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Master's Thesis

Collaboration in Computer Science Teams:A Systematic Literature Review

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Abstract

Systematic Literature Review (SLR) is a strategy, employed when conducting literature reviews on a specific research area, that results in minimal bias, and more reliable insight. It is more approachable than any of the typical ad-hoc approaches, and many research efforts and studies have been carried out following this approach. Thus, It has been considered as an essential method to aggregate and summarize existing knowledge, so that none will present repeatedly.They are explicit, reproducible and without prior assumptions.In all the research purposes, the main use and value of a SLR relies on what was done, what was analyzed, what was found and the quality of clarity in reporting.

Computer Science(CS), particularly Software Engineering(SE) is a rapidly evolving research area which is being conducted by large, collaborative teams. Unfortunately, the diversity among the teams are rarely discussed. Thus, in this thesis, we have tried to find the research gaps between the differences in diversity or similarity among team members and the impact of having them in the teams. We have adapted the techniques of SLR to perform the research in a less biased way. We collected a total of 3130 papers from various digital libraries.We performed the various phases of SLR on the collected papers and tried to filter to a less number of papers and analyzed them. Throughout this research, we have followed the guidelines proposed by Kitchenham on SLR.

The main purpose of this thesis endeavor is to examine and identify current, and relevant state-of-the-art research efforts on collaboration in CS teams and to ascertain both the impact and effectiveness of collaborative engagements.We selected 13 primary studies and conducted a literature survey on them. Every study reported at least one important relationship between teams or the role of women in teams or the intervention and performance of teams. Some non-significant facts were also reported. The quality of the review ranges from medium to high. However, almost every research suggested that team processes behaviors influences team performance and related outcomes.

Acknowledgments

This thesis marks the end of my memorable academic journey towards pursuing a Master of Science degree from Otto- Von-Guericke University of Magdeburg.

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Last but not least, I would like to extend my very profound gratitude to my family, my father Manu Joseph, my mother Saramma John, my brother Manas M S for their courage and support they provided during my tenure.

And to conclude, I would like to thank all the academic and office staffs who helped me throughout my journey.

Statement of Authorship

I hereby declare that I am the sole author of this Master Thesis and that I have not used any sources other than those listed in the bibliography and identified as references.
I further declare that I have not submitted this thesis at any other institution in order to obtain a degree.

Signature: _____ Place: _____ Date: _____

Contents

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List of Acronyms

ACO	Ant Colony Optimization
AI	Artificial Intelligence
ALM	Application Lifecycle Management
AMSTAR	Assessment of Multiple Systematic Reviews
API	Application Programming Interface
CDE	collaborative development environments
CL	Collaborative Learning
CS	Computer Science
CSCL	Computer Supported Collaborative Learning
DARE	Database of Abstracts of Reviews of Effects
DBMS	Database Management System
DL	Deep Learning
EA	Enterprise Architecture
EBSE	Evidence based Software Engineering
EC	Exclusion Criteria
FFM	Five Factor Model
GSS	Group Support Systems
IC	Inclusion Criteria
IDE	Integrated Development Enviornment
IE	Information Extraction
IR	Information Retrieval
IVi	Information Visualisation
JSON	JavaScript Object Notation
KPI	Key Performance Indicators
KS	Knowledge Sharing
LMS	Learning Management Systems
LSA	Lag Sequence Analysis
ML	Machine Learning
PBL	Project-Based Learning
PICO	Population Intervention Control Group Outcome

PICOC	Population Intervention Control Group Outcome and Context
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PTPA	Predicting Teamwork Performance
QA	Quality Assessment
QUOROM	Quality Of Reporting Of Meta-analyses
RDBMS	Relational Database Management System
ROB	Risk of Bias
RQ	Research Question
SE	Software Engineering
SESRA	Software Engineering Systematic Review Application
SLR	Systematic Literature Review
SR	Systematic Review
StARt	State of the Art through Systematic Review
STEM	Science
TM	Text Mining
VS	visual studio
VTM	Visual Text Mining

1. Introduction

Systematic Literature Review (SLR) finds, collects, analyzes and critically aids research efforts towards the objective of formulating near precise strategies to address respective research question.[K+07]. This scientific approach has been conventional in the fields of medicine and sociology, and currently, and is the de facto strategy employed to systematically discover scientifically feasible answers to Research Questions(RQ) that motivated the need for a literature review. SLR's are different from normal literature reviews as they begin with an intentional, and purposeful selection of data that is included in the research study.

Since Kitchenham [KDJ04]introduced the Evidence Based Software Engineering EBSE method in 2004, many researchers have been motivated to apply the SLR method in the field of Computer Science(CS.

Now, SLR is the most evident based methodology for evaluating provisional data. The main aim of doing a systematic review is to adapt a systematic method of research, analyzing and critiquing the research and finding solutions to a specific issue. In simple language, SLR is a study of multiple papers and journals using different techniques. This will give a clear summary of the current evidence which can be later used for evidence based researches. Ergo, it is essential to review existing papers in order to find relevant proof of concept about a specific topic. SLR is the perfect systematic method to perform literature surveys.

Collaboration is a key strategy employed to cope with the complex, rapidly evolving tasks in today's research environments, and more specifically in computer science related disciplines. Collaboration can be defined as a complex task that depends on the team member's attitude towards various social and academic factors that involves cooperative factors. Teamwork, co-ordination, communication are some of the soft skills that are demanded in academic life as well as in real life [Mar15]. Thus, collaborative learning(CL) is an efficient learning technique to boost participation and performance in teams [SB19]. It is good to exchange and share knowledge among people who have different perspectives on a specific topic, as knowledge sharing(KS) is an excellent opportunity to manage knowledge among peers. Recent research and

studies shows that there are many factors that influence the performance of a team project. In the course of this SLR, we will be investigating different aspects of these concepts with respect to our research questions(RQ).

1.1 Motivation

Collaboration, and collaborative learning (CL) scenarios arise when two or more individuals actively work together on a defined objective, and possibly comes up with a set of possible results. Ergo, the main motivation behind this thesis is the analysis, comparative evaluation, and summarizing of relevant contributions in the research area of collaboration and collaborative learning in various fields of CS and SE. Thus, the need to perform an SLR on collaborative, and cooperative learning techniques. In the past, computer science, and software engineering tasks work was chiefly an individual task, and any form of collaboration was deemed as fraudulent [BSWH04]. Later on, as projects became more complex, the idea of "divide and conquer" was incorporated to the end that team members were assigned different tasks or modules to focus on. The outcomes of each individual task are then presented after a given deadline [BSWH04]. Therefore, it is crucial to comprehend the variables influencing team performance. The statement "Together, everyone accomplishes more" is evident...

Prior studies indicate that female students were not interested in working alone for a long period of time, in Computer science or Information Technology projects.As the time went, it was proved that women were capable of doing projects or task alone as well as in a group. Over the past 30 years, a considerable number of gender related research studies in the context of team collaboration have been conducted, and thus the challenge of measuring the influence of women in the information technology sector, and sciences in this context.[BSWH04].

This thesis focus on the factors that affect the behavior and stipulation of each of the individuals participating in different Computer Science project teams. As a matter of fact, collaboration can also be termed as cooperation. It means for a team work needs to be done, the cooperation and participation among the members is a very important factor. While the body of literature strongly suggests that team collaboration greatly improves learning, especially in computer science based courses. Several factors can be attributed to the success of a team. The purpose of this thesis will be the exploration of factors influencing collaboration in teams. Evidence regarding the impact of the gender gap on work teams and teamwork will also be crucial. The benefits of having women on teams are a crucial component of this review.
Being a woman, in a "male dominant" field, I find my thesis to stand out and hope it could be a motivation to all the women around the world to come forward to various STEM fields irrespective of whatever diversities existing.

1.2 Goal of this Thesis

Global computer science courses offer researchers and students the opportunity for evaluating the differences among the avenues of communication, particularly as they

might affect collaboration among teams. Also, the growing representation of women in the organizational workforce [BG97], and the use of relatively homogeneous teams in investigating group effectiveness in previous empirical studies [dWCKH15] suggest a need to determine the role of gender in shaping leadership dynamics within teams in the context of a given task.

Whenever group tasks were assigned in multi-gendered work groups, the members are potentially constrained by latent gender roles as a consequence of an unproved theory that men are more efficient than women in every way. Thus, men voluntarily select themselves as leaders in a collaborative group which suppresses the role of women. This can be referred to as "gender-role-constraint". To accomplish the goal of this thesis, we follow the following steps:

First, we assemble a collection of surveys and research papers to identify, select and review potential studies and articles to synthesize those which explains the importance of collaboration in teams, and also which specifically answers our research questions. On the selected literature, a quality assessment will be carried out. Finally, a comparative analysis, and evaluation will be carried out on the state-of-the-art strategies and answers we have elicited from the selected literatures.

1.3 Structure of the Thesis

The thesis is structured as follows,

Chapter 2: Through this chapter of background we try to explain the background information about SLR and CL.
Chapter 3 :Here we describe the SLR techniques that we perform to identify, analyze and selection of the primary studies and the quality assessments techniques.Following, we explain the research methodology of the SLR ,the results and proofs we obtained.
Chapter 4 :In this chapter, we are implementing the approach for the conducting phase of the SLR to obtain the most relevant and promising studies from the pool of journals we have. We define the steps for our approach ad the quality criteria we used for the assessment method.
Chapter 5: This will be the chapter where we recall the precision of the primary studies we selected and will assess a quality score to each of them.
Chapter 6 This is the chapter where the limitations and drawbacks we faced during the thesis are described.The validation of the data, accuracy of information and authenticity of the paper will be discussed in this chapter.
Chapter 7:Finally, we summarize our thesis achievement. Furthermore, We outline the potential future work in this field of study and can give authorization for it to be referred to in the future.

2. Background

In this chapter, the term SLR will be explained and will try to go further deep into the details of the stages of this research method. We explain the background information about collaborative learning and the impact of behavior on each individual team member's contributions to a team performance. Furthermore, we spotlight on several areas in which gender, personality or other criteria's that may or may not affect the performance and the outcome of the team.

2.1 Systematic Literature Review

An SLR, most frequently known as systematic review, is a systematic representation of the literature review of scientific contributions. This can also be referred to identify, evaluate and understand information related to a specific research question (RQ) for an area of interest. Before the review is undertaken, several criteria are carefully defined, and made apparent in the systematic review's protocol or plan as it is a thorough, transparent search conducted over multiple databases and gray literature that can be replicated and reproduced by other researchers [[DD16]]. The review will find out the searched type of information, analyses or criticizes it, and reports within a given time of interest. The keywords used for the search which including the research sites, other platforms, databases etc. needs to be added in the review. According to Pittway[PRM+04], he outlines the seven key principles behind basic SLR's [PRM+04]:

- Transparency
- Clarity
- Integration
- Focus
- Equality
- Accessibility
- Coverage

SLR begins with the selection of data and information that is needed to be included in the research study. Following, the data collected will be analyzed and criticized. To be specific, the data will be deeply analyzed to get the information from any piece of word. In the next step, the derived information is compared with the RQ. A correlation between the strategies used in the source papers, and, RQ will be carried out accordingly. Thus, in general, the primary step involves gathering data and information from different research platforms.

The three different phases that we have for SLR are :

- Planning
- Conducting
- Reporting/Documentation

The fig 3.2 shows a description of these phases which are further described in the next sub-subsections.

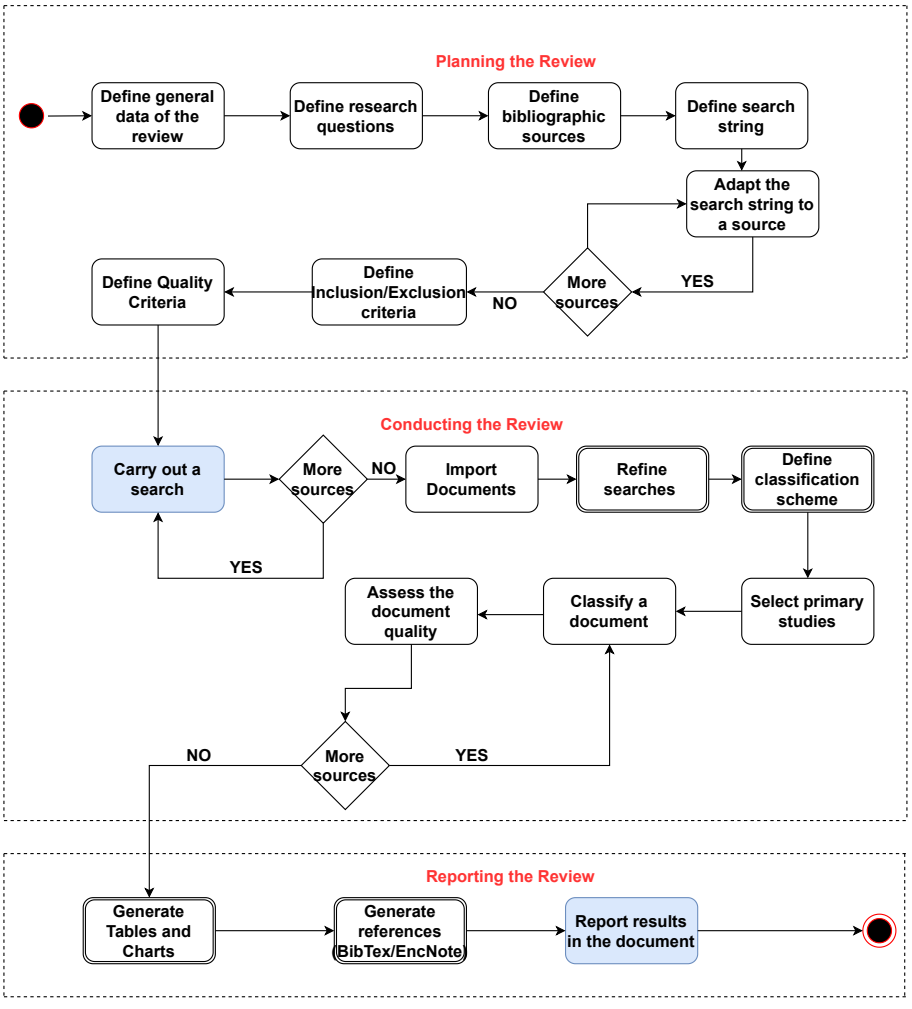

Figure 2.1: Phases of an SLR.,referred from ([ASG19])

2.1.1 Planning

Planning is the initial phase of an SLR. As the name itself says, a proper planning of what to do, how to do, what to get, how to get, are defined in this phase. This is an important phase as it is the foundation for the next phases. Next, the RQ is used to develop the review protocol.

The planning phase can be classified as follows[AKSL21]:

- Identification of the purpose for the SLR.
- Commissioning a review.
- Defining the research questions(RQ's).
- Creating a review protocol.
- Validating the review protocol

Identification of the purpose for the SLR.
The fundamental point of the review is to create a foundation for knowledge about the topic in question, to the end of which a clearer scope of which body of work the literature search will be covering.

Commissioning a review
In some cases, where the systematic reviews are commissioned, a document for the commissioning must also be prepared during this stage.
Defining the Research Question (RQ's)
Then, a necessary step is to specify the RQ's, which is the most important part of any SLR. The RQ's drive the entire systematic review methodology, and thus, :

- A relevant and significant set of primary studies, that responds to the research questions must be found through the search procedure.
- The RQ's must be answered, as well as the data items must be extracted.
- The data must be synthesized during the data analysis process so that the questions can be addressed. [FSBR10].

The crucial problem in any systematic review is to formulate the right RQ. The (RQ) must be meaningful and significant for researchers as well as practitioners. PICOC criteria are recommended by York University to structure the question(s). PICOC elements include Problem/Patient/Population, Intervention/Indicator, Comparison, Outcomes and Context of the Study. Since PICOC was designed to address SLR in the area of medical systems, we research on more or other form of criteria to define the RQ's for our context. Also, Kitchenham's guideline paper recommends this criterion that was suggested by Petticrew and Roberts in, to frame RQ's.[KBB+09].

Developing a review protocol.
A review protocol is an essential step to ensure validity and quality of the reviews. It outlines the methods and review questions to be addressed in the review, Inclusion criteria(IC) and Exclusion criteria (EC), search strategy, data extraction, and quality assessment. Introduction and usage of a well-defined protocol can result in a proper

basis for the review. The protocol defines in advance how the systematic review is going to be conducted, and such definition is necessary to structure the work, however, defining a protocol is a complex task[KBB+09]. The review protocol builds the review plan, which should cover the following components:

- Background: The background section is the literature survey section, which is the key foundation for the research questions.
- Research Questions: The RQ's that the review is intended to answer shall be included in the review plan. These RQ's must be clear to find and provide answers with significant data which can which can further be utilized. RQ's should be stated clearly and precisely using the protocol. They can be extremely specific or very vague, even if they are vague and broad, it may be more appropriate to narrow it down to more related questions to be more clear and specific questions[KBB+09].
- Search Strategy: The strategy used to search for collecting primary studies, including the search terms, search strings, keywords and resources (digital libraries, specific journals and conference proceedings) that will be searched.[FSBR10]. The strategy defines the RQ's, search terms with their abbreviations/synonyms and alternative spellings and builds the search query using Boolean expressions. The search resources are also defined in this step. Multiple searching methods might be used during the search, for example; snowballing, automated searching, manual searching, and contacting important researchers in the field (Primary level of review).
- Study Selection criteria: Some criteria for the studies are defined to determine which among them should be included in, or excluded from, an SLR. It is usually helpful to apply some criteria for selection on a selected subset of primary studies. The IC and EC are defined based on these RQ's.This step is helpful, because it saves effort and time. The IC should capture all studies of interest. If the criteria are too weakly defined, there is a risk of missing important and relevant studies. On the contrary, IC also needs to be practical to apply, if they are too detailed, screening and analyzing may become very complicated, time-consuming and tedious.
- Study quality assessment and procedures: To evaluate each study individually, we should create quality score criteria and quality checklists. The goal of the quality assessment will direct how checklists are created. The most challenging and time-consuming process is the QA. The purpose of quality evaluation is to determine the likelihood that the findings are accurate and whether they are pertinent to our understanding of the topic at hand. Each article is given a score based on its own criteria, and the study is then given the overall points. This is not common practice, as various quality factors are often evaluated through sensitivity analysis at the synthesis step.[KBB+09].
- Data extraction strategy: In this step, it defines how the data and information collected are obtained. If the collected data requires changes or sum-risings to be made, the protocol ought to indicate the course of validation.
- Synthesis of the extracted data: This defines the synthesis strategy.Synthesis can be defined as the process of collection, combination, evaluation and summary of

each study that has been selected and included for the review. The main task of that is to build the report of the result.The famous approaches that can be used for this technique are narrative and quantitative approaches. This enables reliable conclusions to be drawn. The stability and consistency of the evidences are also analyzed in this phase.

