success in the modern workplace, responding to the growing significance of teamwork and computer literacy in today's job market. [5, pp. 1–4]

One form of CSCL is Collaborative Writing (CW) [6]. In its simplest form, CW requires the combined efforts of two or more authors to create a cohesive text. Storch characterizes CW as an activity that requires co-authors at all stages of the writing process, promoting shared responsibility and ownership of the entire text creation. [7, p. 41] This distinction clarifies the difference between collaborative writing (CW) and cooperative writing. In cooperative writing, the team members have a common goal but divide their tasks into subtasks that are brought together later in the process. However, the individual may not have complete responsibility for the entire text, as the tasks are divided into subtasks. [7, p. 40], [8, pp. 351–352]

Writing tools have become increasingly important in today's society. Through platforms such as blogs, wikis and Google Docs, individuals can easily share their thoughts, give feedback to others and collaborate on documents in real time or asynchronously. In this way, several people can work together on the design of a text in order to achieve a common understanding. These tools make it easier to document work meetings and ensure that important information is not forgotten, as several people can edit the minutes. These writing tools also make it easy to share ideas and develop them together.

Collaborative writing tools are ubiquitous, yet the practice of feedback on the writing process itself remains largely absent from our daily routine. This raises the question of whether feedback on collaborative writing can improve the quality of the results. It should also be investigated whether feedback on group dynamics during collaborative writing can lead to more efficient and structured processes. Furthermore, the importance of feedback on collaborative writing also extends to the field of higher education, where students

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bring their experiences from their home learning environment into the university setting. As the use of online platforms for learning and collaboration becomes more widespread among students, it is crucial to normalize the provision of feedback on their collaborative writing practices. This would not only enhance their online collaborative skills, but also foster an environment conducive to effective group work and learning outcomes.

In online CW, students write content together in small groups or pairs using online tools supported by teachers or technical resources [9, p. 1]. Collaborative writing enhances individual writing skills and promotes critical and conceptual thinking as well as reflection on writing and self-regulation processes [9, p. 1], [10, pp. 1293–1294]. Collaborative writing, therefore, appears to be an extremely valuable method for teaching a variety of foundational skills. However, the time required to integrate CW into the learning environment is significant, as teaching staff must first understand the collaborative writing process as such in order to be able to implement it effectively, and ultimately provide both formative and summative assessments for students [11, p. 27].

In addition, incorporating CW in higher education can be challenging if the focus on improving writing skills is not consistently supported by direct and ongoing theoretical and pedagogical guidance [10, p. 1294]. Chen, Ouyang and Jiao [9], Kaliisa et al. [12], and Ferguson and Buckingham Shum [13] point out that social learning analytics (SLA) is becoming increasingly important in addressing this problem. SLA is a branch of learning analytics that recognizes that learning is not just an individual endeavor, but also a collaborative process. The focus is on how learners build knowledge together within their social and cultural context. In online social learning, SLA considers formal and informal educational environments, as well as networks and communities.

When using SLA in studies, the lack of combined analysis is a common challenge [12]. A recent study [9] exploring collaborative online writing identified a significant gap in integration of social, cognitive, and temporal analyses. Although these aspects were investigated, the study did not consider the specific roles that individual students took during the writing process. However, the quality of learning outcomes is strongly influenced by social environments and the evolving role dynamics within these environments. As a result, emerging social roles serve as a valuable reference point for facilitating knowledge construction processes. [14]

2. State of the Art

The following subsections discuss the current status of relevant topics for the doctoral project.

2.1. Collaborative Writing in Higher Education

As mentioned in the motivation, the education sector plays a major role in the development of collaborative skills, including the ability to write collaboratively. Many studies have already been conducted using CW to develop various skills or to help improve the learning process [3], [5], [6], [7], [8], [9], [15], [16], [17]. Some of the research focuses intensively on second language improvement through collaborative writing and many different scenarios are being investigated for this particular task [7], [17], [18].

According to a proposal by Drachsler et al. [19, pp. 16–38], CW can be considered a data-enriched learning activity (DeLA). This perspective emphasizes the importance of purposefully designing tasks to generate meaningful indicators rather than relying on generic indicators. Designing, developing and evaluating CW as a DeLA requires a robust learning design approach. For example, Menzel et al. [14] investigated a DeLA that focuses on providing automated feedback for a collaborative forum discussion in the context of a teacher education class.