- Project timetable: This defines the review schedule in detail. The time needed for performing an SLR is considered depending on the difficulty level and complexity of the review. And that, too, each step should be specified clearly with the time needed and also with the deadlines.This is an essential organizing step, as it is helpful for building motivation and forming well organized steps.

Validating the review protocol

As it has already been discussed on how to develop and define the review protocol, we now discuss steps for evaluating the protocol. The protocol is an important element of SLR. Therefore, evaluating the proposed protocol is a critical task that should be considered by a group of experts in the research field and thus, should be carefully considered, and documented to obtain reliable results which can be used for future references.

2.1.2 Conducting

The second phase of an SLR is conducting. Once the review protocol has been created, evaluated and finalized, the phase of conducting, which includes finding relevant research, choosing and evaluating the quality of primary studies, data extraction, and information synthesis.[MCD+]

Following the guideline proposed by Kitchenham[KBB+09] for executing this stage while conducting the review ,are as follows:

- Identification of relevant research.
- Primary studies selection.
- Perform quality assessment.
- Data extraction and monitoring.
- Data synthesis.

Identification of relevant research
The first step of conducting the survey is to identify and finalize primary studies using an unbiased search strategy. For that, the review protocol defined in the planning phase is applied. The search strategies and methods can vary in different ways. For a more technical assistance, we can use semi-automated techniques. Manual strategy is also one form of method. Using semi-automated techniques, we can use existing digital libraries, databases, journal sites, indexing systems etc. [MCD+].

Primary studies selection
This step can be described as to ensure that the studies that are included for

consideration are relevant. Manual or semi-automatic selection of papers are the first step to gather information and collect papers, which could be more than a handful of papers. These papers must be reviewed, after which the relevant ones are selected.The selection of paper must be unbiased to confirm that these can be monitored for inclusion and exclusion steps. The selection is being done by various steps. The first selection of the papers are done by using keywords, key performance indicators, abstracts, titles etc.The resulting set of papers are then subjected to the Inclusion and the exclusion criteria. Once these criteria are met, then these papers are considered for the further steps as to find the relevance and finding solutions to our research questions.

Perform quality assessment
This is the most important step in the selection process.Analyzing the studies which we obtain from the final selection of primary studies is the function for QA. The implementation of the quality criteria defined in the planning phase is adopted here. The only problem in the quality assessment is that there is no guaranteed example or definition for quality. Thus, it is a challenge for reviewers. An illustration of the utilization of QA of essential studies in SE is the systematic review of experimental investigations of agile programming advancement[DD08]. As Kitchenham proposed principles of good practice of quality assessment, we are trying to implement the same here. The eleven criteria used to assess the quality of the studies covered four main issues:

- Reporting :Reporting: the accuracy with which the purpose, setting, and outcome of a study are reported.
- Rigor : The accuracy and reliability of the research techniques used to validate the methodologies and tools used for data gathering and analysis, as well as the veracity and accuracy of the conclusions.
- Credibility : The evaluation of the study methodologies' reliability to make sure the results were accurate and significant.
- Relevance : The evaluation of the study's applicability to both the larger software business and the research community. [DD08]

Data extraction and monitoring
In the data extraction stage, the aim is to collect the information that we obtained from the primary studies. The forms for the data extraction are defined in the review protocol. This helps in the consistency of the data extraction in an unbiased manner. These forms consist of RQ's, quality assessment criteria, IC and EC and all the basic information.

Data synthesis
This is the final step of conducting phase, which is the summarized result of all the included relevant primary studies. There are two ways for conducting the synthesis, either by formal statistical techniques (quantitatively) or through a rendering manner. Both quantitative and delivering synthesis ought to start by developing a reasonable descriptive synopsis of the included studies. As well as having the synopsis together, the delivering synthesis should consider the consistencies, inconsistencies, and strength

of the evidence. This ensures forming reliable results from the assembled body of evidence.[Sha17]

2.1.3 Reporting

This is the final phase of the SLR process. Ergo, the final reporting and documenting of the findings is done in this phase. This phase has significant impact on the whole SLR process. The findings are documented as a journal paper, technical report, a conference paper or a thesis chapter. There must be a specific method and structure followed to report these findings.Presentation manner, layout should be well-defined for that. According to Kitchenham, the stages associated with the reporting phase are:

- Specifying dissemination mechanisms.
- Formatting the main report.
- Evaluating the report.

Specifying dissemination mechanisms
The dissemination mechanisms are specified, for overall time saving. It should be precipitated and anticipated that what a reader is expecting from the report. Thus, it should be clear enough to present the findings of the review concisely. As a result, an accurate and consistent report can be obtained.

Formatting the main report

The format for reporting the review can be of two methods:

- As a technical report or as a research report.
- In a journal or a conference paper.

Evaluating the report

After completing the documentation of the findings in the final report, this report should be assessed and reviewed by several researchers with expertise in the topic area. The evaluation process can use quality checklists for SLR.

2.2 EBSE-Evidence Based Software Engineering

EBSE explains the use of evidence-based model for SE research and practice. The practice of empirical SE provides a cutting edge direction and guidance on how to conduct secondary studies and optional studies. The five steps used in EBSE are as follows[KDJ04],

1. Converting the need for data (about management procedures, development and maintenance methods, etc.)into a question that can be answered as well as a reliable inquiry.
2. Finding the best evidence to support your answer.

3. Evaluating that evidence critically for its applicability (usefulness in software development), impact (size of the impact), and legitimacy(practically possible)[KDJ04].
4. Integrating the critical evaluation with our SE expertise and the values, requirements, conditions, and situations of our stakeholders.
5. Evaluating the efficiency and effectiveness of Steps 1 through 4 and looking for ways to improve them for the next time that question is asked [KDJ04].

2.3 Snowballing

"Snowballing" also referred to as 'Pearl Growing', 'Bibliographic Search' or 'Citation Tracking' is a famous and proven search method for identifying important relevant articles on the research area of interest. The figure below shows the snowballing procedure.

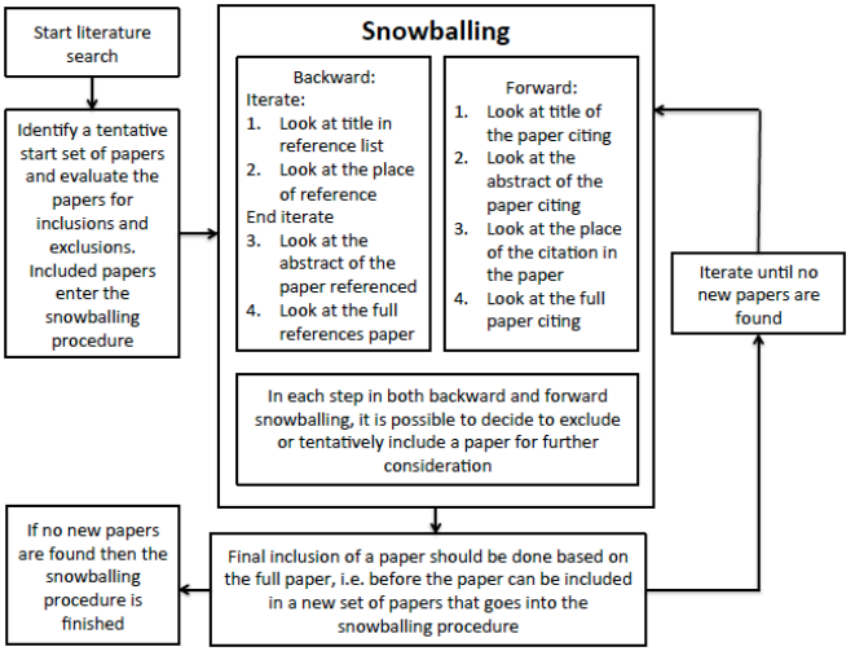

Figure 2.2: Snowballing procedure [Woh14]

2.4 Collaborative Learning(CL)

Collaboration is an ordinary action in business undertakings, and thus an essential skill for a person to possess when planning to apply for a new position in today's commercial sector[LY21] as seamless collaboration can increase the productivity of an endeavor. Collaborative learning is a success when a person is willing to share and contribute their ideas in a group to accomplish the project goals effectively. Individual assessment can be done before assigning the roles to a person to confirm what or which role that member should fulfill. According to [LY21], there are three primary team performance indicators, "Good","Pass","Marginal". Before the covid pandemic, collaboration was mainly achieved through physical and face-to-face meetings. However, during and after the pandemic, virtual collaboration became the

main avenue for most interactions and thus, the rise of online collaboration.

According to ([FC92]), a model of collaboration consists of five components:

- Personal Commitment.
- Communication skills.
- Interaction processes.
- Programs or services.
- Context.

Collaborative learning is also considered as an educational approach where student groups develop and enhance learning through working together. At the least, two individuals cooperate to take care of issues, to complete assignments, or to learn new ideas and concepts. For collaborative learning to be effective, Panitz and Panitz ([Pan99]) described five elements must be present. They are :

- Positive Interdependence.
- Face-to-face promotive interaction
- Individual accountability
- Interpersonal and small group skills
- Group processing

To encourage CL, and to make it simple and informal for groups working together, two methods can be adapted.

- Think-Pair-Share : Team members come up with a question on their own before discussing the ideas with another student to come up with a consensus.
- Jigsaw : One or more team members becomes “experts” on a concept and are responsible for teaching it to other team members.

2.5 Collaboration in Teams

Teams fall into a variety of categories.The term “action teams,” “project teams,” or “decision-making teams” is one such classification among them. “Action teams” typically engage in more behaviorally interdependent activities, requiring team members to arrange their activities to perform time-sensitive or actual tasks, whereas “Decision-making teams” are interdependent in relation to the relevant data. However, in order to achieve team objectives, “Project teams” engage in both informational-knowledge processing and behavioral actions.([Zho17])

2.5.1 Collaboration Technologies

History demonstrates the way that people can accomplish incredible things when they work together, coordinate and cooperate in teams. Strongly designed tasks, effective collaborative work practices and adequate information systems facilitates teamwork.[SBB+20]. The role of research on collaboration has intensively grown in general and research on Group Support Systems GSS in particular. There are currently 6 known contingency factors that affect group decision-making.

- Group size - Large/Small.
- Member proximity - Face-to-face/Dispersed.
- Task type - Generating ideas/Choosing Alternatives/Negotiation.
- Environment - Cooperative/Non.cooperative.
- Group type - Functional/Task (Project)/Interest or Friendship.
- Development Stage - Orientation & amp Internal problem-solving /Growth & Productivity/Evaluation Control [Ven96].

2.5.2 Factors of Successful Teams

When people from different backgrounds, cultures, and situations come together to work toward a common goal, many interpersonal dynamics determine whether the team succeeds or not. Sometimes a group of people can work well together and accomplish anything;However, it appears that other teams fail, despite the availability of resources. The effectiveness of a team performance can be determined by the seven factors mentioned below:

- Cohesiveness
- Communication
- Group-think
- Homogeneity
- Role identity
- Stability
- Team size

2.5.3 Five Factor Model

The probability that a user will use a technology may depend on their personality characteristics. A person's personality can be characterized as an enduring disposition that results in specific patterns of interaction with their environment[DVdVARP12]. Genetic influences on personality traits are averaged out by heritability. There are several ways to categorize personality qualities. The Cattell Sixteen Personality Factors, Eysenck's Introversion-Extraversion/Stability-Instability, Psychoticism-Self-Control, and Five Factor Model of Personality are the most widely acknowledged among them. (FFM)

- Extraversion
- Agreeableness
- Openness to Experience/Intellect
- Conscientiousness
- Emotional Stability/Neuroticism

2.5.4 Predictors of Team Work Satisfaction

A Predicting Teamwork Performance (PTPA) framework was created to help recognize the practical jobs of each member automatically[LY21].Thus, the outcome can be obtained from the factors such as:

- Personal skill sets results
- teamwork performance indicator
- Individual performance indicators
- recommended skill sets improvements

A simple representation of interaction of collaborative experiences can be seen in the figure below,

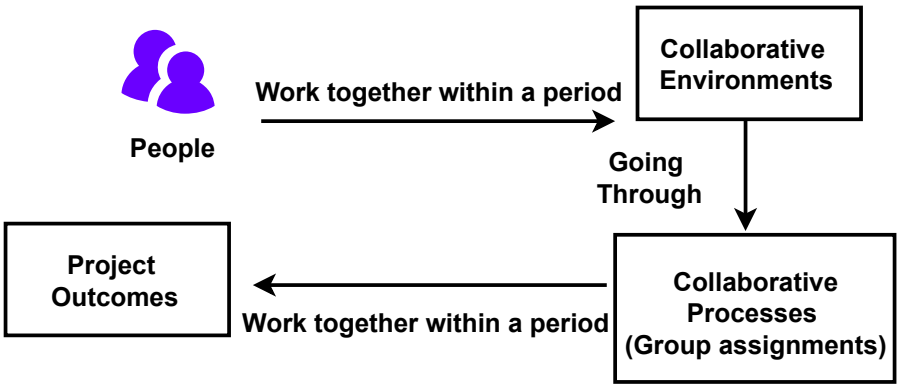

Figure 2.3: Interactions of collaborative experience [LY21]

Previous researches have demonstrated various elements that are intended to have an influence in student fulfillment with cooperation. Specifically, the span of the project and the structure of the group seem, by all accounts, to be significant. In particular, the duration of the project and the composition of the team appear to be important [HHHVBB06]. For a team work to be successful, the following criteria should be met:

- working towards a shared objective
- cohesive-i.e.share resources and are aware of each other's capabilities and assignments
- works together to obtain a common goal
- sharing resources

2.5.5 Ways of Measuring the Effectiveness of Team Work

Several measures have been used to evaluate the effectiveness of team work. They include:

Performance measures
This action might show up as a summative assessment, which includes contrasting a group's design and a model game plan arrangement [HHHVBB06].

Satisfaction measures
This involves a questioner based inquiry on a team's process from the team participants themselves.

Efficacy
This is a measurement in which the team's shared belief in their ability is used to evaluate whether a specific task can be completed [HHHVBB06].

Group Potency
This is a measure of a team's shared belief in their own ability [HHHVBB06].

Satisfaction
The estimation of how 'blissful" and 'fulfilled' students are while engaged in team collaboration [HHHVBB06].

Decision process satisfaction
The satisfaction of colleagues with their decision-making processes [HHHVBB06].

2.5.6 Tools and Interactive methods of Collaboration

There are various interactive methods and strategies to achieve success in the course of a collaborative task, or engagement. During the COVID-19 chaos, the importance of distributed collaboration had inevitably increased. Without the physical, face-to-face interaction, people including working employees and students had to find an alternate method to interact. The various media that were used for communication during those times were Microsoft Teams, Zoom, GitHub, Slack, Google Drive etc. Many researches and reviews were proposed in-order to share the tasks and collaborate among team using different repositories and compendium technique. To be clear, there were **Synchronous and Asynchronous** platforms for collaboration. Recent collaboration tool researchers investigated individual characteristics of the tools to benefit for different distributed teams[CR10]. Thus, a 5 evaluation framework characteristic was created. These are:

- Awareness
- Calendar Assist
- Context Persistence
- Coordination
- Visualization

2.6 Text Mining

Text mining(TM) is the process of deriving interesting information, potential and valuable patterns, non/trivial knowledge and trends from textual documents. Text is one of the quite possibly of the most widely recognized data types within databases. Depending on the data structure, this data can be organized as:

- Structured data
- Unstructured data
- Semi-structured data

Since the majority of data in the world is unstructured, text mining is a very effective strategy used by businesses. Companies can investigate and find hidden links in their unstructured data by using cutting-edge analytical approaches like Na ve Bayes, Support Vector Machines (SVM), and other deep learning algorithms.[[T+99]].

There are different categories for the classification of Text Mining. Some of them are:Information Extraction, Information Retrieval, Information Visualization, Document classification, Document Clustering, Document summarization. figure below explains the main TM applications that are being used in SLR.[FCL17]

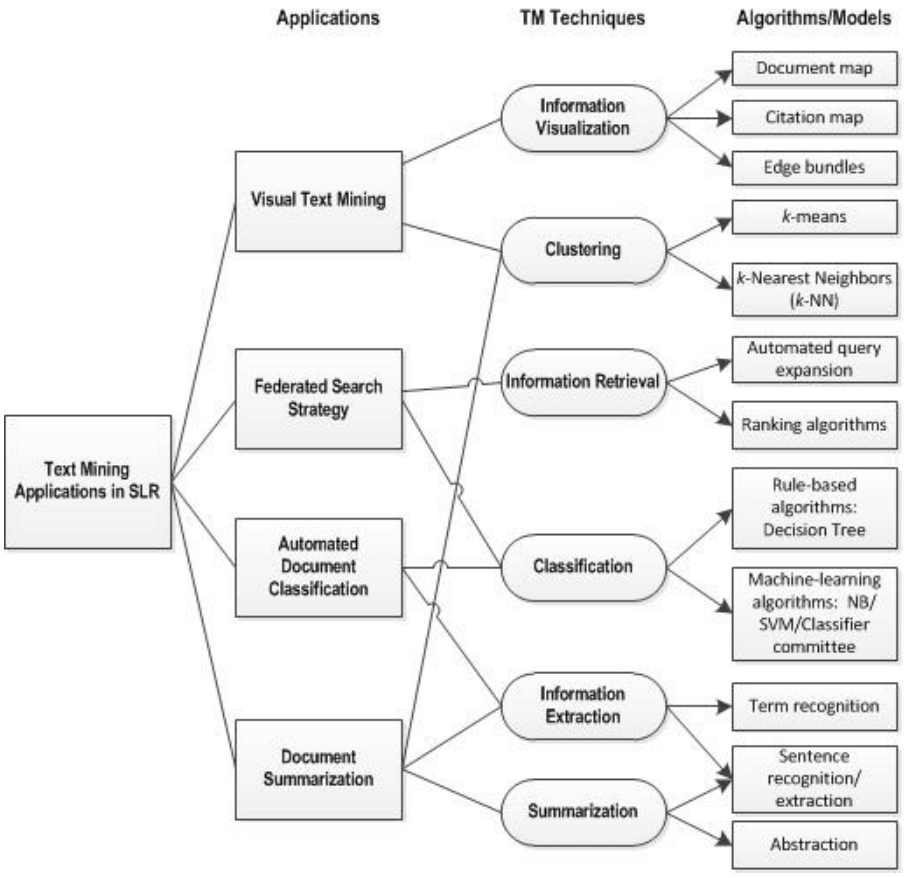

Figure 2.4: Text Mining in Systematic Literature Review from [FCL17]

Now, we will discuss more on different TM methods :

Information Extraction(IE)

The extraction of information is the basic step in text mining.This acts as a starting point for analyzing unstructured text and identifying key phrases, key performance

indicators Key Performance Indicators(KPI) in the document.This method is very much useful when handling huge data sets such as SLR's.

Information Retrieval(IR)

The retrieval of information gives easy access of information to the users.This IR deals with multiple aspects.Documents, webpages, and other items that contain information must be represented, stored, organized, and made accessible. A traditional IR model is the vector model. It is an algebraic paradigm in which the number of distinct terms in a collection, t, is used to represent documents and queries as vectors in t-dimensional space.[BYRN+99]

Information Visualization(IVi) The visual representation of the information as a hierarchy or map is termed as information visualization.This helps the viewers for a wide understanding of the information within a short time.In SLR,IVi helps for the decision-making faster than manually checking of huge amount of data.

Document Classification

Document Classification aims to identify the main theme of a given document.As the name itself suggests, it is the grouping of similar documents on some predefined criteria or concepts.In SLR, classification can be used with topics to specify the relevance of the document.After the classification, these documents can be ranked in order of which documents have the most content of a specific area.

Document Clustering Clustering is the technique that comes after classification.It is used for grouping of similar documents depending on the content and the topic shared.This clustering can be used in different areas, such as for grouping similar documents and eventually discovering meaningful implicit objects across all the documents.

Document Summarization This technique helps the users to make a quick decision on a document whether the relevance or need of them has been met or not.Summarizing can be considered as a difficult task as it is difficult to teach a software to analyze the sentences and the words and understand their meanings. There are various summarization tools. Some among them are position information and sentence extraction.In short, summarization can be used to analyze and then summarize the documents collected on a particular topic.

2.7 Visual Text Mining

Recently, there is a trend of increasing interest for Visual Text Mining(VTM) techniques as a supporting tool for SLR.VTM is a potential extension of TM,used to extract patterns and non-trivial knowledge from unstructured or textual documents[FSM13]. In our case, VTM is useful for the systematic finding of relevant primary studies.To be clear,VTM is an algorithm that helps the users to have a sense of collection of documents, without actually reading all of them[MHP+07].There are several approaches to handle VTM.The supporting tools such as Projection Explorer(PEx) and ReVis are used for the implementation. Some of them are:

- Document Map

- Edge bundles
- Citation Networks

The most common technique among the above is **Document Map**.The steps to create the document maps are as follows:

- **Clusters and Topics**: Text preprocessing for cleaning the primary studies.
- **Expression Occurrence**: Points on the document map represent the frequency of occurrence of particular user-defined terms from the original studies.
- **Neighborhood relationship** : stablishes a connection between primary studies and their neighbors to encourage study inclusion by association, i.e., the more closely related the neighbors of an included study, the more likely to be relevant to the SLR.[FSM13]

2.8 Technical Background

2.8.1 StArt Tool

StARt Tool is a tool which supports the whole SR process. The introduction to SR was happened in 2004 and from then, the problem of performing the review was difficult due to the time-consuming for that. Start tool was one among different tools developed for minimizing the effort and time investment or doing the SR.StARt currently has more than 3000 downloads from unique clients around the world, including nations like Brazil, the United States, Italy, Spain, the United Kingdom and others.[FSH+16]
This tool helps SR in the following steps:

- Defining a SR protocol.
- Initial Selection activity.
- Data extraction activity.
- Data Synthesis activity.

The tool has recently updated to a version which is helpful to perform collaborative systematic reviews.[1].

2.8.2 API

The searching and finding of papers are very difficult to handle if it has to be done manually. Hence, an approach which is reliable and time saving is by using existing API's. Some of the API's are Elsevier by Science Direct, IEEE Explorer, dblp etc.These API are very much helpful to integrate content and data to our own websites and applications.

1 https://www.youtube.com/watch?v=zCTKl1TBmxUab_channel=LaPESUFSCar

2.8.3 Database Management Systems

DBMS is a management system which is used by the user or an application program to access a database. The DBMS provides a wide range of features, such as improved database operation performance, data recovery, limited user access, and more. Usually an DBMS is for managing a large amount of data and these data can be stored in any manner.If the data is stored in relations (tables), it is known as a Relational Database Management System (RDBMS).

3. Literature Review

This chapter presents and discusses the SLR process conducted in the SE or CS domain for the purpose of identifying and learning about collaborative learning and collaboration in teams. Through this study, we assess and aggregate previous research outcomes in order to provide a balanced and objective summary of research evidence to answer our RQ's and find any gaps or unresolved problems. We describe in detail the process of conducting this SLR and the need to perform it. For this purpose, we follow the guidelines proposed by Kitchenham.[KBB+09]

3.1 Research Method

In this thesis, the focus is on the collaboration predictors and the collaborative learning techniques that are important when doing projects or any kind of research in a group or team. The impact of the contribution by the team members and the other factors that affect the performance of the work group is being analyzed.SLR, an efficient and unbiased strategy, is used for the analysis and comparison of the existing articles on the same topic. According to the guidelines proposed by Kitchenham, the three phases including planning, conducting and reporting is performed to find solutions to the research questions. These were summarized in the second chapter (Chapter 2).

3.1.1 Research Questions

In literature reviews, it is important to define research questions as part of the first phase, which is the planning phase. These questions will be the foundation for the further steps in the thesis. The thesis aims, among other objectives, is to explore the factors that influence collaboration in teams. Furthermore, of importance is the evidence of gender diversity on group processes and team performance. An important aspect of this review is the positive effects of the presence of women in teams, and will include a comparative analysis of the above-mentioned factors. Thus, the following RQ's are of interest:

RQ1:How do women shape the dynamics of groups and teams in computer science based course projects?
The main objective behind this RQ is to find the influence and effect of having women in the work groups. Nowadays, there are researches going on to find out the impact of having diverse people in various SE groups. Many researches have proved that having women in work groups shows a good result than a group with just men.[KBWN14]

RQ2:Which personality or behavior stimulates effective group interaction and how they affect the performance of the work teams?
The motivation behind this RQ is to find out which personality or behavior stimulates a positive outcome and how does the full effectiveness of doing projects or work in group can be achieved. The requirements people consider when forming a group and the factors that affect the performance of teams should be discussed as a response to this RQ. Whether there is any consideration of homogeneity or heterogeneity in the selection of group also needs to be discussed.

RQ3:How does the work groups and project team perceive the usefulness of collaboration?
The outcome of a teamwork depends on how the team members accept the ability, diversity and performance of other team members. Collaboration is a term defined to express the need of doing tasks in a group rather than working independently. This RQ is defined to discuss more on the usefulness and need of collaboration in computer science teams.

RQ4 : What factors can affect performance of work groups and teams?
The outcome of a project depends on various factors of the work groups/teams. The various diversities among different individuals and team members affects the performance of the group. The integration of technology and education promotes CL. The various student factors will include gender, openness to argue, learning style etc. Thus, the outcome of a work consists of knowledge construction and acquisition process [SBSH14].

RQ5:What are the different tools and approaches used for conducting SLR in CS or SE domain?
The aim of this RQ is to perform a comparative analysis on various tools used to perform SLR in SE or CS areas.

These RQ's will be discussed elaborately in the Reporting(3.3) section

3.1.2 Search Strategy

After describing and formulating the research questions, we give a description on the strategy for searching for, and identifying suitable literature. This methodology involves formulating the keywords for the search step and utilizing them inside the search string. The search process for the literature survey is basically made using

forward and backward snowballing techniques. A good and well-structured search strategy can help the researcher to identify and retrieve as many studies as possible. The figure below shows a typology of the search methods used in systematic reviews.

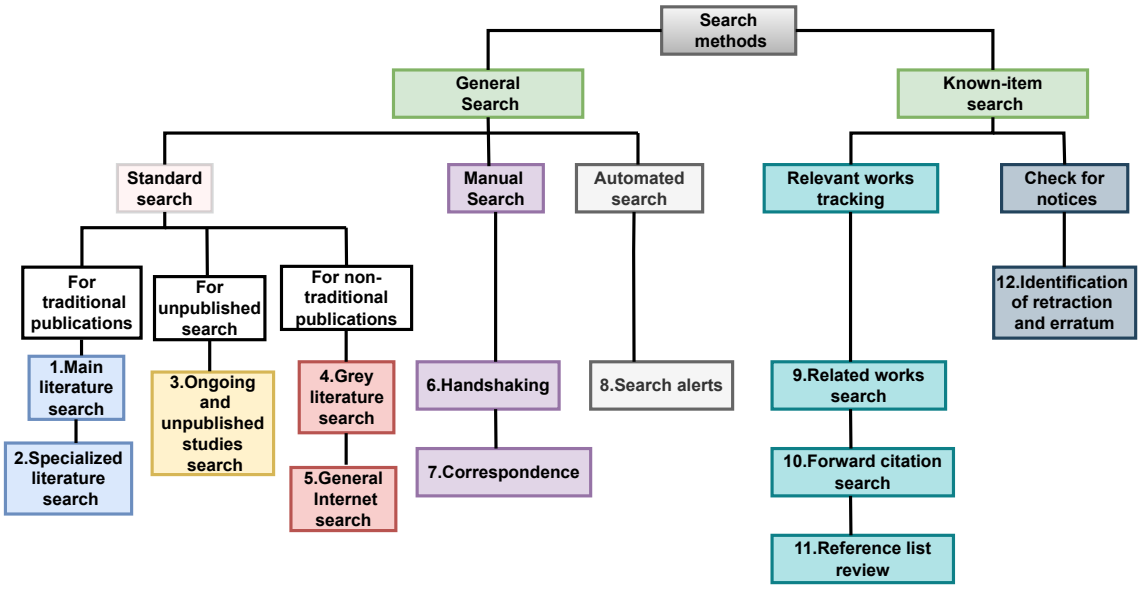

Figure 3.1: Search Method typology

3.1.2.1 Search terms/keywords

For obtaining better and most relevant studies, it is important to define the keywords or search terms which are most related to the research questions and the main aim of the thesis. In fact, the keywords should be closely related to the RQ's. We created the search string based on the following keywords, shown in table 3.1.

Section	Keywords
A	" collaboration" and all synonyms
B	" systematic literature review" and all synonyms
C	" work groups" and all synonyms
D	" teams" and all synonyms
E	" collaboration predictors" and all synonyms
F	" collaborative learning" and all synonyms
G	" computer science" and all synonyms
H	" data mining" and all synonyms

Table 3.1: A search string structure

3.1.2.2 Data sources

The search strategy will not be complete if the sources to be used and how to search them is not mentioned. The list of sources will be containing the relevant online digital libraries for finding CS publications. These digital libraries are trustworthy

to a certain extent and covers the majority of the high quality publications in CS. The data sources which we chose for the selection of primary studies is shown in the table below.

Data Source	URL
Scopus	http://scopus.com.
IEEE Explore	http://ieeexplore.ieee.org.
ACM Digital Library,	http://dl.acm.org.
Springer	http://link.springer.com.
Google Scholar	http://scholar.google.com.

Table 3.2: Data sources for the SLR

3.1.2.3 Search strings

The search terms/keywords mentioned in the Table 3.1 are used for creating a search string. These search strings are used in different data sources to identify the relevant studies with the mentioned keywords. The keywords are thus joined using AND, OR Boolean operators to apply conditions. Using these Boolean expressions, we formulate the search string which can be used to obtain maximum relevant results:

TITLE-ABS-KEY(“collaboration” OR “collaborative learning”) AND TITLE-ABS-KEY (“systematic literature review” OR “systematic review” OR “systematic literature reviews” OR “systematic reviews” OR ”SLR”) AND TITLE-ABS-KEY (“quality assessment”)AND TITLE-ABS-KEY (“data mining” OR “recommender) AND TITLE-ABS-KEY(“collaborative learning”OR “collaboration predictors”) AND TITLE-ABS-KEY(“work teams”OR “work groups”)

3.1.3 Study Selection Criteria

To identify and collect relevant primary studies for addressing and answering the research questions, we define certain criterion’s. Such criterion’s can be termed as Inclusion and Exclusion criteria(IC and EC). These criterions are applied to the papers that we collected from the different data sources (mentioned in the section above).The IC and EC defined for our literature is as follows:

Inclusion Criteria

- Papers must be officially published in a journal/conference.
  To ensure the quality of the result, the proposed approach should be reviewed the proposed approach must be reviewed prior to the publication.
- The content format of the paper should be PDF.
  Audio, video or HTML pages are ignored.
- The paper should be related to Computer Science domain.
  As this SLR focuses only on SE domain, we limit our focus on studies conducted in the Computer Science domain.

- The study has been conducted or released between 2009 and 2021.
  The guidelines to lead an SLR in SE were proposed by [KBB+09]. Articles that published after these guidelines and up until the time we conduct the review are the focus of this review.
- The paper should include a part addressing Collaborative learning, work groups or participation of women in project groups.(Primary priority content)
- The paper should include gender roles on the primary priority content.(Secondary priority content)
  This review will focus mainly on Collaborative Learning and the impact of having women in the work groups.
- There should be accessibility for the whole paper.
  Due to the limitations in digital libraries and databases, many articles are inaccessible even though we use the university subscription. Thus, only papers with full accessible text are considered.
- Technical reports and Bachelor/Master/PhD thesis papers.

Exclusion Criteria

- Papers not written in English.
  A standard language is selected for the purpose of addressing data.Here, we are using the language English
- Abstracts and PowerPoint Presentations.
  Complete text of the study is preferred to ensure good quality and provide the required amount of data.
- Articles with unknown publication type or publisher.
  To acquire better quality outcomes, articles with inadequate data with regard to creators or distributors are rejected.

3.1.4 Quality Assessment

Assessing the quality of the primary selection of studies is another critical step after defining the IC/EC criteria. The guidelines proposed by [KBB+09] defines how to perform meticulous quality assessment of the selected papers. After the set of studies have undergone the IC filtering process and EC criteria, the next step is the implementation of the QA. For the completion of this step, we define some quality criteria check lines. Some of these criteria are as follows:

Problem Statement

QC 1 Has the aim of the research been clearly defined?
The aim and goal of the research in the study should be clear. If there are unclear descriptions, the paper can be given a score 0=NO. If the description is partial, then the score can be 0.5=PARTIAL. If none of the above cases, which means the paper is pretty clear about the aim of the study, the score can be 1=YES.

QC 2 Is there a proper description addressing the choice of research area?
Studies with a clarification to help determination of the subject for research are appointed a score of 1=YES, if not 0=NO.

QC 3 Does an experimental procedure, if present, been properly explained to justify the aim of the research?
The experimental procedure must be clearly explained by the authors. This includes all the steps required to achieve established goals. A score of 1 may be assigned to the paper if adequate descriptions are provided; a score of 0 will be assigned if the descriptions are insufficient or unclear.

QC 4 Were the results achieved via feasible methods?
The results of the study conducted represents the permissiveness of the proposed approach. If the proposed approach is useful, a score of 1=YES can be assigned, otherwise a score of 0.5=PARTIAL is assigned.

QC 5 Does the test proof help the discoveries that were introduced?
If there is a feasibility solution is described to evaluate the proposed approach with results that support the findings, a score of 1 can be assigned. If there is no study performed for the evaluation, such that the results do not support the presented findings, a score of 0 will be assigned.

QC 6 Is the research method appropriate and of benefit to the SLR in the SE field?
If the research method is appropriate for the SLR and can benefit the researchers in the SE field, then yes and a score of 1 is given and 0 otherwise.

The four main areas of empirical research for the quality assessment criteria as explained by [DD08] are:

- *Reporting*
- *Rigor*
- *Credibility*
- *Relevance*

The quality of each of the selected primary papers are assessed using the quality criterion's mentioned above. On a scale of 0 to 1 we assign a score to each of the papers to find the best quality paper.

3.1.5 Data Extraction and Data Synthesis

After assessing the quality of the primary studies, next it comes to extract the relevant information for answering the defined RQ's. In this step, the step intended to follow is that, we try to collect information from each of the selected primary studies and synthesize in a manner which is really appropriate for the whole study. The papers should properly address the research questions, and then only the consistent extraction could be performed. The standard information defined by [KBB+09] should be included for the data collection forms:

- ID
- Author(s) details
- Title
- Publisher details
- Year of publication
- Publication details: Volume and Issue
- Page numbers

To ensure consistency, the extraction forms should be well-defined. To achieve that, along with the above information, the following sections from each primary study is collected[KBB+09]:

- Aim and Summary of the study
- Name of the proposed method
- Description of the method proposed
- Explanation of the methodology
- Summary of the findings
- Results of the evaluation and the goals achieved
- Limitations of the approach

3.2 Conducting the Review

Conducting the review based on the defined methodology is the next phase after the planning phase. After defining the review protocol in the planning phase, the conducting phase is initialized. This phase includes relevant research based on the keywords and the search strings defined, selection of the primary studies and the quality assessment.

3.2.1 Identifying relevant research

This is the first step of the conducting phase. The previously mentioned search strings are applied to all the available and selected data resources. When done with the search, there are more than a handful of studies to evaluate. The table below shows the number of articles (studies) initially retrieved from each of the digital sources. The table below represents a part of the result of the initial selection. We have tried to retrieve as many papers as possible. After the initial selection of the primary studies, we manually checked the title-abstract-keyword of each paper to decide whether to hold or remove the paper from the list.

Database	Number of papers
ACM Digital Library,	2706
IEEE Explore	214
Scopus/ScienceDirect	160
SpringerLink	50

Table 3.3: Search results

3.2.2 Selection of Primary Studies

According to Kitchenham, the selection of the primary studies is usually done in a two staged process. At first, as mentioned in the above section, the primary list of studies are filtered by analyzing the title, abstract and keyword. Irrelevant papers are thus rejected. After this step, the full copies of the accepted papers are obtained and the IC,EC criteria are applied. Thus, the results are obtained using the snowballing technique. The set of primary studies is shortlisted. The figure below shows the process and the steps included in selecting the primary studies.