2.2. Emerging Roles in Group Activities

In a recent study by Dowell, Nixon, and Graesser [20], the identification of emergent roles at the linguistic level was accomplished through their approach of group communication analysis (GCA). Menzel et al. [14] builds on this approach by analyzing collaborative discussion in a forum to identify emergent roles which were then the basis of automated personalized feedback. GCA indicators included participation, responsivity, social impact, internal cohesion, newness, and communication density. From this, a set of seven emergent roles were described, including Influential Actors and Drivers to Summarizers, Cautious Leaners, Left-Behinds, Chatterers, and Deferrers.

Since the emergent roles in the study by Menzel et al. [14] were identified in the context of a collaborative forum discussion, a transfer to collaborative writing has yet to be made. The question arises as to whether and how many roles are similar in the collaborative writing process and what characteristics a collaborative writing tool must possess to capture the vast majority of roles. There seem to be few other studies investigating the emergence of roles during the writing process. The findings of their emergent roles are also not as fine-grained as in the aforementioned papers [4], [21]. Furthermore, a recent 2023 study by Chen, Tan, and Lei

[21] lacks evidence for the emergent roles they found in terms of sample size, as they selected only six participants out of 38 possible candidates, which they claimed to be the most different from each other regarding characteristics.

2.3. Social Learning Analytics

Buckingham Shum and Ferguson [13] describe social learning analytics (SLA) as one of the specializations of learning analytics resulting from the shift to a more learner-centered design approach that focuses on cultivating and disseminating skills and ideas through collaborative interactions in learning environments. In their paper, they introduce five social types of learning analytics that arise from five drivers, namely social media, open or free content and data, a society that increasingly values participation, and innovation dependent of social media connections.

A recent 2022 systematic literature review by Kaliisa et al. [12] examines SLA in computer-supported collaborative learning environments. Their study identified areas for improvement and outlines suggestions for research methods, theories, and practices to drive the further development of SLA. In their review they also utilize the five categories presented by Buckingham Shum and Ferguson, which are:

1. Social learning network analytics, where the focus lies on the many interpersonal relationships between the students.
2. Social learning discourse analytics, where the focus lies on analyzing the text generated by students during online interactions.
3. Social learning content analytics, which employs automated techniques to analyze, categorize, and review content created by learners.
4. Social learning context analytics, which refers to the use of analytical tools to analyze factors that influence learning in social contexts.
5. Social learning disposition analytics, which combines information about individuals' learning tendencies with data from computerized assessments to gain insights into how these dispositions influence learning outcomes in social settings.

One of the gaps in the literature identified by Kaliisa et al. [12, pp. 7–10] is the lack of learning theories to support the interpretation of observed online interactions and artefacts. In addition, they criticize that the analysis of many tools is cumbersome to perform and often takes place outside the learning environment, which is why they advocate that future researcher use flexible tools that can be easily reconfigured by practitioners, such as teachers. Another criticism is the use of only one data source, failure to conduct user feedback to understand the impact of design decisions made for feedback visualization, and the exclusive focus on analyzing student contributions and interaction data, potentially missing relevant interpretations of the results of a particular activity. Finally, they suggest integrating advanced network analysis techniques, incorporating temporality into SLA analysis, and linking SLA more closely to the learning design.

2.4. Automated Feedback on Collaborative Writing

An important issue in automated feedback revolves around identifying appropriate feedback and required indicators. Conijn et al. [22] emphasize the importance of involving different stakeholders such as teachers, writing specialists, and students in the designing process of feedback tools to gain insight into the most needed information during the writing process.

In the field of online writing feedback, there are already well-known tools that provide automated feedback in digital writing environments. They are known as Automated Writing Evaluation (AWE) tools. They support the writing process by providing formative feedback using appealing graphical interfaces. AWE tools are not restricted to any genre, but are used in a wide variety of contexts. [23] Although there are enriching tools that support automated feedback in individual writing, there seems to be a larger gap in tools that provide automated feedback in online collaborative writing. This points to a need to extend existing indicators for individual activities to group activities.

Fortunately, potential indicators that can capture group dynamics in collaborative writing can already be found in the literature. Shouthavilay et al. [3] explored this concept using revision maps and probabilistic topic models to analyze the collaborative writing process. In their study, they were able to track not only when team members participated in the writing process, but also the individual's contributions, such as changes to and additions of new topics in the document. By implementing similar techniques, it should be possible to provide automated feedback adapted to emerging roles in a writing group activity. Other possibilities could be providing feedback based on social comparison or group awareness methods [24], [25], [26]. These methods are already being investigated, but few focus on online CW.