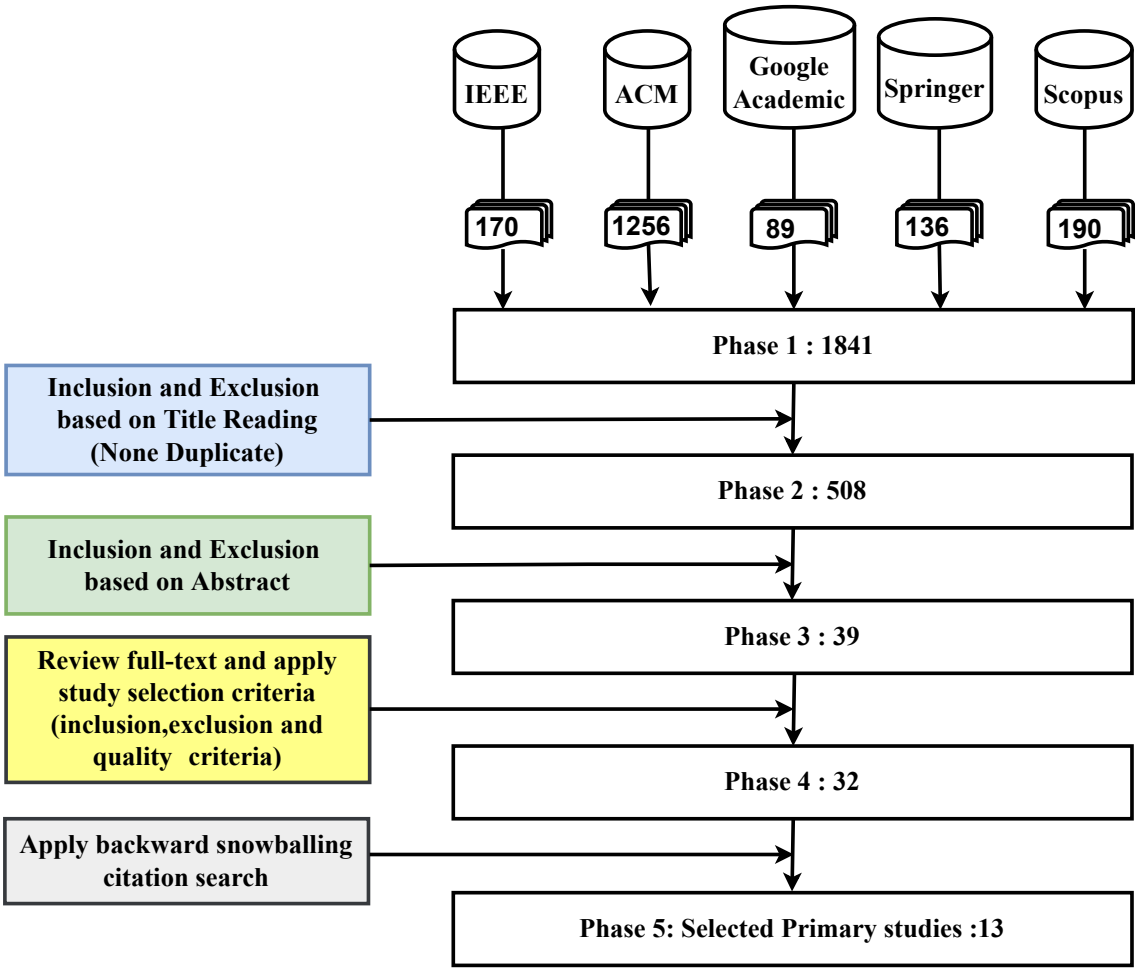

Figure 3.2: Identification and selection of primary studies

- **IEEE**
  IEEE Xplore digital library is a database for research discovery and permission to use to journal articles, conference papers etc. After searching and finding the papers related to our topic, it was clear that there were many false positives. Initial count of the papers were 170. After iterating over the abstract, keywords and the whole paper,6 papers were finalized for the review.
- **ACM Digital Library**
  The ACM Digital Library (DL) is the world's most used and thorough

database of full-text articles and literature of bibliography covering computing and information technology. The count of unwanted and false-positive papers in the search result in ACM library was disappointingly high. The total number of initial results were more than 1000. We applied all the IC/ EC criteria and filtered the papers. Even after that stage, more than a handful of papers was obtained. Then we had to apply the extraction criteria which was to go through the whole paper to get answers for our RQ's significantly resulted in a small list. The final list of papers accepted for evaluation was 2.

- **Google Academic/Scholar**
  Google is a free web search which can be accessed by anyone with a little knowledge. When searching in Google Scholar, it was easy compared to other digital libraries. The data and details of all papers were very much visible and was easy to select/ignore them. The unbiased result included a list of 89 papers, which further was filtered using the filtering criteria we already defined.

- **Springer**
  It is an online database of science journals. From this database, the initial collection of papers count was 136. Through deep reading and analyzing, the count was reduced. By applying the IC,IC criteria and reviewing whether to find answers for our RQ's, a significant amount of false-positive papers were ignored.

- **Elsevier/Scopus**
  This is a multidisciplinary reference dataset of peer-reviewed literature with tools to follow, analyze and visualize the research. It contains almost full text articles from journals and books, fundamentally distributed by Elsevier, but including some facilitated societies. Scopus attempts to file and index the metadata from abstracts and references of thousands of publishers, including Elsevier. In our research, we could filter and finalize 3 papers from them, related and relevant to our topic.

3.2.3 Quality Assessment

The last step performed in the conducting phase is the QA of all the primary studies selected for SLR. The quality of the papers are analyzed using the guidelines define by [KBB+09]. The purpose of the quality assessment in this research is to assess the quality of papers related to our primary topic shortlisted in SLR. Not every paper focuses on the primary topic. Some of them focuses and on the secondary topic or answers to the RQ's. The main reason for assessing the quality of SLR is to analyze the purpose and confidence of the review findings. Selecting an appropriate tool or defining quality scoring criteria will help to analyze strength of the evidence of quality, as avoids bias with each relevant paper.

Cite	Title	Year	Library
[SBSH14]	Affordances of computer supported collaborative learning platforms: A systematic review	2014	IEEE Xplore
[RPNN21]	Perceived diversity in software engineering:A systematic literature review	2021	Springer
[CAK18]	Towards a Bio-inspired ACO Approach for Building Collaborative Learning Teams	2018	IEEE Xplore
[GDW+20]	A Study on the Behavior Pattern of Collaborative Knowledge Construction by Analyzing the Design Tasks in Collaborative Learning	2020	IEEE Xplore
[YRDB21]	Understanding Women's Remote Collaborative Programming Experiences: The Relationship between Dialogue Features and Reported Perceptions	2021	ACM
[Wag16]	Gender and performance in computer science	2016	ACM
[CRPN14]	Does gender matter for collaborative learning?	2014	IEEE Xplore
[VHL22]	How do table shape, group size, and gender affect on-task actions in computer education open-ended tasks	2022	IEEE Xplore
[DPF15]	What do we know about high performance teams in software engineering? Results from a systematic literature review	2015	IEEE Xplore
[OMB19]	Group Formation for Collaborative Learning: A Systematic Literature Review	2019	SpringerLink
[ACC12]	Dispersion, coordination and performance in global software teams: A systematic review	2012	IEEE Xplore
[Mar15]	Software engineering education—does gender matter in project results?—a chilean case study	2015	IEEE Xplore
[FS18]	Gendered Risks of Team-Based Learning: A Model of Inequitable Task Allocation in Project-Based Learning	2018	IEEE

Table 3.4: Selected primary studies

The main motivation and purpose of our thesis is to research on collaboration in teams. Using the checklist we defined in 3.1.4, we assign score for each primary studies to aggregate and fins the final score. The scoring process is done as follows:

- 1 = Yes
- 0.5 = Partial
- 0 = No

Cite	Q1	Q2	Q3	Q4	Q5	Q6	Final Score/6
[SBSH14]	0.5	1	0.5	1	1	1	5
[RPNN21]	1	1	1	0.5	0.5	1	5
[CAK18]	1	1	0.5	1	1	1	5.5
[GDW+20]	0.5	1	1	1	1	0.5	5
[YRDB21]	0.5	0.5	0	0.5	0.5	0.5	2.5
[Wag16]	1	1	1	1	1	0	5
[CRPN14]	1	1	1	1	1	0.5	5.5
[VHL22]	0.5	1	0.5	0.5	0.5	0	3
[DPF15]	0.5	1	1	1	1	1	5.5
[OMB19]	1	1	1	1	1	1	6
[ACC12]	1	1	0.5	0.5	0.5	1	4.5
[Mar15]	0.5	1	0.5	0.5	0.5	0	3
[FS18]	1	1	1	1	1	0.5	5.5

Table 3.5: Scoring of Selected primary studies

Apart from the primary studies, we have considered some studies for the reinforcing the research area and find more evidences for the research topic. Some of them are the following:

- [TNDC22] : This paper summarizes the foundation for team assembly using online recommender systems for selecting potential teammates. This study also highlights technology enables team assembly from a network perspective.
- [KKS17] : Here, they present a deliberate identification and perception of group communication impacts and varieties for field study on records of more than 30 student programming projects.
- [RRGdO21] :In this article, an automated approach is proposed to help teachers in prescribing gatherings of students to learning the board frameworks systems (LMS's).
- [SB19] : This study is focused to point-out applied specific strategies in the CL environment for creating an online knowledge sharing tool on computer based systems.
- [MMB19] : This paper surveys recently (until 2017) published and relevant papers in group formation process, which provides a systematic literature review
- [AMBS16] : This paper presents a systematic literature review that analyzes the solutions for the obstacles of group formation in mobile computer supported collaborative learning contexts.
- [LY21] : This is a systemPTPA developed to identify the functional roles of each member automatically. It also analyzes the positive and negative effect of each and every group members contributing to the group.

- [QBF+19] : This article uses correlation and linear regression in helping to form groups for collaborative learning.
- [MPN21] : This paper is a systematic review researching on collaborative learning, collaborative memory and gathering conceptualizing, speculations and presumptions about the advantages and disadvantages of individual arrangement for collaboration and what this will be meant for by the plan of person readiness will be created.

Now, we will briefly explain our primary studies.

- [SBSH14] : This is a systematic literature review on different technology driven platforms that supports the design, monitoring or even motivates the members of a group to embrace collaborative learning activities. They have also tried to find different technological tools or platforms that have been developed for CSCL.
- [RPNN21] : This paper is also a SLR which describes about the perceived diversity in SE. Perceived diversity is a high value team property which emphasizes the efforts to create more diverse work teams. Alongside with the gender diversity, this paper focuses on different diversity factors such as race, nationality, disability and age of developers or team members in computer science. The ultimate goal of this paper is to identify the gaps in the current literature and create a call for future action in perceived diversity in SE.
- [CAK18] : This paper is also an SLR to address the relevant research works that addresses the students grouping problem. They have adapted an ACO algorithm to discuss advantages and disadvantages on group formation among students.
- [GDW+20] : This research focuses on the design tasks of collaborative learning. LSA is used to explore the differences in the sequence of behavior activities of the participants in the different stages of completing the design projects.
- [YRDB21] :. This paper covers a study in which 58 introductory computer science students constructed code remotely with a partner following either predefined structured roles (driver and navigator in pair programming) or without predefined structured roles. No matter what the cooperation condition, ladies revealed altogether more elevated levels of pressure, lower levels of perceived competence, and less perceived choice compared to men.
- [Wag16] : They investigated whether there is a performance gap in addition to the gender gap in this article. The author investigated statistical data on student performance in a CS course from 129 universities in the United Kingdom from 2002 to 2013. They were able to achieve their goal of giving male students, on average, more first-class degrees than female students. Subjects Allied to Medicine, Business & Administrative Studies, Mathematical Sciences, and Engineering & Technology are the four other subjects they evaluated and found that they do not exhibit this performance gap. Based on this finding, they looked at possible solutions to close the gender and performance gaps, as well as explanations and clarifications

for those gaps. The majority of solutions do not necessitate significant institutional change, making them straightforward to implement.

- [CRPN14] : This paper describes about the roles of student's gender plays during collaborative learning and their learning performance. They have tried to explore and investigate on the different mixture of groups such as just female, just male and mixture of male and female groups. The result from this study is that the female groups tends to work simultaneously and achieves better results as male group members engage less and work in sequences.
- [VHL22] : This is an evidence to the CS field by focusing on the interaction between the shape of the tables, size of the group, gender and their effects on-task collaborating leaning actions. As a result of this study, the analysis shows the tendency of female students to engage is more in the team activity.
- [DPF15] :This article is a SLR researching on the high performance teams in SE. The authors have tried to understand different contexts and conditions in which SE teams are likely to achieve their success.The result suggests that there are many characteristics that positively and negatively affects the process of teamwork.
- [OMB19] : This paper is also an evidence of SLR that investigates group formation, which is a first step in collaboration or collaborative learning.The review has revealed the current state of the art in the group formation (till 2019). Ideal proportion of group, different learner characteristics etc. has been reviewed in this paper.
- [ACC12] : The authors have performed a SLR to summarize the evidence on the relationship among dispersion, cooperation and coordination within teams and performance in global software projects. This paper can also be referred in the future for establishing effective distributed team coordination.
- [Mar15] : Does gender matter for better project results in CS or SE teams? Yes, they do.From this study article, the author tried to find answer to this question from her experience over assisting SE courses.Her study result summarized that mixed gender teams were more effective and coordinated.
- [FS18] : This paper proposes a conceptual model for task allocation among students in project based learning(PBL).The authors have also tried to find how the gender affects the working of project teams, and how does the team(STEM) works with the apportioning of gender roles in inequitable ways.

3.3 Reporting the Review

The last and final step of conducting the SLR is to summarize the obtained results and collecting the findings into one clearly described report. The studies we obtained and the assessment of the paper's quality are defined in the Table 3.5. The brief description about the primary studies shall help us find answers to our RQs.

- **RQ1) How do women shape the dynamics of groups and teams in computer science based course projects?**
  The intention to define this RQ is one of the main goal of our thesis. Along with finding the importance of coordination and collaboration in a group, we would like to find the importance of the presence of women in those groups.
  Software development is a stunning development that requires a social event of people working really as a team.Recent studies recommend that adding more ladies to a group can make them on the whole more astute, as ladies are by and large observed to be better (than men) at perusing and answering to others' feelings. ([KBWN14]). In a Chilean case study on SE education conducted by Maira Marques([Mar15]), she observed that mixed gender teams performed better in CS courses. She performed an analysis of the behavior and result of software projects over students of nine different semesters.Thus, she obtained the result stating that an effective and coordinated team performance happened in mixed gender teams.
  There have been many researches conducted to find out the impact of having female presence in work groups.But, there are only very fewer papers focussing the same in SE or CS domain.
  Recently, a bunch of researches has begun to investigate the environmental factors that promote or deter women's participation in STEM fields, including the culture and gendered stereotypes and incidents of bias as well [LS22].
- **RQ2) Which personality or behavior stimulates effective group interaction and how they affect the performance of the work teams?**
  The aim behind this RQ is to figure out what are the different characteristics that stimulate effective group interaction and how those personalities affects the group performance.
  In a study conducted by Wolley et al., [WCP+10], she established three main factors that have the most effect on team performance and collective intelligence. Those three factors are,
  - Social Sensitivity
  - Turn-taking behavior
  - Proportion of females in the group

  The objective of her research was to test the speculation that gatherings, similar to people, do have trademark levels of knowledge, which can be estimated furthermore, used to foresee the gathering's presentation on a wide variety of errands.In theory, the performance of cognitive tasks cannot be correlated because, one task if it is relying on a specific set of capacities can cause neglect of others. The main question that arise when considering the cognitive capacity of a group is that, is there any single factor that acts as a common denominator for analyzing the capacity of an individual as well as the capacity and performance of a group.In a research [WCP+10], it was proved that the average and maximum intelligence scores of individual group members are not significantly correlated.
  The consequences of these investigations gave significant proof to the presence of cognitive intelligence in groups, undifferentiated from a notable

comparative capacity in people. To note, this collective intelligence factor appears to be influenced by elements that emerge from how the group is put together as well as factors that were present before the group was formed, i.e, their turn taking behavior.

Many researchers have identified that there are two main measures of team effectiveness: **task performance** and **team member effectiveness**. The team member effectiveness can be obtained by analyzing the satisfaction, participation and willingness to work together [KBWN14]. There are various findings presenting the subjects of team composition and the factors that affect the team effectiveness. But unfortunately, there is no single factor that shows the key to a greater performance of teams.Recent studies have shown that team success has less to do with individual smartness, but it's the team's dynamics.

- **RQ3) How does the work groups/ team perceive the usefulness of collaboration?**
  It is an obvious fact that "Together, everyone accomplishes more"(Michael Lembach,2005). A study was conducted in the Web Interaction Design and communication in Copenhagen Business School focusing on the student's perception of collaboration, e-collaboration and group performance.The survey consisted of questions covering different aspects of collaboration including satisfaction, assessment of outcome of collaboration, factors that may impact joint effort and different method for collaboration. For each of their questions in the survey, they received recurring responses.Additionally, the survey included some questions about the different tools used for collaboration [RK15]. The graph below was the final result of the survey, showing the overall satisfaction of the collaboration.

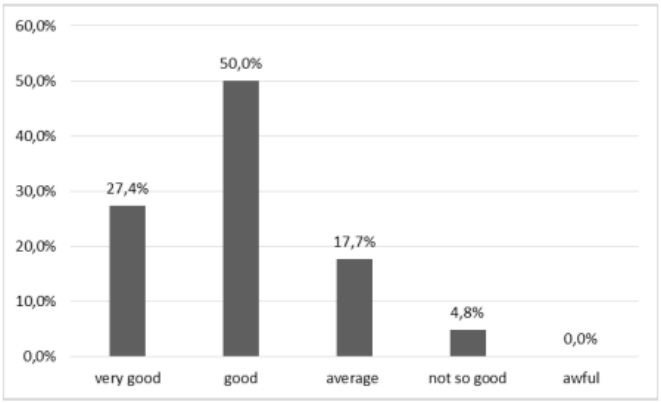

Figure 3.3: Overall satisfaction of collaboration.[RK15]

- **RQ4) What factors can affect performance of work groups and teams?**
  Collaboration can be characterized as an interaction by which "people negotiate and share meaning pertinent to the critical thinking job that needs to be done" [SBSH14].Many researchers has identified that the three main components of CL is mutual engagement, joint decision-making and

discussion [SBSH14].The table below shows the major 5 dimensions of collaborative learning defined by [SBSH14].

Main Dimension	Sub-Dimension	Description
Communication	Sustaining mutual understanding	– verbal and non-verbal acknowledgements – grounding concepts – explicit feedback strategies
	Dialogue Management	– turn taking – attention grasping
Joint Information Processing	Information pooling	– eliciting information from one's partner – by externalizing one's own knowledge in a timely manner
	Reaching consensus	– reaching a decision concerning solution alternative – critically discussing different perspective
Coordination	Task Division and Technical Coordination	– individual work phases should be scheduled – discussion plans for how to approach a task – allocation rules are set up
	Time Management	a time schedule is set up
Interpersonal Interaction	Reciprocal Interaction	– encourage and respect contributions – equality in contribution
Motivation	Individual task orientation	individuals show interest/enjoyment in their tasks

Table 3.6: 5 Dimensions of CL
[SBSH14]

Effective team coordination is a main aspect of successful global projects.High performance teams formed by groups relies on each of the team members

should have a common vision to identify and motivate each other and develop activities and task through communication. Even when there is diversity of culture and other characteristics in the group, enable and appreciate the innovation from every individual builds confidence and yields a better result.