Those papers are helpful in providing feedback to students, which is also a big challenge not only in collaborative writing but is universally difficult. A common problem in feedback design is to make it understandable and appealing, and not to overwhelm

students' feedback literacy. Jivet et al. [27] address this issue in their work by offering help in building a dashboard in higher education for effective feedback.

3. Research Objectives

This PhD project will focus on integrating Social Learning Analytics into the online collaborative writing process in higher education settings to facilitate the development of essential collaborative skills among students and provide effective feedback mechanisms for enhancing their writing skills and engagement in the learning process. To do that we are in need of a student-centered tool utilizing Social Learning Analytics to analyze social environments and emerging roles within online collaborative writing tasks. The emphasis on understanding how these emergent social roles impact knowledge construction and learning outcomes highlights the gap in current research on effectively supporting students in developing collaborative skills and engaging in meaningful collaborative writing activities in higher educational settings.

Based on these preliminary thoughts, the overarching research question will be:

[Main RQ] How can learning analytics approaches be used to identify key performance indicators in collaborative writing, provide personalized process feedback, and evaluate the effectiveness of that feedback?

With five sub-research questions further investigating the following:

[RQ1-key aspects] What are the key performance indicators (social, cognitive, temporal) in collaborative writing?

- **[RQ1a-measurement]** How can key performance indicators be elicited and measured using learning analytics approaches?
- **[RQ1b-roles]** Are emergent roles useful lenses to describe the collaborative process and communication in collaborative writing?

[RQ2-automated feedback] How can personalized, textual process feedback be tailored to given tasks by using the identified indicators and emergent roles?

- **[RQ2a-performance]** How effective is learning analytics feedback on collaborative writing (on student learning experiences, cognitive learning, group performance, and/or attitudes toward collaborative writing)?

To gather rich and comprehensive data on emerging roles in collaborative writing processes, develop effective feedback strategies and evaluate the impact of feedback on students' performance, a mixed-method sequential exploratory research design will be used. The intended design will be elaborated on in the next section.

4. PhD Plan

The research design of this PhD project can be described as a sequential, exploratory design with mixed methods. **Figure 1** provides a quick overview of the current plan. In phases 1 the design plan includes an initial review of the literature and user feedback, followed by the development of a first prototype in phase 3. In phase 3 and 4 feedback based on social comparison will be investigated, while further collecting collaborative writing data, that is to be analyzed by emergent social roles. The planned longitudinal study in phase 4 allows for a comprehensive assessment of the long-term effects of feedback in collaborative writing tasks.

The research design includes a combination of qualitative and quantitative methods to investigate the impact of the student-focused tool to be developed utilizing Social Learning Analytics on knowledge construction, collaborative writing skills, and learning outcomes. The iterative nature of the design, with sequential phases, enables a systematic approach to the development, validation, and evaluation of the tool in higher education.

4.1. Phase 1

In the first phase, a systematic literature review will be conducted to develop a student-centered tool that uses Social Learning Analytics for collaborative online writing tasks in higher education. To develop such a tool, the following topics must be considered in more detail.

Before looking at existing collaborative writing tools, it would be useful to first understand the key measures and indicators of effective collaborative writing. To achieve this, researching collaborative writing in analog contexts or investigating CSCL environments may be crucial. Once an overview of potential key indicators has been gained, we should concentrate on reviewing existing studies on collaborative writing tools. From this research on tools and technologies used for collaborative writing in educational settings, their functionalities and effectiveness can be inferred, as well as the impact on learning outcomes and key indicators for analysis.

Afterwards, the application of SLA in education needs to be researched. Here, the focus is on how it has been used to analyze student interactions, roles, and dynamics in collaborative learning environments. Another important part is exploring how the automated

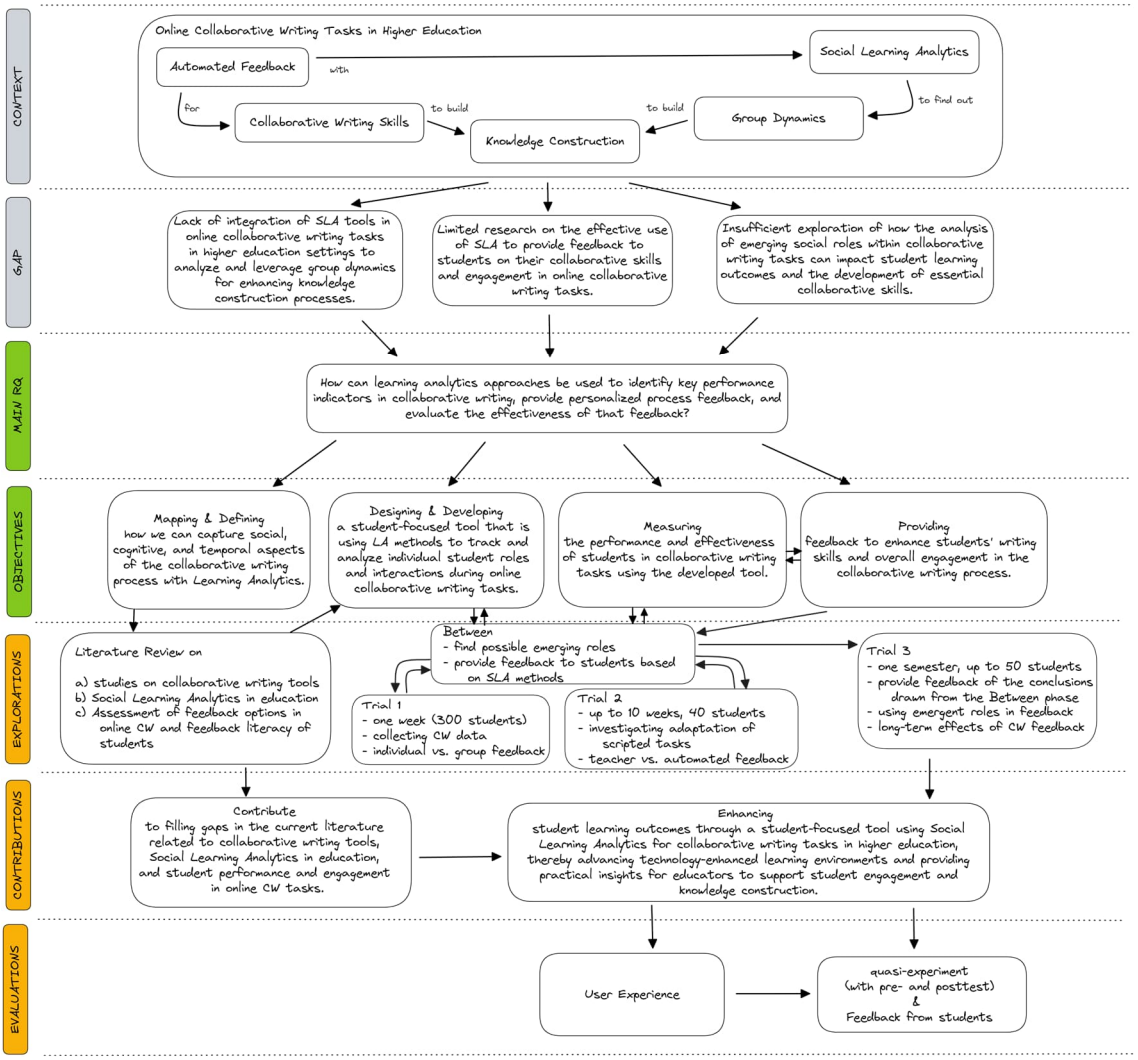

Figure 1: Overview of the PhD plan. Context, gap, main research question, objectives, explorations, contributions, evaluations.

feedback given to students should look like, in order to have the best impact on student understanding.

Finally, it is crucial to assess the impact of collaborative writing tasks on students' knowledge construction, critical thinking skills, and overall learning outcomes, considering the role of the social environment and emerging social roles in this process.

After conducting the literature review, an initial prototype, consisting of a text editor for collaborative writing, will be developed. Before initial testing in phase 2, a pilot test will be conducted with a small group of participants to refine the data collection methods, the usability of the prototype, and procedures.

4.2. Phase 2

In this phase, an initial trial with a group of students is conducted to identify emerging roles within the collaborative writing process. The exact implementation of this first trial depends on the findings from the literature research and still needs to be worked out in detail. As part of a collaboration between the Educational Psychology Department at the Goethe University Frankfurt and the IMPACT [28] project, the prototype can be tested in an online seminar in the upcoming semester. It will also be possible to design the experiment together with the lecturers at the faculty so that it can be adapted to the results of the literature review. To further improve the tool, it will be important to obtain user feedback at the end of the trial on the usability and effectiveness of the prototype.