- **RQ5) What are the different tools and approaches used for conducting SLR in CS or SE domain?**

  Large SR's are complex and difficult to manage manually. In order to support the production and updating of high quantity data for SLR,different and standard tools can be used as reference managers to get an elaborated and error-prone review.

  – **SLuRp**[BHB12] : SLuRp is an open source web enabled database that supports the management of SLR's.It is very much intact and helps in supporting almost all the phases for conducting SLR. The different steps included to use SLuRp is as follows:
    * Identifying relevant research :Define RQ, search terms,IC/EC criteria,QA criteria.
    * Select primary studies: SLuRp have access to almost all the digital databases(ACM portal is an exception).
      · Thus, semi-automatically, it extracts papers from the available databases and saves them.
      · Imports the bibliographic details in BibteX/RIS format by using different management systems.
      · Allows to apply the IC/EC criteria (Assigned for more than 2 reviewers)
      · Saves the assessment and saves the reason for rejection/acceptance
      · Identifies difference in the proof of concept of the reviewers (If there is more than 1 reviewer)
      · If there is a clash between the selection/rejection reasons, the frequency of disagreements is calculated and reliability scores are produced.
      · Finally, SLuRp will store the data of the accepted papers.
    * Assess the quality of study

    Advantages
    * Allows searching of individual digital libraries with library specific queries.
    * Maintains records of past SR's and their results.[MBK18]

    Limitations
    * No support of cross-library queries
    * Automated Search is not supported.

  – **StArt**[HZFT12] : StArt is a tool created aiming to facilitate and support the conduction of a repetitive research and review processes such as SLR. This tool provides support to almost all the phases in an SLR except the automated search of primary studies in digital/electronic

database. This is restricted because it has been categorized as a robot action. Therefore, the researcher is supposed to manually find the primary studies. This step should be done following certain protocols which the researcher has to define as a primary step when starts to use the tool.
After the collection of primary data, the bibliographic data of the needed papers or studies has to be exported in the for of BibTeX/RIS files. And then should be imported to the tool for further steps. Different stages of SLR implemented using the StArt tool is as follows:

* Planning

  In the planning phase, the primary steps of the SLR are performed.

  - Finding the keywords and selecting the source list is the primary step in that.
  - After defining the keywords and the source list, then it comes to define the IC/EC criteria ad the information extraction attributes. This information is added beforehand and will be used in the latter stages.

* Execution
  Once the protocol is defined, then comes the execution stage.
  There are three steps included in this stage : Studies Identification, Selection and Extraction.
  The study's identification is used to filter the papers according to the protocols defined in the first stage and also by using he bibtex data we will get more information on each of the papers... And the table we received from the data will have various attributes such as title, year of publishing, reading priority and an automatically calculated score(which is calculated depending on the number of times the keywords used in the protocol).There is another field called status which needs to be filled by the researcher. Then comes the selection phase, which is used to select the papers according to the protocol and the criteria defined in the former stage. At the end of this stage, all the accepted papers are then moved to the extraction step.
  In the Extraction step, what happens is that, the researcher must go through the selected papers and read in full and must be analyzed again whether to accept or reject.After that, the researcher extracts the information according to the attributes defined in the Information Extraction form, which was defined along with the protocol.
* Summarization
  In this stage, the researcher explains the state of the art of the topic.
  After the summarization stage, there is am option to visualize the data from the research in any manner, in which the researcher has to choose to select from a graph, tree or bar model.

We have used this tool mainly for our thesis and will be discussed more in Chapter 4.

- **SLR-Tool**[FSBR10] : This tool has been developed using JAVA and has implemented it IDE in Eclipse.This tool is a multi-language tool which is available in English and Spanish interfaces.The SLR-Tool empowers all the data expected to complete the SLR cycle proposed by [KDJ04] to be stored and managed.Text mining is the technique use din this tool to allow the search session or the primary stage of the review.When all the primary studies have been arranged with the grouping plan characterized, SLR-Tool can create tables and graphs to sum up the information, [FSBR10]. Hence, the tool will make visual admittance to the papers .SLR-Tool sends out all the information gathered in the survey process as Excel document sheets and the charts as PDF records.

  Advantages:

  * This tool allows the researcher to build a classification scheme that aids in data synthesis and analysis.
  * SLR-Tool additionally empowers every one of the bibliographic information from the primary studies transferred in the device to be traded to the configuration acknowledged by bibliographic bundles like EndNote, BibTeX and Ris.

  Disadvantages:

  * SLR-Tool is not just a metasearch tool, but the search of the documents or papers has to be performed manually and independently of the tool.
  * This tool does not allow collaborative systematic reviews.

- **Kitchenham QA reporting**[KBB+09] : Kitchenham's study aims to address the issues from already published SE studies on SLR conduction.There are very fewer papers on QA reporting which is from SE department.This level of QA is carried out based on [DD08] and has the following major points.

  * A 12 point checklist of item was defined and subjected to a group for getting opinions, suggestions and drawbacks.
  * A weighted scoring mechanism is used.
  * The extraction stage of assessing the quality to get good scores on the collected papers.

  Advantages

  * Gave improvement scope for future regarding the procedures for quality evaluation of the SE studies based on empirical methods.
  * Proposed changes in guidelines that handle removal of unwanted docs and also inclusion of various text analysis and quasi-gold standard tools.

  Disadvantages

  * Poor decision on the study content quality as the scoring mechanism is really error-prone.

– **SESRA** [MB15] : An automated tool for the web that supports systematic literature reviews. Results and comments from early use have demonstrated that SESRA could support the SLR process by automating some of its essential tasks. An advantage about SESRA is that it will provide instructions and support recommendations at each stage to help the researcher avoid biases that could taint the review results. According to some researchers[MB15], and the survey they conducted results in showing that the users broadly agree with the tool support of SLR in terms of productivity on an average of 60.7% and reliability on an average of 72.1%. This can be categorized as a subjective evaluation on the tool.
To maintain the objective metrics and the interpretation of the objectives suggested that SESRA can increase output and dependability on SLR process in SE.]. Additionally, as discovered in a prior study, the tool uses automated approaches to minimize effort on the more time-consuming processes [MB12].SESRAseeks to provide automated assistance for SLR's in the context of SE and CS, enhancing process productivity and reliability.
Advantages

  * High rate of average on productivity and reliability.

Disadvantages

  * Most of the guidelines provided within the tool are in Portuguese, which might be difficult for non-portugese researchers to understand.
  * Data from certain databases cannot be retrieved through this tool.

– **JabRef** [SDDK19]: JabRef is a reference management system to organize the bibliographic references. It is a free and open source software. It offers a graphical user interface for viewing and editing bibliographic references and saves them in the LaTeX-native BibTeX or BibLaTeX formats. Unlike, other tools we are referring, JabRef only manages the bibliographic stages and not any other phases. So, this tool is not that relevant to our studies.

– **SLRTOOL**[BRAC14]:- This tool is a web-based, open source program with a reasonably large support base that assist researcher through the SLR studied across a variety of research areas. Initially, this tool was proposed to perform SLR on EA. Just like every other tool, SLRTOOL also follows the same stages and phases for conducting the SLR. The only exceptional feature that differentiates the START tool from other tools is that it supports collaborative SLR's. Specifically, the tool could be reasonable for the fledgling research community. Another key component in this approach was an early acknowledgment that the potential for significant automated examination of reviews could be made conceivable, assuming that we adopted a model based strategy to tool improvement.[BRAC14].
Advantages

  * All the code for the overall SLR can be generated from this model.

* It is able to accommodate changes in the tool protocol, and also in other parts of the SLR process, just by modifying the model and then reusing or regenerating to support research on different disciplines.

Limitations

* The search area is just limited to google scholar.
* Management of resources (auto uploading the references) is poor and error-prone.

– **PRISMA**[LAT+09]The PRISMA Statement consists of a 27-item checklist and a four-phase flow diagram. The checklist includes items deemed essential for fundamental for straightforward detailing (transparent) of a systematic review.The main objective behind this tool was to improve the SLR reporting efforts and set a standard for the same.The development of QUOROM which was a reporting guideline published had several conceptual, methodological, and practical advances regarding the conduct and reporting of systematic reviews and meta-analyses.Hence, after that, the invention of PRISMA is considered as an evolution of QUOROM. It is mainly useful in reviewing or meta-analysis of health care interventions.The main scope of this tool is to ensure complete and transparent reporting ofSLR's.This method predominantly handles randomized studies except some non-randomized, quasi-experimental studies and interrupted time series.

Advantages

* Describes in detail about the risk and impact of bias within various studies, which in fact helps in ensuring the methodological consistencies.
* Ensures the clarity and transparency in SLR reporting process.
* Gives a clear-cut idea on the different protocols ,strategies and other IC/EC criteria used for various phases of the research review.

Limitations

* This is not recommended to be used as a Quality Assessment tool as such, because it does not elaborate on the methodologies used in the SLR review process.
* Even though an evidence-based approach was used to develop PRISMA, an SLR itself was not conducted to produce the checklist.

– **Parsifal** : Parsifal is a Python based library typically used in AI,ML,DL and TensorFlow applications. It is an online tool designed for supporting researchers to perform SLR in the domain of SE. It provides collaborative support for research in case of multiple researchers. Thus, it is made possible for geographically distributed researchers to work within a shared workspace, to design the protocol and conduct the research.
The tool has an important feature which helps to remind the researcher about the important steps and guidelines during the SLR. During the first phase of the SLR , which is the planning phase, Parsifal will help with the objectives,PICOC, RQ, search string, keywords and synonyms,

source selection ,IC and EC criteria.As a next step after this phase, it will also help in creating a QA checklist and data extraction forms. During the conducting phase, the tool will help to import the BibTeX files from corresponding digital sources and helps in selecting the primary studies, finding duplicates, executing the QA and extracting important data from the selected papers.

Advantages,

* Allows collaboration support.
* Displays a single review even when there are multiple researchers.
* Exports the results of a review.
* Helps in visualization of the summary, as a table.

Limitations

* It is an online tool, and you have to register to use the functionalities.
* Does not provide any elaborated tool or guide to use the tool.
* The program does not offer automatic duplication detection, but it does support human duplicate labeling in the event that there are any.[Kar21].

We will summarize the important characteristics of all the collected tools in Table 3.7.

3.4 Summary

Finally, we will summarize our SLR conduction and findings. Our main objective was to research on the impact of collaboration of people in CS teams. As a secondary objective, we wanted to do a brief comparative analysis on different SLR tools being used in SE any CS departments. For the primary objective we shortlisted 13 papers which were closely relevant to our topic and 10 more papers were shortlisted as a set of reinforcement for our primary findings.

To get to the result of primary findings, we performed SLR by defining various search terms, search strings and keywords. For a proper arrangement and organized solution, we prepared 4 RQ's .

The impact and perceptiveness of various gender being grouped together had to be determined. With the help of shortlisted papers, we had to get to the result whether there is any effect of women in CS teams. The table below shows an overview of the different tools we found. Since Kitchenham QA reporting is a theoretical guideline on conducting SLR ,we are not including it in the table. PRISMA is a tool created focusing on the reporting phase of the SLR so, it is also excluded from the table. We will use the scoring method to get a better understanding of the tools.[AZ17][1]. The rating of the score is as follows:

- 0-30% : Satisfactory
- 31-60% : Good
- 61- 100% : Very Good

1 http://carver.cs.ua.edu/Studies/SLR-Requirements

Sl.No	Requirements	StArt	SESRA	SLuRp	SLR-Tool	SLRTOOL	Parsifal
1	Collaboration Support	100%	100%	100%	0%	60%	100%
2	Integrated Search	20%	50%	10%	10%	10%	60%
3	Supports Text Mining	20%	10%	30%	10%	10%	30%
4	Traceability	100%	75%	25%	50%	50%	75%
5	Supports IC/EC criteria	100%	30%	20%	30%	30%	30%
6	Supports QA	100%	50%	50%	50%	50%	50%
7	Data Maintenance	100%	100%	100%	100%	100%	100%
8	Automated Analysis	50%	50%	60%	30%	30%	50%
9	Visualization	90%	60%	90%	60%	60%	60%
10	Storage of studies	70%	70%	70%	70%	70%	70%
	Average	75%	56.5%	55.5%	41%	47%	62.5%

Table 3.7: Comparative analysis of SLR tools [AZ17]

4. Methodology

In the previous chapter, we discussed the various SLR phases focusing on our topic. We discussed the impact of teams and diversity in teams when and during CL. We have also analyzed and summarized various available tools for performing SLR in CS or SE departments. The domain and limitations of those tools were also discussed. In this chapter, we will discuss more on the approach we selected for the selection of primary studies. We will also discuss the way of comparative analysis we performed on various tools that support SLR.
Through this chapter we will also explain an analysis on the different primary studies we selected, the way of selection, why is it selected and what are the important aspects of those papers.
We will begin the chapter with an explanation of our approach and describe the methodology we used for that approach. Following that, we will explain in detail how we analyzed the selected studies to answer to the RQ. Finally, we will discuss the difficulties and limitations we had to face during the research and possible solutions to them.

4.1 Stages of the approach

The main approach we used for our SLR is based on the guidelines proposed by Barbara Kitchenham [KBB+09]. The three phases planning, conducting and reporting has been covered for our review following her guidelines. Finding the effectiveness of collaboration in CS teams is the main aim to follow. Selecting the primary studies and evaluating and analyzing the relevant papers are satisfied by using the StArt tool, which we will discuss more in this chapter. The guideline overview for performing SLR can be understood from the figure below.

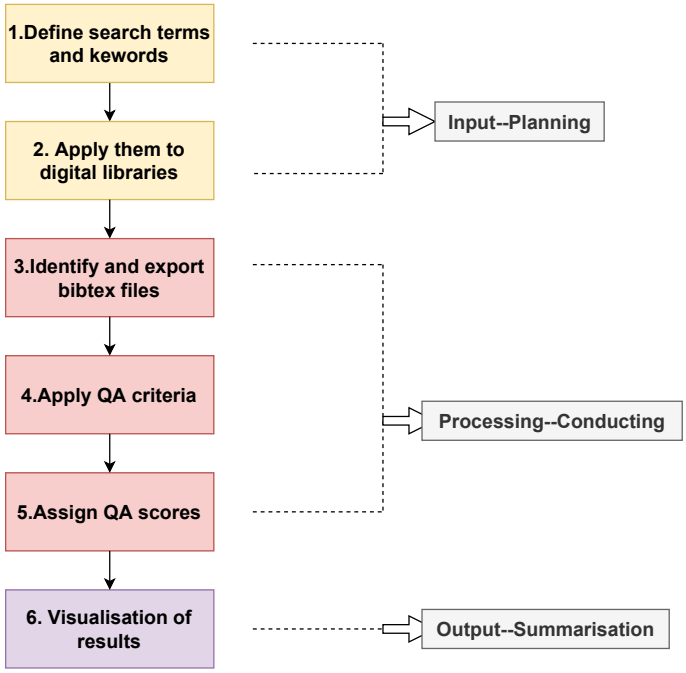

Figure 4.1: Guideline for performing SLR[KBB+09]

4.1.1 Planning of the review: Phase 1

The various stages of the proposed approach will be elaborated and summarized in the following sections. The first step of a systematic review is to plan. As part of the planning phase, initially we have to define research protocol. As we defined in the Section 2.1.1, the reviewers need to specify the need of the review in the selected specific area. Along with that, before conducting an SLR, the RQ's, search strategy and study selection criteria must be defined. Constructing clear and useful RQ's is the most fundamental prerequisite for recognizing relevant primary studies.
And on the basis of the defined RQ's, keywords and the key performance indicators are determined. Using the keywords and the search terms, we define a search query to find the primary studies. During the search process, every synonym and alternate terms for the keywords and search terms must be used in order to get an unbiased search result.

4.1.2 Identifying Relevant Research

After the planning phase, following the review protocol and RQ's, the search string is defined and the database sources for the collection of data are selected.

As part of our research, we started from the universal directory of journals and articles, which is the Google Scholar. All the available papers are collected according to the area and topic of interest using the defined search query. Apart from Google Scholar, we used another digital libraries such as ScienceDirect, ACM and IEEE Explore. For conducting and performing an SLR, it is required to export the details

of papers, including the abstract. We exported the **BibTeX** file format to get the bibliographic metadata and abstract of each and every paper.

There are other digital approaches defined for handling Bibliographic notes such as EndNote, RIS, refer etc. Almost every digital libraries support exporting citations in any one of these formats. We mainly focussed on the BibTeX file format.
In a BibTeX file, the bibliographic information is represented in the form of (JSON) JavaScript Object Notation. This way it is more compact and can be easily loaded in JavaScript. The structure of the data is well-defined and each BibTeX record includes all the metadata of different papers with a choice of having abstract and keywords in it. The entry types identify various types of article, journal, book, or conference. The structure of the BibTeX entry begins with the symbol '@' indicating the entry type, followed by a citation-key and the number of tags for the specific BibTeX entry. The information on these tags includes the author, title, DOI, published year, etc. The figure below shows an example for a BibTeX entry.

```
@ARTICLE{5432299,
author = {McLennan, Michael and Kennell, Rick},
journal = {Computing in Science & Engineering},
title = {HUBzero: A Platform for Dissemination and Collaboration in Computational Science and Engineering},
year = {2010},
volume = {12},
number = {2},
pages = {48-53},
abstract ={The HUBzero cyberinfrastructure lets scientific researchers work together online to develop simulation and modeling tools.
Other researchers can then access the resulting tools using an ordinary Web browser and launch simulation runs on the national Grid
infrastructure, without having to download or compile any code.},
keywords = {Collaboration;Containers;Middleware;Computational modeling;Computer networks;Collaborative tools;Videos;Nanotechnology;
Pharmaceuticals;Heat engines;Cyberinfrastructure;process infrastructure;collaborative research;distributed software engineering tools and techniques;
Internet-based software engineering tools and techniques;data dissemination;collaborative work environments},
doi = {10.1109/MCSE.2010.41},
ISSN = {1558-366X},
month = {March},}
```

Figure 4.2: An example for a BibTeX entry

4.2 Approach for selection of primary results

We follow a predefined approach for the selection of primary studies. There are various methods and tools available to do the same. As we already discussed in the second chapter, selecting relevant studies from a large collection of documents manually takes a lot of time and effort. Therefore, the approach we have selected is to efficiently reduce manual effort and selects primary relevant studies. We use an offline tool(StARt tool) to perform the SLR. We perform the three phases, planning, execution and summarization using this tool.
As the system is semi-automated, user intervention is needed. First, we need to define and decide the keywords, search terms and search strings. The reviewer completes the first phase of planning, uses the defined search terms in the selected digital libraries (Section3.2.2) and exports the results in the BibTeX format. And then, filtering the pool of papers with regard to the titles, abstract and keywords, we reach to a point with only a handful of studies. We have used the IC and EC criteria to do the filtering. Furthermore, the final step of the assessment is to assign scores to the studies according to the defined QA criteria. As the final stage of the review, visual representation of the result in the form of pie charts, graphs or radical graphs will be shown to the user.