In the IMPACT [28] project, funded by the German Federal Ministry of Education and Research (BMBF), five German universities - the Goethe University Frankfurt, the Humboldt University Berlin, the FernUniversität

Hagen, Freie Universität Berlin, and University Bremen – are working together to implement AI-based feedback and assessment with Trusted Learning Analytics in universities. In a large online seminar at the Educational Psychology Department at the Goethe University Frankfurt, the IMPACT project researchers can conduct their experiments together with the teaching staff each semester with around 200 to 300 students. The seminar titled "Use of digital media in the classroom (BW-B/Sb4)" is linked to the study "Highly informative and competence-oriented feedback" to ensure the quality of the feedback, its use, and impact. The seminar usually takes place on a Moodle platform and focuses on providing automated and personalized feedback for students.

The aim of this phase is to collect data on the collaborative writing process. The quantitative data on collaborative writing is used in the next phase to identify potentially emerging roles and to analyze group dynamics on a deeper level.

Festinger's social comparison theory from 1954 states that people compare themselves with others in order to better understand where they stand in the social hierarchy. This comparison process can influence self-esteem, motivation and interaction with others. [29] Slavin's review [30] on cooperative learning and achievement in collaborative learning emphasizes the importance of all group members contributing to the writing process, while Johnson & Johnson's perspective on shared responsibility in cooperative learning highlights the benefits of working together towards a common goal and holding each other accountable [31]. This theory is relevant for all social comparison approaches regardless of the unit-of-analysis used. For our unit-of-analysis, we focus on the comparison of individual social comparison feedback (comparing a group member to its peers) and group-based social comparison feedback (comparing a group with other groups). This perspective is consistent with the principle of socially shared analysis in classic CSCL, which studies group dynamics [32]. However, we particularly want to examine student's reactions to the feedback after they have received it. Do they take it positively or negatively? Do they perceive the feedback as fair or unfair? Tajfel & Turner's social identity theory [33] may help to explain why individuals react differently to feedback, as individual feedback can make students feel isolated, while group feedback reinforces a sense of belonging.

In this trial, students are given initial feedback based on social comparison. Students are randomly assigned to two groups: one group receives individual feedback based on their performance compared to their own group, the other group receives feedback based on their group's performance compared to all other groups.

Student perceptions of the feedback quality will be assessed via self-report measures capturing constructs like usefulness, fairness, motivation, support for self-regulated learning, and others. They will be collected to determine which feedback is judged more suitable for this learning activity.

4.3. Phase 3

In this phase, the collected data on the writing process of phase 2 will be analyzed to identify potentially emerging roles and to evaluate group dynamics on a deeper level. The then identified social roles with the findings of the literature review and feedback strategies will be validated based on the roles and behaviors identified within the collaborative writing process.

In phase 3 a collaboration with the Data Intelligence (DI) Lab [34], a research group of the Netherlands is in prospect. For the collaboration with the DI Lab a cohort of 40 students are available over a period of 10 weeks. A period starts anew after those 10 weeks with a new cohort. The students of the cohort have either a Dutch or/and international background and their education backgrounds are also diverse.

A detailed design for this trial is yet to be defined and will depend on the outcomes of the first trial. It is important to notice, that because the collaboration is to take place in between analyzing the collaborative writing data for emergent roles, the feedback on emergent roles may not be possible yet. Therefore, for this collaboration the following questions could be addressed in a second trial:

- How do different levels of education impact the collaborative writing process? Are there differences in communication patterns, roles, or outcomes based on the participants' educational backgrounds?
- How do teachers' feedback impact the collaborative writing process compared to automated feedback? What are the differences in student learning experiences, group performance, and attitudes toward collaborative writing between the two feedback methods?
- Can the algorithms implemented in the writing tool help teachers provide more personalized and effective feedback to students during the collaborative writing process? How do students perceive and respond to feedback provided by both teachers and algorithms?
- How do the scripted collaboration scenarios influence the dynamics of the writing groups? Do certain types of scripts lead to more

effective collaboration and better writing outcomes?