4.3 Quality Assessment and Quality Scoring

After the identification of relevant research and primary studies is done, the reviewer must assess each study for analyzing the quality and the amount of bias. In addition to the general IC/EC criteria defined for the quality assessment, it should be considered important to assess the q̈uality" of the primary studies. The main aim of this to pave way for the interpretation of findings and determine the strength of the inferences.[KBB+09]. In the 2007 update by Kitchenham and Charters added the CRD Database of Abstracts of Reviews of Effects (DARE) set of four questions to the list[K+07].

4.3.1 Limitations of DARE criteria

The guidelines defined by Kitchenham [KBB+09] were used by reviewers to perform SLR in the SE domain. Even though many researchers came forward to modify these guidelines, it wasn't enough to handle SLR appraisal. Thus, it had a lot of limitations and thus was restricting the reviewers to get a clear perspective to use the DARE criteria. Some of the limitations are :[AU19]

- Lack of search strategies.
- Poor reporting quality estimation for the SLR.
- DARE is not a CAT (Critical Appraisal Tool) per se; it is intended to provide the criteria that SLR's should meet to be included in the CRD's (Center for Reviews and Dissemination) database of SLR's [bAU19].

The table below shows the quality evaluation criteria of DARE to appraise SLR in SE domain.

Table 4.1: DARE quality evaluation criteria used to appraise SLRs in SE domain. [AU19]

DARE - 4 items a, b, e and c/d are typically used, depending upon situation.
a. Were inclusion/exclusion criteria reported?
b. Was the search adequate?
c. Was the quality of the included studies assessed?
d. Are sufficient details about the individual included studies presented?
e. Were the included studies synthesised?

4.3.2 Evaluation checklist

Taking the limitations of the DARE criteria into account, after proper research and revision, we have acquired a number of checklists for quality scoring. This QA evaluation checklist has been created based on the reporting guidelines defined by Kitchenham [KB13] and an article prepared by Nauman bin Ali and Muhammad Usman [bAU19] on a critical appraisal tool for SLR in SE. We will also refer the evaluation checklist of AMSTAR-2 tool for the quality scoring. Since, AMSTAR-2

tool [SRW+17] has mainly defined for systematic reviews of randomized or non-randomized studies of healthcare interventions, we can omit some of the checklists which are not relevant for the SE domain.An AMSTAR-2 score of 8 to 11 indicates high quality, 4 to 7 a moderate quality and 0 to 3 a low quality The table below explains the quality evaluation criteria used to appraise SLRs in SE domain by AMSTAR-2 [2].

Table 4.2: AMSTAR-2 quality evaluation criteria used to appraise SLRs in SE domain [SRW+17] [AU19]

AMSTAR-2
a. Did the RQ's and IC for the review include the components of PICO?
b. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review, and did the report justify any significant deviations from the protocol?
c. Did the review authors explain their selection of the study designs for inclusion in the review?
d. Did the review authors use a comprehensive literature search strategy?
e. Did the review authors perform study selection in duplicate?
f. Did the review authors perform data extraction in duplicate?
g. Did the review authors provide a list of excluded studies and justify the exclusions?
h. Did the review authors describe the included studies in adequate detail?
i. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
j. Did the review authors report on the sources of funding for the studies included in the review?
k. If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results?
l. If meta-analysis was performed, did the review authors assess the potential impact of ROB in individual studies on the results of the meta-analysis or other evidence synthesis?
m. Did the review authors account for ROB in individual studies when interpreting/ discussing the results of the review?
n. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?
o. If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?
p. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

Using the available instrument/tools, we have given quality scoring to each of our primary selected papers. The checklist we created for our scoring criteria is as follows:

2 https://amstar.ca/Amstar_Checklist.php

- **QC1** : How relevant is the information in the study according to the title under observation?
  These criteria define whether the information and the content in the paper is relevant and is important and considerable for our primary research goal. In our case, we have to analyze whether the paper explains about collaboration in computer science teams or the importance of women in teams. The papers with higher occurrence of keywords and search terms can be given a higher score, while with less occurrence will be given a less score or rather 0.
- **QC2** : How reliable and important is the contribution according to the author?
  The contribution of the author should be considered as an important factor for the quality scoring. The higher the contribution of the author in the specified field, the higher the expertise. The authors publishing more papers on the relevant field can be considered and given a high score, while the opposite can be given less score.
- **QC3** : Does the content of the study present in the abstract is relevant to the conducted SLR?
  Through these criteria, we meant to analyze the content of the paper. As an initial stage of the study selection, we consider the title, keyword and abstract and check the occurrence of keywords in them. In our method, we have defined Boolean expressions to search for key terms and their synonyms related to the topic. One term and its synonyms are connected by the logical operator OR to create a group of terms. The groups are connected by the logical operator AND in order to create a complete string of keywords. According to [KDJ04]a review of the title and abstract of a primary study should be sufficient to decide whether a study is relevant to SLR or not.
- **QC4** : Does the study carry a strong and clear introduction?
  The primary understanding of the paper is understood from the introduction. In fact, introduction is the shorter summary of the whole paper, irrespective of the length and pages.Kai Petersen [Pet11] has said that strong and structured abstracts and introductions may be a great help in conducting SLR. We can give a score of 1 to structured introduction and 0.5 to unstructured introduction.
- **QC5** :Are the results of the study reported in a clear and concise manner? The clarity and clearness of the paper should be well reflected in the result. If the result of the paper is well-structured and addresses all the needed criterion's defined in the introduction and RQ's, a score of 1 can be given. Else, give a score of 0 to 0.5 according to the percentage of result and findings satisfaction.
- **QC6** : What is the impact of the study on the overall research, and SLR?
  The impact of the studies that perceives the usefulness of the research has to be scored.In the study, the area of research must be clearly defined and should have created an impact on the overall research. If the study is conducted as an SLR, a score of 1 can be given and if not, a score of 0.5 can be given. If the study satisfies both the criteria, the impact on overall research and the study is an SLR, then a high score can be allotted and if not, a low score can be given.
- **QC7** : Does the study have been officially published?
  Studies that are officially published are selected prior and primary for observation.

Articles or papers which are published in globally accepted platforms and formats are given a high score, while the rest is given less.

- **QC8** : How often does the study have been referred or cited?
  The frequency and citation count must also be considered. Studies that provide useful and relevant findings are usually referred and cited by other researchers. Hence, We will use the citation count to find out the most reliable ones.(Used the Harzing's Publish or Perish tool to find the citation count([Har10]))

For an easier interpretation, the table below shows each scoring criteria and their corresponding term to use.

Term	Scoring criteria
QC1	Title
QC2	Author
QC3	Abstract
QC4	Introduction
QC5	Results
QC6	Impact
QC7	Published
QC8	Citation Count

Table 4.3: Quality scoring criteria and corresponding terms

4.4 Threats to Validity

In the methodology we followed and the approach we considered was semi-automated and human intervention was needed in most of the stages. Doing an SLR itself takes a lot of time and effort, to research on papers, selecting relevant studies, scoring the papers according to their quality etc. Mostly, the initial stages were very difficult as because of the unawareness of defining boolean operators in between search terms to obtain an unbiased result. For each and every study, the occurrence of keywords had to be determined independently, regardless of their synonyms and antonyms.
Defining RQ's and finding papers to get answers to them was a bit tedious as there were very fewer papers available for the same. Many studies and articles were available online, but many of them doesn't have full access to the article. When the full article was available, the frequency of citation count was very less. Despite all these limitations and putting a lot of manuals and semi-automated approach, we finally were able to conduct all the stages of SLR according to Kitchenham's [KDJ04] guidelines.

4.5 Summary

In this chapter, we have discussed the methodology and the approach we followed to perform the SLR. We have explained about the fundamental concepts of the approach, the different stages of the approach, tool used for the approach. The tool we used is an existing tool (StARt). The manual entry that had to be done was in the

initial stage of planning, to define RQ,IC/EC criteria and the research protocol. We used the defined search terms and search strings to find relevant papers by applying Boolean operators in different digital libraries. We then used the tool to insert all the papers using the BibTeX data we exported from the digital libraries and used them to select the primary studies. Manual intervention was needed, as the tool we used was semi-automated. We then define quality scoring criteria and gave scores to each paper, which we see more in the next chapter.
We will explain more about the evaluation of the primary studies, different collaboration tools and the scoring of the primary studies in the following chapter.

5. Discussion and Evaluation

This chapter will mostly discuss the results and analysis of the conducted SLR. As we discussed the methodology and approach we adopted to do the SLR in the previous chapter, we will evaluate them as well as we will try to find proofs and evidences to answer our RQ's and their drawbacks and the possible solutions for that.We will also mention the lacking criterion's that we came across in our research and possible "nice-to-have" features for future references.
The main aim of an SLR is to search, identify, analyze and interpret all available proof relevant and related to one or more RQ's in a way that is unbiased and (to a certain point) repeatable [KC07]. We will give evidence to our thesis by proving, valuating and analyzing collaboration in CS teams, and make sure that the strategy that we employed is robust and transferable.

5.1 Glimpse of our SLR using StARt tool

We have already discussed and explained in the previous chapter, the methodology and approach we used for SLR. At a point, we have mentioned the tool we used for conducting the various phases of SLR, which is the start tool.

In section 3.1.2.2, we mentioned the various digital data sources we used to apply the search string and the search terms to find relevant papers. After, collecting the papers and exporting the BibTeX format of the relevant papers, we uploaded the result to the StARt tool. The objective of the research, research protocol, research questions, inclusion and exclusion criteria were defined in the tool at the beginning phase. As the planning phase was finished by exporting the pool of paper's BibTeX data, extraction had to be done. This phase was to filter the papers needed according to the keywords, abstracts. As the tool was semi-automated, a human intervention and manual selection was needed at this phase. Once the selection was done, extraction, which is another level of filtering, had to be done in-order to select less and most relevant papers. Thus, we ended up having 13 very-high priority papers and 9 high priority papers. The pie chart representation is a graphical representation of the steps we completed using the tool.

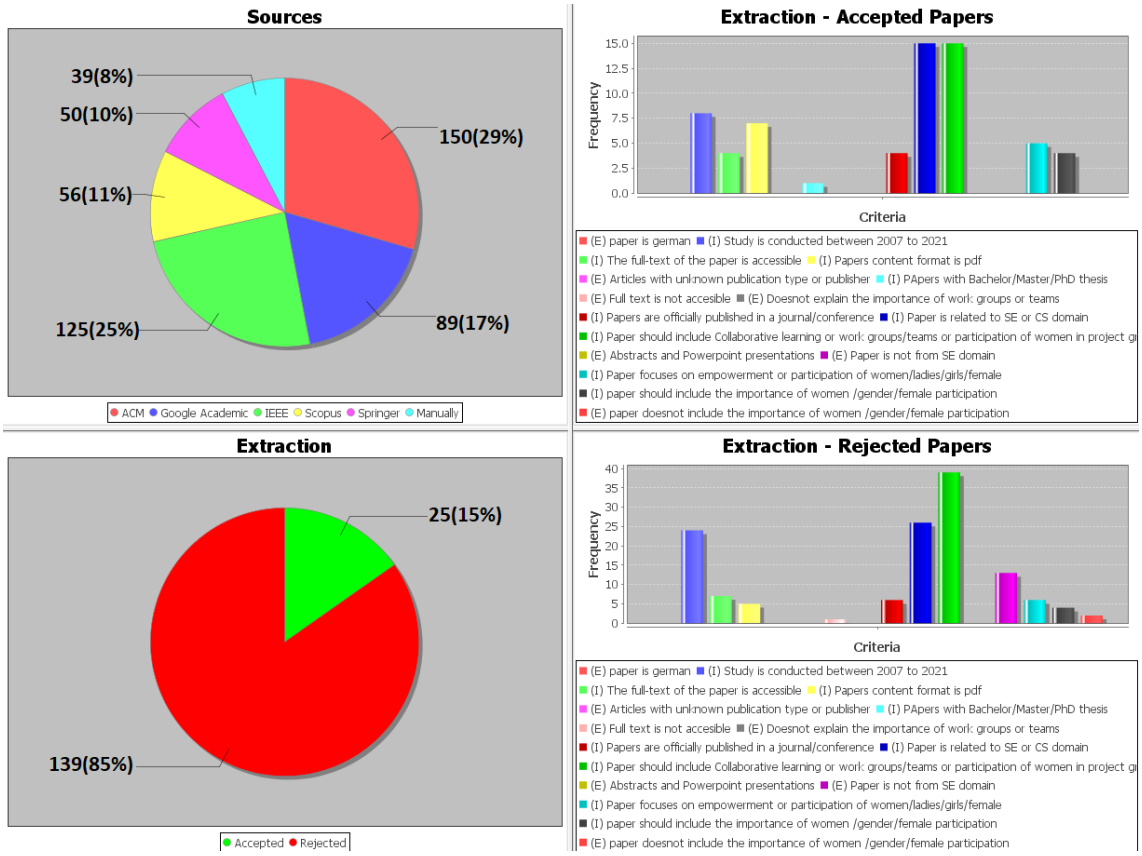

Figure 5.1: Pictorial representation of selection using StARt tool

5.2 SLR- Results Set

In this section, we will discuss in detail and analyze the primary set of results we obtained as part of the SLR and the impact of those papers that helped in answering our RQ's. The need to analyze the relevancy of the papers will also be discussed thoroughly. Here, we will mention once more the RQ's that we had to find evidence and prove the dissertation.

- **RQ1) How do women shape the dynamics of groups and teams in computer science based course projects?**
- **RQ2) Which personality or behavior stimulates effective group interaction?**
- **RQ3)How does the team perceive the usefulness of collaboration ?**
- **RQ4)What factors can affect performance of work groups and teams?**

Now, we will categorize the selected primary studies according to the RQ's. The first RQ is in favor of the impact of women in CS and SE project teams. The rest of the RQ's focuses on the factors that affect the performance of work groups and teams. We can consider these RQ's together, as it implies almost the same meaning. We will consider all the papers selected, including the 13 primary studies and the secondary studies.

5.2.1 RQ1) How do women shape the dynamics of groups and teams in computer science based course projects?

Among the 13 papers we took for consideration, we mainly focussed on collecting papers on this RQ. This is the first and foremost goal of our thesis. From [RPNN21] SLR, the researcher created a demographic data on the synthesized data of papers that studying perceived diversity. The papers published were conferences, journals, workshops etc. The data is as follows.

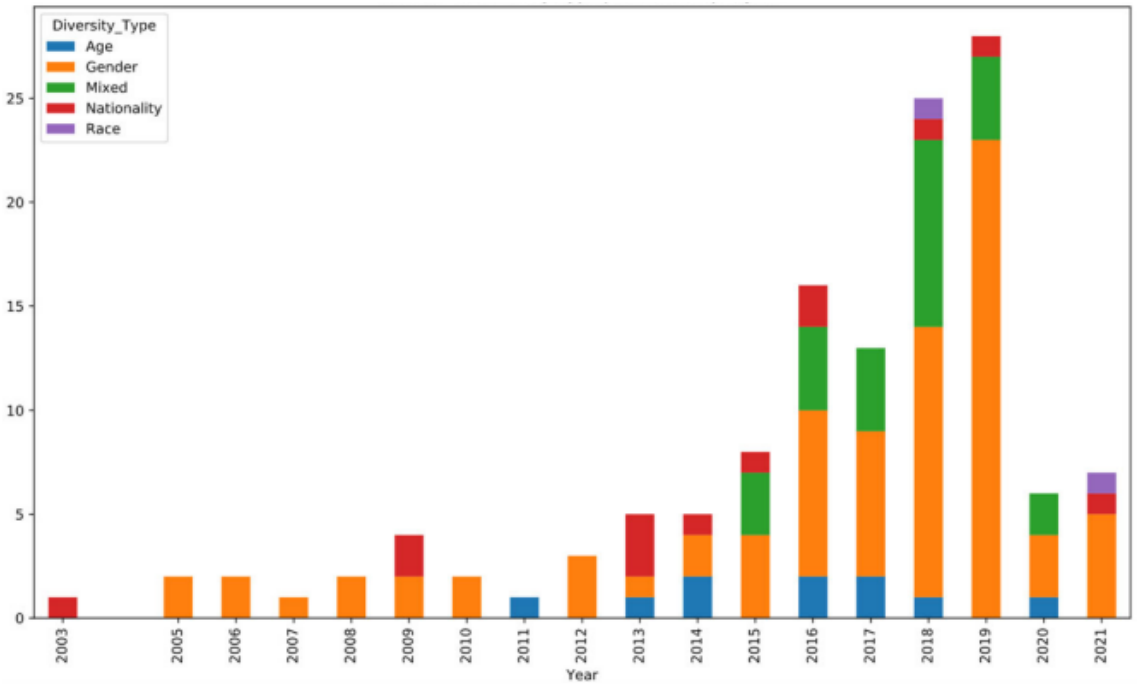

Figure 5.2: Number of papers published on perceived diversity until 2021, [RPNN21]

We analyzed the importance of women in computer science and the impact that occurs with the presence of women in teams. From a study conducted in the University of Hull, the author mentioned that the significant under-representation of females in CS can be commonly referred to as the gender gap [Wag16]. She also analyzed an aspect of the gender gap by finding the difference in the performance of male and female students.
The IT sector is thriving and developing day by day. Even in this digital progressive era, many women continue to be underrepresented as compared to their numbers in the overall work area[MAWH21].CS and SE jobs are seen as a job for men, ignoring the efforts of women's competence. The basis for the under-representation are social and cultural. The stereotyped career choice is one aspect which people, especially women, are forced to follow. Interaction with people are meant for women, while software development and technical activities are left for men. This is something that has to be considered for the overall persistence of women.
The students in a team tends to allocate the tasks of a project among themselves, different to working collaboratively on the tasks. They believe and follow the 'divide-and-conquer-approach' for a better outcome. But when they do that, do they consider

having equal proportion of girls and boys on the team? Or do they go for just boys, who they believe is "highly qualified and efficient" compared to women?. To find proof of evidence for this RQ,we will set up a hypothesis.
Hypothesis - Presence of women in groups and teams in CS based project yields a positive and better outcome.
A social sensitivity perspective created by [KBWN14], the researcher tried to report about the presence of females in teams and the factor that leverages the team performance activities. The experiment was conducted based on forming teams in 5 different manner.M being Male and F being Female, they created groups of MMMM, MMMF, MMFF, MFFF, FFFF. The essential finding they showed up after the experiment is that the extent of female students were not exceptionally corresponded with the execution of the student teams. Average social responsiveness score of groups with large number of female individuals was altogether less in contrast with groups with low number of female. The presence of female affected the Group execution exercises, for example, Exploration, Data Sharing and Collaboration. Another perspective of this paper was that the female attitude towards the jobs were more favorable than males. Research across various nations across Europe asserts that females show a high level of job and work satisfaction than compared to men. Through the qualitative analysis of data, it is suggested that females tend to have a more favorable attitude towards job and report more satisfaction than males, even in the same work environment [KBWN14].