At the end of this phase the prototype is to be enhanced by the results of the first and second trial. Furthermore, additional features based on the user feedback of the first and second trial will be added. Results of the analysis of emergent roles during the collaborative writing processes will be regarded to enhance the feedback options.

4.4. Phase 4

Ideally, phase 4 is carried out at the end of phase 3. In this phase, the long-term effects of the feedback on the student's writing performance in the collaborative writing process are assessed. Therefore, the trial's design should include conducting writing tasks with the same group of students over some time.

A collaboration with the department Academie Data Science & AI of the Zuyd Hogeschool of the Netherlands [35] is in prospect. For the collaboration with the Zuyd Hogeschool a cohort of 50 students are available over a period of one semester in the years 2024-2025. A semester starts at February until September or September to February. In this timespan it is planned to evaluate 40 different learning activities, which one of those could be the prototype invented in this PhD thesis.

A detailed design for this trial is yet to be defined and will depend on the outcomes of the first and second trial. Since the analysis on emergent roles should be done till this phase, the feedback could be enhanced depending on the results. Possible questions could be addressed in a third trial:

- How does the collaboration process evolve over time in the semester-long course or multiple workshops? What are the key indicators of successful collaboration in terms of social, cognitive, and temporal aspects?
- How do the students' prior experiences with collaborative writing impact their performance and engagement in the writing workshops or course? Are there differences in outcomes based on students' familiarity with collaborative work?
- How do the group dynamics, such as leadership roles, conflict resolution strategies, and communication patterns, influence the quality of the collaborative writing produced in the workshops or course?
- How do emergent roles impact the influence of the feedback in collaborative writing scenarios?

Knowledge tests will be conducted to assess the improvement of students' skills administered while using the prototype and to analyze the impact on knowledge construction and learning outcomes.

The plan of the four phases described is intended for a period of three years. The following overview of the phases in **Figure 2** contributes to a better understanding of the plan.

Ethical considerations must be taken into account during the pilot test and the trials. Participants must be informed and informed consent must be obtained. The protection of the participants' privacy and the confidentiality of the data must be integrated throughout the research design.

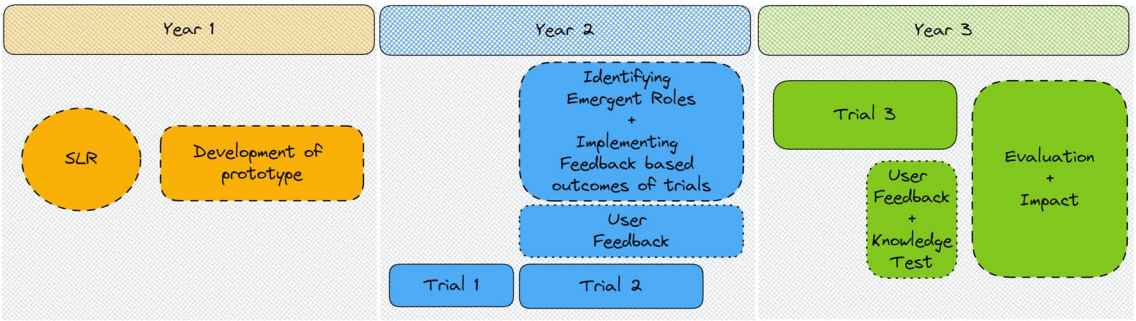

Figure 2: Overview of the timeline of the three years PhD trajectory

5. Conclusion

This paper provides an overview of a doctoral project to integrate social learning analytics into the online collaborative writing process in higher education to promote the development of basic collaborative skills in students and provide effective feedback mechanisms to enhance their writing skills and engagement in the learning process. To achieve these goals, the project will utilize a mixed methods approach that is sequential and exploratory.

The research process will begin with a systematic literature review, while a prototype will be developed in parallel and refined based on the findings of the

literature review. A test pilot will improve the user experience of the tool and procedures. In the first trial, two feedback types based on social comparison will be compared, while data on the collaborative writing process will be collected. To understand the group dynamics during the writing process the collected data will be analyzed by identifying emerging roles. After comparing these roles with the findings of the literature review, feedback strategies will be developed. A second trial will further investigate how the tasks can be adapted through the use of identified indicators and emerging roles. In a third trial, long-term effects of the feedback on the student's writing performance in the collaborative writing process are assessed. At the end of the trials, tests and user feedback will be used to assess the potential of the developed tool and its impact on student's writing skills.

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