From another study conducted by [Wag16], she defines the term gender gap as the under-representation of females. And in her study, she analyzed that male students were awarded more first class degrees than female students. So, she proved that there is gender gap and performance gap existing in SE and CS areas, where the ability of women is undermined because of the poor consideration of women. The hypothesis she considered were cross-checked with the performance indicators first degree and good degree. The table below was her finding that supported her hypothesis.

	First-Class Degree	Good Degree
Female computer science students perform worse than male students	Yes	Mixed
Female students perform better as their total number and percentage increases	No	No
Both male and female students perform better as the year of entry increases	Yes	Yes

Table 5.1: Support hypothesis findings[Wag16]

Agreeing to this finding, a Chilean case study was conducted describing and comparing the results of mixed gender teams in student software projects. The result was that mixed gender teams offers more coordination and focus to student teams, which helps to focus on the efforts for a good result in the project. This can be proved by saying that mixed gendered groups perform better in terms of self-efficacy.

On the contrary, in terms of group processes, recent researches and evidences suggests that the group collaboration is greatly increased by the presence of women in groups [WCP+10]. [WCP+10] found that the proportion of female in a work group is strongly related to the whole group's measured collective intelligence. From the social sensitivity [KBWN14] it was clear that, women have the greater ability to read nonverbal cues and make inferences about what others are feeling or thinking. Thus, the groups with women exhibits greater equality in the conversational turn taking behavior and making the rest of the team members to be responsive among them and make use of the best use of knowledge and skills. When the group performance has to be evaluated, the results of several meta analyzes had to be considered, which shows either no effects or slightly negative effects for gender diversity of team members on team performance. Indeed, the researches show that in areas dominated by male, the integration of women may be difficult initially but should get better as their efforts and participation equalizes with men.
In a study conducted by [YF22], the researchers tried to find about the gender differences in collaboration patterns in CS. Fundamental discoveries are that the gender gap changes incredibly by field, extending from 6% female creators in hypothetical CS to 42% in CS education, sub-fields with the next gender gap to tend to display lower female efficiency, bigger coauthor bunches, and higher gender homophily.
Our hypothesis can thus prove that, Presence of women in groups and teams in CS based project yields a positive and better outcome. Gender balance and diversity have the potential to improve group outcomes, which is just as important as collaboration, becoming a main attraction in the production of CS. However, in order to be truly effective, the role that women play in scientific teams should also be taken into consideration and promoted in order to yield the significant benefits of increased gender diversity.[WCP+10].

5.2.2 RQ2 & RQ4) What are the factors that affect effective group interaction and how they affect the performance of the teams?

RQ2 and RQ4 can be considered together. These RQ's are defined to find and assess the factors that affect the teams and how it yields a perfect outcome. In one word, effective group interaction is an outcome of proper communication and coordination. A high performance team is one that overcomes all reasonable expectations and produces good and extraordinary results [DPF15]. A good team is a group of people that bring together the team members to mutual growth and personal development. Other attributes that affect high performance teams are participation, accountability, clarity, creativity and flexibility. The performance of a team can be characterized using technical and behavioral excellence [DPF15]. The participation in a team, irrespective of the diversities existing between them, increases the commitment, which results in delivering high quality work. There are some real life examples of companies which has used high performance inter functional teams to improve the efficiency and service to the clients, such as ATT, Boyett and Boyett.

When working remotely or in person, every team and team members should be mastered to keep their colleagues encouraged, engaged and productive. There must be some factors that enhance the performance of every one. Some of them are as follows:

- **Reinforce a common goal** : Each of the team members should be aware of the goal. A manager or a leader should be able to inspire the team with a proper sense of purpose and vision. Everyone should know if their team goals are aligned with their colleagues, overall. Teams should understand why their team even exists.

- **Ensure the clarity of individual role.** The people working in teams should maintain frequent communication and make sure each of the individual roles are properly explained and understood by them. At the final stage of coordinating all the results of the team, there should be a uniformity and continuation of the results. Thus, it is essential to clearly and carefully explain individual roles and tasks.

- **Being aware on the emotional safety.** Team members need to feel great, esteemed, and involved. Emotional security is one of the main elements in groups, particularly in the midst of emergency and uncertainty. The respect and consideration given to one another could result in a blissful climate, which will ponder the results.

- **Promoting the progress** : The team knows the objectives and tasks they are assigned to. But it is essential to make sure that they are aware of how to accomplish them.An effective team should share and collect feedback. They must have the time and effort to accept the success and failures. Successful teams have clear team processes for planning, tracking, documenting, and managing work.

- **Encouraging collaboration** :The main reason behind collaboration is to make sure each person needs the rest of the team to accomplish the goals. That collaborative spirit enhances the team to tackle the work. Collaboration is not a guarantee, but when working remotely and without personal physical interaction, it is important that remote workers are not feeling isolated, hence collaboration is essential.

- **Promoting orientation of growth**:Team members learning from each other is one way to keep growing. Teams give everyone a chance to grow and learn from each other. If people want to do better in their performance, they need to learn and grow. It doesn't mean that they should do additional courses and gain a pool of knowledge, we are trying to talk about mutual cooperation and collaboration. Brainstorming and encouraging each other gives a potential growth individually, thus affects the performance of the group.

Autonomy and Diversity are two factors which acts as the base for a team formation.The figure below is an instance table on the grouping and abstraction process of the evidence and the finding on the papers we collected, which mentions the factors that generally affects a team performance.

Evidence	Factor	Finding
Autonomy increases the response efficiency	Autonomy	influence the team performance positively
Difference in decisions by high and low performing groups during ALM	Autonomy	Influences the team negatively
Diversity slows down the response efficiency due to the conflict in communication,	Diversity	influence the team performance negatively
Could have a significant influence on the speed of introducing to the market and functionality of a new product	Diversity	influence the team performance positively

Table 5.2: Grouping and Influence on team performance

There have been many papers publishing every year addressing and mentioning the factors that influence the performance of computer science teams.The publishing papers are journals, conferences, books etc. Among the 13 primary studies we selected, we could find only two or three authors published more than one paper.There were only a few SLR conducted focussing on the importance of the high performance teams. In most of the papers we selected only the ”communication”,”motivation”,”cooperation” are discussed. While ”personality”,”mutual respect”,”autonomy and diversity” are less addressed. Fortunately or unfortunately, we could not find any paper reporting negative effects of individual characteristics over the performance of processes in the CS teams.

5.2.3 RQ3)How does the team perceive the usefulness of collaboration

This RQ is defined to address the after effects of the previous RQ's. We have discussed the factors that affect the performance of different teams and those which affects effective group interaction. But how does the team conceive the usefulness of interaction and collaboration?
”Use what you have” is a quote by a famous researcher. When working in teams, being motivated and having confidence to communication with your peer and share knowledge is one way of perceiving the usefulness of collaboration.

Increase in productivity and creativity are the perfect result of good collaboration. The main impacts on the usefulness of collaboration can be defined as follows:

- Improves team efficiency.
- Increases the result quality.
- Teamwork supports individual learning
- Teamwork inspires innovation and creativity

- supports accountability on the tasks they did.

In terms of efficiency, the most likely factors included are better decision-making, little lonely thinking and improved communication and coordination. There can be seen an imbalanced collaboration between different roles in a team.We can speculate that the collaborations within the teams may have been highly directional, which caused an imbalanced collaboration.This can be solved by having proper communication and less intuition.

5.3 Tools used for CS teams collaboration

During the Covid-19 pandemic situation, communication and cooperating physically was impossible. Thus, the need for a remote modelling collaboration increased and the use of them became inevitable. Irrespective of the location, timezone, working hours, many software teams started relying on them. Collaboration tools can be defined as an implementation used to carry out a particular function, which here in specific to collaborate between and among different researchers.In this section, we will present various collaborative development environments and tools to enable effective software development, either global or collocated[LEPV10]. When people are told to suggest collaboration tools, the different software programs available for audio conferencing and videoconferencing comes on top of the list, as it reflects a generic opinion that collaboration tools should imitate the direct verbal interaction.A good collaboration tool will have the following characteristics.

- Enhances communication.
- Able to share digital formats of media.
- Enables mutual interaction
- Easy to learn and use

The collaborators should be able to share in virtual environments, which are not easily approachable to the physical constraints in real life. An example for an innovative collaboration can be in such a way that, a faculty deliver the class standing in front of the room while the students collaborate on lecture notes in a synchronous text environment. From the above section, it is almost clear that collaboration tools are different from the communication tools. Now, we will have an inside look onto what are the features that sets the collaboration tools different from communication tools [LBP08].

5.3.1 Features of collaboration tools

Communication is a basic feature for collaboration. But, does these two terms imply same meaning or different meaning? The following are some basic and important features of what makes collaboration tools stand up.

- Capability of Strong communication
- Easy-to-use and understandable User Interface

- Capability of Collaboration

In short these can be termed as **Communication, Coordination and Cooperation**. These features were extended to permit and promote new and different types of interaction.

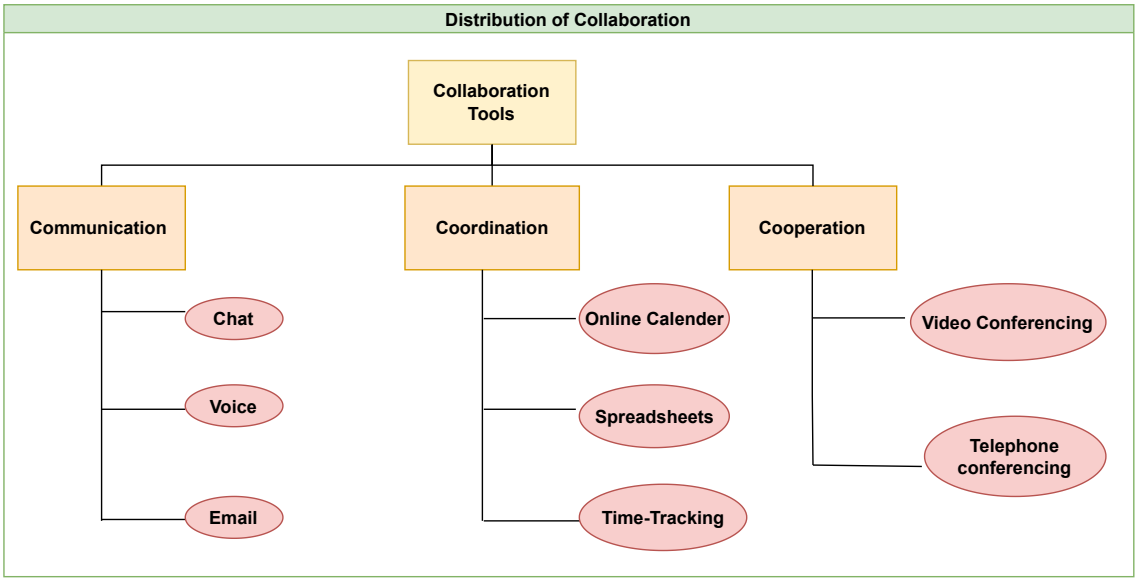

Figure 5.3: Levels of Collaboration [JvdHP22]

When choosing a tool, the researchers should make sure of the following 5 critical requirements. The following items were taken into account for that.

- Does the tool allow multiple collaborators?
- Does the tool support synchronous and asynchronous collaboration? i.e, whether the tool supports real-time collaboration.
- Does the tool allow or restrict functions to every collaborator participating using the tool?
- Is the tool encouraging and entertaining to the users?
- Is the tool social and helps to integrate different solutions?

Here, we briefly name and explain standard collaborative development tools and collaborative development environments(CDE). We will differentiate the tools according to the use of the tool and then the CDE's and collaborative software applications.

Use	Tool
Communication Via Chatting	Slack, WhatsApp, WeChat, Google Chat
Communication Via Video-conferencing	Microsoft Teams, Zoom, Google Meet
Diagram Management	Lucid Chart, Figma, draw.io, diagrams.net
Digital Drawing	Mural, Miro, Jamboard
Document Sharing	Google Docs and Sheets, MS Office 365,VS Live Share
Code Sharing and Knowledge Management	GitHub, Confluence
Task and Project Management	JIRA, GitHub, Asana, Smartsheet

Table 5.3: Collaboration tools referred from [JvdHP22]

Collaborative Software application is a very vast term. These applications help to monitor the development of code and knowledge and makes it accessible to all the users. The main purpose of these applications are for the unification of communication and for a better and productive cooperation between the collaborators. Since 2019,some of the widely used such IDE's are [MZ20]:

- Office 365
- Trello
- JIRA
- Asana
- Basecamp
- Monday.com
- Bitrix 24

The standard features of these IDE's are cloud storage capacity, chatting and video conferencing, sending and receiving notifications. Some exclusive collected data on the above-mentioned CDE is as follows:

	Office 365	Trello	Atlassian JIRA	asana	Basecamp	monday.com	Bitrix 24
Cloud version	✓	✓	✓	✓	✓	✓	✓
On premises	✓	✗	✓	✗	✗	✗	✓
Mobile application	✗	✓	✓	✓	✓	✓	✓
Desktop application	✗	✓	✓	✗	✓	✓	✓
Free version available	✗	✓	✓	✓	✓	✓	✓
File sharing available	✓	✓	✓	✓	✓	✓	✓
Instant messaging available	✓	✗*	✗*	✗*	✓	✗*	✓
Video conferencing available	✓	✗*	✗*	✗*	✗*	✗*	✓
Email integration available	✓	✓	✓	✓	✓	✓	✓

Figure 5.4: Collaboration Development Environments referred from [MZ20]

5.3.2 Limitations of the tools

- **Integration** - Most of the tool allows and provides collaboration features, but individual features created on different tools doesn't allow to be integrated across them.
- **Security** - When the tools are made available to everyone, a compromise on the security will be affected. The data security,(which normally the data in the tool will be stored in cloud) which the collaborators think is not securer than their personal servers.

- **Availability** - The best collaboration tools might not be available free and once the size of the team increases, collaborative system should maintain unified. So every penny we spend should be worthy.

5.4 Quality Scoring of the primary studies

As a final stage of evaluation, we will now score our selected primary studies according to the scoring criteria (Section4.3.2) we defined in the previous chapter. The score we calculated for the QC2(for abstract, title and keyword) is obtained from the StARt tool we used. It is calculated based on the frequency of occurrences of keywords in title, abstract and keywords of the publication as defined in the review protocol. The citation count QC7 is obtained using a software tool called Publish and Perish [1], in which it calculates using the reference count of the paper within a particular time period.

1 https://harzing.com/resources/publish-or-perish/

Table 5.4: Quality Scoring of the primary studies

Lit.ID	Title	Author	Abstract, title and keyword	Introduction	Results	Impact	Published	Cited-by	Final
455	Affordances of computer supported collaborative learning platforms:A systematic review	0.5	0.32	1	0.5	0.5	0.5	0.18	3.5
3777	Perceived diversity in software engineering: A systematic literature review	1	0.11	1	1	0.5	1	0.17	4.78
7369	Towards a Bio-inspired ACO Approach for Building Collaborative Learning Teams	0.5	0.05	0.5	0.5	1	1	0.02	3.57
451	A Study on the Behavior Pattern of Collaborative Knowledge Construction by Analyzing the Design Tasks in Collaborative Learning	0.5	0.15	1	0.5	0.5	1	0	3.15
1710	Understanding Women's Remote Collaborative Programming Experiences: The Relationship between Dialogue Features and Reported Perceptions	0.5	0.08	0,5	0.5	0.5	1	0.09	3.17
1742	Gender and performance in computer science	1	0.56	1	1	0.5	1	0.26	5.32
3676	Does gender matter for collaborative learning?	0.5	0.27	1	0.5	0	1	0.16	2.43
3692	How do table shape, group size, and gender affect on-task actions in computer education open-ended tasks	0.5	0.14	0.5	0	0	1	0	2.14
11685	What do we know about high performance teams in software engineering? Results from a systematic literature review	1	0.05	1	1	1	1	0.35	4.85
3826	Group Formation for Collaborative Learning: A Systematic Literature Review	0.5	0.24	1	0.5	1	1	0.23	4.47
7351	Dispersion, coordination and performance in global software teams: A systematic review	1	0.12	0.5	0.5	1	1	0.36	4.48
11700	Software engineering education— does gender matter in project results?—a chilean case study	0.5	0.2	0.5	0.5	0	0.5	0.07	2.27
3611	Gendered Risks of Team-Based Learning: A Model of Inequitable Task Allocation in Project-Based Learning	1	0.14	0.5	0.5	0	1	0.26	3.4

6. Threats to Validity

The SLR we performed was a detailed and statistical analysis on specific area of research.But certain limitations and drawbacks we came across cannot be ignored.Since we performed the SLR on a small manually selected set of studies could definitely result in variations.We were obliged to select less number of studies for a less biased result, but the selected studies functions based on manual search strategy in digital databases.Therefore, a deviation and can be noticed.

Secondly, only minimal reviewers reviewed the overall process. Therefore, the intervention and participation of multiple reviewers can result in more conflicts and innovations on ideas and observations.So, the robustness of the whole process will be affected.We also used a semi-automated approach for the conduction of SLR, that can also be a reason for less accurate result.
A very important point regarding the refinement of the dissertation is that, technology and information develops every single day. For our research, we considered a timeline of 2009-2021.There could be studies that uses much more and strong checklists and RQ's on the same area of research.So, It cannot be guaranteed that the proposed studies we considered and the RQ we answered does not ensure 100% coverage.In that case, some of the key factors could have been missed. The research string and the research questions we formulated need not always yields the best possible outcomes.So, if there is a need for altering the search strings and RQ is there in order to get better results, that also has to be considered, which is something that might have been missed in our review.

7. Conclusion and Future Work

Computer science is a collaborative discipline.The aim of our SLR was to summarize the evidence and analyze the effects of collaboration and performance in CS teams.SLR is the most significant and reliable method to aggregate available information for scientific research. We used this method for our thesis in order to arrive at a less biased and more importantly to get a statistical evidence on our area of research interest.

As a result of this SLR, we found 13 papers reporting the factors has an impact on various team processes and collaboration in CS and SE teams.Our main aim was to do this using a systematic procedure and organize the results in such a manner which would help to identify research gaps and helps to improve the understanding in the specific topic.

In this study, we were able to understand that most of the studies has assumed an exploratory approach, which means we should be able to understand problems in SE teams more in the upcoming future.Collaboration in SE and software development happens in every levels of development process,between customers, developers and stakeholders. Selection of the collaboration tool depends on the developers and the area of domain which can be determined for the success of projects.Proper communication and collaboration will be the basic criteria to yield a good result.Let it be face-to-face or virtual, a good team with team-spirit and positive attitude can achieve every goal irrespective of gender,culture,ethnicity or whatever diversity is present among them.

This research can be identified as reference for further findings on doing a statistical analysis on the size of project and teams. This can also be extended by analysing the relationship between different types of collaboration ,impact on the selection of collaboration tools and the success and quality of different CS projects.

Appendix

Table A.1: Search results of the SLR

Year	Title
2022	The Minority Matters: A Diversity-Promoting Collaborative Metric Learning Algorithm.
2022	A Learning-based Honeypot Game for Collaborative Defense in UAV Networks.
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2016	Multidisciplinary Project Based Learning Within a Collaborative Framework: A Case Study on Urban Drone Conception.
2016	Fifth International Workshop on Adaptive Learning via Interactive, Collaborative and Emotional Approaches (ALICE 2015).
2016	Collaborative Environment for Remote Clinical Reasoning Learning.
2016	Sparse Online Learning for Collaborative Filtering.
2016	Speaker-Independent Speech Emotion Recognition Based Multiple Kernel Learning of Collaborative Representation.
2016	A Computer-Supported Collaborative Learning Design for Quality Interaction.
2016	The effects of sentiments and co-regulation on group performance in computer supported collaborative learning.
2016	Transfer Learning for Heterogeneous One-Class Collaborative Filtering.
2016	A visual recommender tool in a collaborative learning experience.
2016	Transforming a large-lecture course into an active, engaging, and collaborative learning environment.
2016	Pre-service teachers' experiences of scaffolded learning in science through a computer supported collaborative inquiry.
2016	A survey of active learning in collaborative filtering recommender systems.
2016	A methodological approach for trustworthiness assessment and prediction in mobile online collaborative learning.
2016	Improving collaborative learning in the classroom: Text mining based grouping and representing.
2016	Quantitative approach to collaborative learning: performance prediction, individual assessment, and group composition.
2016	Exploring embodied social presence of youth with Autism in 3D collaborative virtual learning environment: A case study.
2016	Collaborative e-learning systems using semantic data interoperability.
2016	Online collaborative learning in dyads: Effects of knowledge distribution and awareness.
2016	Knowledge building and the quantity, content and quality of the interaction and participation of students in an online collaborative learning environment.
2016	Collaborative science learning in an immersive flight simulation.
2016	Iterative learning control with time-partitioned update for collaborative output tracking.
2016	Agent-based modeling of collaborative interaction in ubiquitous learning environment using local dynamic behavior.
2016	Different Futures of Adaptive Collaborative Learning Support.
2016	Expressive Collaborative Music Performance via Machine Learning.
2016	Effectiveness of the Multi-Mouse Quiz System for Collaborative Learning in Elementary Schools.

2016	Reasoning Under Uncertainty: Towards Collaborative Interactive Machine Learning.
2016	A collaborative mobile learning system to facilitate foreign language learning and assessment processes.
2016	Optimizing collaborative learning path by ant's optimization technique in e-learning system.
2016	Effects of Knowledge Construction Tools on Students' Learning Patterns in Collaborative Game-Based Learning Activities.
2016	Effects of Flipped Jigsaw Collaborative Learning on English as a Foreign Language Learning Anxiety.
2016	Investigating Collaborative Learning Effect in Blended Learning Environment by Utilizing Moodle and WeChat.
2016	A Video Comic Drama Based Learning System for Collaborative Learning.
2016	Lifelong Learning and Collaboration of Smart Technical Systems in Open-Ended Environments - Opportunistic Collaborative Interactive Learning.
2016	Creating Instructor Dashboards to Foster Collaborative Learning in On-Line Medical Problem-Based Learning Situations.
2016	Enabling deep conceptual learning in computing courses through conflict-based collaborative learning.
2016	OPPIA: A Context-Aware Ubiquitous Learning Platform to Exploit Short-Lived Student Networks for Collaborative Learning.
2016	Face-to-Face Collaborative Learning by Enhancing Viewpoint-Sharing of Learning Materials.
2016	Collaborative Online Learning of an Action Model.
2016	A Collaborative Learning Model in Teaching-Learning-Based Optimization: Some Numerical Results.
2016	Collaborative Learning in Teacher Education Community for Pre-service Teacher Practice Learning.
2016	Scaffolding wiki-supported collaborative learning for small-group projects and whole-class collaborative knowledge building.
2016	Exploring the Impact of Learning Styles on the Acceptance of Open Learner Models in Collaborative Learning.
2016	The Impact of the E-Collaborative and Traditional Learning Styles on Learning Outcomes and Anxiety.
2016	Enhancing Metacognitive Language Learning Strategy Use and Business Language Proficiency in Technology-Enhanced Collaborative Learning Environment.
2016	A collaborative recommender system for learning courses considering the relevance of a learner's learning skills.
2016	Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation.
2016	Active learning through collaborative knowledge building using an automatic free-text scoring system in a b-learning environment.
2016	Technology Support for Discussion Based Learning: From Computer Supported Collaborative Learning to the Future of Massive Open Online Courses.
2016	Supporting Seamless Learning Across Individual, Collaborative, and Community-Based Learning in One-to-One Learning Age.
2016	A Literature Review on Enterprise Social Media Collaboration in Virtual Teams: Challenges, Determinants, Implications and Impacts.
2016	Hybrid Teams: Flexible Collaboration Between Humans, Robots and Virtual Agents.
2016	Remote Working and Collaboration in Agile Teams.
2016	Experience Report of Teaching Agile Collaboration and Values: Agile Software Development in Large Student Teams.
2016	Asynchronous Creative Collaboration in Distributed Design Teams.
2016	Trust Development in Globally Distributed Collaboration: A Case of U.S. and Chinese Mixed Teams.
2016	Collaboration technology in teams and organizations: Introduction to the special issue.
2016	Investigating individual trust in semi-virtual collaboration of multicultural and unicultural teams.
2016	Women in computer science research: what is the bibliography data telling us?
2016	Accounting for the Role of Policy in the Underrepresentation of Women in Computer Science.
2016	Storyboards as a Lingua Franca in Multidisciplinary Design Teams.
2015	Storytelling of Collaborative Learning System on Augmented Reality.
2015	Cross-Domain Collaborative Recommendation by Transfer Learning of Heterogeneous Feedbacks.
2015	Codechella: Multi-user program visualizations for real-time tutoring and collaborative learning.
2015	Collaborative learning using tablets in EFL to develop oral communication.
2015	Collaborative Learning In An Artifact Ecology: A Distributed Cognition Perception.
2015	Architecting Collaborative Learning Places.
2015	Selection of Collaborative Learning Techniques Using Bloom's Taxonomy.
2015	Gamification of Collaborative Learning Scenarios: Structuring Persuasive Strategies Using Game Elements and Ontologies.
2015	Collaborative Q-learning path planning for autonomous robots based on holonic multi-agent system.
2015	Robot services development by international collaborative PBL(Project Based Learning) with universities in three countries.
2015	Learning Context-aware Latent Representations for Context-aware Collaborative Filtering.
2015	Keynote: The Interplay of Discussion, Cognition and Instruction in Computer-Supported Collaborative Learning Environments.
2015	Can a child feel responsible for another in the presence of a robot in a collaborative learning activity?
2015	Learning Distributed Representations from Reviews for Collaborative Filtering.
2015	Collaborative Multi-view Learning with Active Discriminative Prior for Recommendation.
2015	Supporting Peer Help in Collaborative Learning Environments: A Discussion Based on Two Case Studies.
2015	Clustering Learning Objects for Improving Their Recommendation via Collaborative Filtering Algorithms.
2015	Quality of service considerations in collaborative learning environments.
2015	Mobile Multimedia Platform for collaborative learning in Virtual Mobility Context.
2015	Cross-Domain Collaborative Learning in Social Multimedia.
2015	Algorithms and Machine Learning Techniques in Collaborative Group Formation.
2015	Designing MOOCs as Interactive Places for Collaborative Learning.
2015	Collaborative Learning Support System in a Classroom Using Ad Hoc Network of Tablet Devices.
2015	A Meta-Analysis on Students' Argumentative Knowledge Construction Process in Social Collaborative Learning Environment.
2015	Collaborative Learning in Computer Programming Courses That Adopted the Flipped Classroom.
2015	Feasibility of Collaborative Learning and Work Between Robots and Children with Autism Spectrum Disorders.
2015	Towards the Definition of a Framework for the Management of Interactive Collaborative Learning Applications for Preschoolers.
2015	Improving e-Assessment in Collaborative and Social Learning Settings.
2015	Investigating the Determinants of Information Sharing Intentions of Learners in Collaborative Learning.
2015	Collaborative and Cooperative-Learning in Software Engineering Courses.
2015	Learning multiple collaborative tasks with a mixture of Interaction Primitives.
2015	Using Open edX Forum for Supporting Collaborative Learning.
2015	Predicting Participation Styles using Co-occurrence Patterns of Nonverbal Behaviors in Collaborative Learning.
2015	Potential of Social Media Not Only in Collaborative Learning: Expectations and Reality Case Study.
2015	Using Distributed Cognition Theory to Analyze Collaborative Computer Science Learning.
2015	The Empirical Study on Self-Regulation, Co-Regulation, and Socially Shared Regulation in Computer-Supported Collaborative Learning.
2015	The Impact of Cross-Age Peer Tutors on Knowledge Elaboration, Knowledge Convergence, and Group Performance in Computer Supported Collaborative Learning.
2015	Constructing Collaborative Learning Groups with Maximum Diversity Requirements.
2015	Online Collaborative Learning for Improving Argumentation of Student with Different Levels of Science Prior Knowledge.
2015	Improving Communication and Project Management through an Adaptive Collaborative Learning System.
2015	A Design Proposal for Learner-Centered Visualisations of Learning Analytics in Collaborative Scenarios.
2015	Collaborative Learning in the Cloud: A Cross-Cultural Perspective of Collaboration.
2015	Efficient Model Learning from Joint-Action Demonstrations for Human-Robot Collaborative Tasks.
2015	Can We Solve Low Participation, Distraction, and Inefficiency? A Case Study of Distributed Collaborative Learning in Industries.
2015	CATALYST: Technology-Assisted Collaborative and Experiential Learning for School Students.
2015	Influence of Social Communication Skills on Collaborative Learning with a Pedagogical Agent: Investigation Based on the Autism-spectrum Quotient.

2015	VR based Collaborative Errorless Learning System using Humanoid Avatar for People with Alzheimer's Disease.
2015	A Secure Collaborative Machine Learning Framework Based on Data Locality.
2015	Privacy-Preserving Collaborative Learning for Mobile Health Monitoring.
2015	Smart grouping tool portal for collaborative learning.
2015	WebRTC based remote collaborative online learning platform.
2015	Graph Patterns, Reinforcement Learning and Models of Reputation for Improving Coalition Formation in Collaborative Multi-agent Systems.
2015	A new model for collaborative learning of programming using source code similarity detection.
2015	Collaborative learning with cyber-physical systems.
2015	Collaborative learning from Mobile Crowd Sensing: A case study in electromagnetic monitoring.
2015	Do autonomously motivated students benefit from collaborative learning methods?
2015	Towards MOOCs scenaries based on collaborative learning approaches.
2015	Collaborative Learning Orchestration Using Smart Displays and Personal Devices.
2015	Collaborative feature learning from social media.
2015	Conceptualizing Collaboration in the Context of Computer-supported Collaborative Learning.
2015	Collaborative and Individual Learning - Mixing the Two.
2015	Designing the assessment of the collaborative learning process in LMS courses.
2015	A Behaviour Awareness Mechanism to Support Collaborative Learning.
2015	A collaborative distributed multi-agent reinforcement learning technique for dynamic agent shortest path planning via selected sub-goals in complex cluttered environments.
2015	A Methodology to Evaluate Complex Learning Resources to Improve e-Assessment from Collaborative and Networking Settings.
2015	Experiences in a Collaborative Space for Learning Digital Systems.
2015	Robust collaborative learning by multi-agents.
2015	A Hybrid Collaborative Filtering recommendation algorithm for Web-based Learning systems.
2015	The Effects of Temperament and Team Formation Mechanism on Collaborative Learning of Knowledge and Skill in Short-Term Projects.
2015	Item Similarity Learning Methods for Collaborative Filtering Recommender Systems.
2015	Toward Combining Individual and Collaborative Learning Within an Intelligent Tutoring System.
2015	Predictive Knowledge Modeling in Collaborative Inquiry Learning Scenarios.
2015	Steps Towards the Gamification of Collaborative Learning Scenarios Supported by Ontologies.
2015	Supporting collaborative work on ontology learning from Relational Databases.
2015	Lifelong learning lab: collaborative design of hands-on science for chinese schools.
2015	The Comparison of Creating Homogeneous and Heterogeneous Collaborative Learning Groups in Intelligent Tutoring Systems.
2015	A Novel Continuous Learning and Collaborative Decision Making Mechanism for Real-Time Cooperation of Humanoid Service Robots.
2015	Towards a Notification System for Mobile Devices to Support Collaborative Learning.
2015	Collaborative work with linear classifier and extreme learning machine for fast text categorization.
2015	Collaborative work with linear classifier and extreme learning machine for fast text categorization.
2015	Dynamic Group Formation as an Approach to Collaborative Learning Support.
2015	A Self-Adaptive Multi-Agent System Approach for Collaborative Mobile Learning.
2015	Collaborative Active and Semisupervised Learning for Hyperspectral Remote Sensing Image Classification.
2015	SSCLS: A Smartphone-Supported Collaborative Learning System.
2015	Collaborative Multifeature Fusion for Transductive Spectral Learning.
2015	Analysis of collaborative learning in social network sites used in education.
2015	A 'Mixed' Approach to Group Formation in Collaborative Learning.
2015	Collaborative Learning Automata-Based Routing for Rescue Operations in Dense Urban Regions Using Vehicular Sensor Networks.
2015	Collaborative-Learning-Automata-Based Channel Assignment With Topology Preservation for Wireless Mesh Networks Under QoS Constraints.
2015	A numerical similarity approach for using retired Current Procedural Terminology (CPT) codes for electronic phenotyping in the Scalable Collaborative Infrastructure for a Learning Health System (SCILHS).
2015	Learning Circles: A Collaborative Technology-Mediated Peer-Teaching Workshop.
2015	Building an evaluation framework for social media-enabled collaborative learning environments (SMECLEs).
2015	Assessing learners' perceived readiness for computer-supported collaborative learning (CSCL): a study on initial development and validation.
2015	Using wikis and collaborative learning for science teachers' professional development.
2015	Interaction-based Collaborative Recommendation: A Personalized Learning Environment (PLE) Perspective.
2015	The effects of gender variety and power disparity on group cognitive complexity in collaborative learning groups.
2015	Design 'the Pori hidden beauties geocaching series': computer-supported collaborative web-based learning and sharing experiences.
2015	Collaborative video blended learning for exercising higher-order thinking - evaluation using community of inquiry framework.
2015	Evaluation and selection of group recommendation strategies for collaborative searching of learning objects.
2015	TSCL: A conceptual model to inform understanding of collaborative learning processes at interactive tabletops.
2015	Collaborative experience sharing with the support of M-Learning 2.0: a fundamental framework, a case study and research issues.
2015	Applicability of virtual collaborative learning environment in Saudi Arabian Universities.
2015	Pilot Study on the Feasibility and Indicator Effects of Collaborative Online Projects on Science Learning for English Learners.
2015	Gaining Hands-on Experience via Collaborative Learning: Interactive Computer Science Courses.
2015	Fourth International Workshop on Adaptive Learning via Interactive, Collaborative and Emotional Approaches (ALICE 2014).
2015	Young Language Learners' Collaborative Learning and Social Interaction as a Motivational Aspect of the iPad.
2015	Transforming Teacher Education with Digital and Collaborative Learning and Leadership.
2015	Collaborative learning using tabletop and interactive whiteboard systems.
2015	Network-structured discussions for collaborative concept mapping and peer learning.
2015	Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning.
2015	Designing a role structure to engage students in computer-supported collaborative learning.
2015	Transforming collaborative filtering into supervised learning.
2015	Scalable learning of probabilistic latent models for collaborative filtering.
2015	A semi-supervised learning algorithm for relevance feedback and collaborative image retrieval.
2015	Process modeling and decision mining in a collaborative distance learning environment.
2015	An approach to collaborative learning and the serious game development.
2015	Collaborative group engagement in a computer-supported inquiry learning environment.
2015	Investigating the effects of prompts on argumentation style, consensus and perceived efficacy in collaborative learning.
2015	Constructing liminal blends in a collaborative augmented-reality learning environment.
2015	Organizational Learning for Library Enhancements: A Collaborative, Research-Driven Analysis of Academic Department Needs.
2015	Mapping development of social media research through different disciplines: Collaborative learning in management and computer science.
2015	Effects of gender grouping on students' group performance, individual achievements and attitudes in computer-supported collaborative learning.
2015	Electronic service quality of Facebook social commerce and collaborative learning.

2015	A collaborative learning lesson from using effective information technology combinations.
2015	Youth appropriation of social media for collaborative and facilitated design-based learning.
2015	Usability of a cloud-based collaborative learning framework to improve learners' experience.
2015	A novel justice-based linear model for optimal learner group formation in computer-supported collaborative learning environments.
2015	Knowledge workers' collaborative learning behavior modeling in an organizational social network.
2015	A collaborative testbed web tool for learning model transformation in software engineering education.
2015	A pedagogical model to develop teaching skills. The collaborative learning experience in the Immersive Virtual World TYMMI.
2015	Creating recommendations on electronic books: A collaborative learning implicit approach.
2015	Peer-supported badge attribution in a collaborative learning platform: The SAPO Campus case.
2015	Scripting and awareness tools for regulating collaborative learning: Changing the landscape of support in CSCL.
2015	An evaluation framework for comparing business-IT alignment models: A tool for supporting collaborative learning in organizations.
2015	A collaborative learning approach for geographic information retrieval based on social networks.
2015	An ontology-based approach for representing the interaction process between user profile and its context for collaborative learning environments.
2015	Augmented reality to promote collaborative and autonomous learning in higher education.
2015	Collaborative learning in postgraduate level courses.
2015	Human organizational patterns applied to collaborative learning software systems.
2015	Technostress in ICT enabled collaborative learning environment: An empirical study among Indian academician.
2015	Emotions ontology for collaborative modelling and learning of emotional responses.
2015	SCHOM. A tool for communication and collaborative e-learning.
2015	Open linked data and mobile devices as e-tourism tools. A practical approach to collaborative e-learning.
2015	ICT and collaborative co-learning in preschool children who face memory difficulties.
2015	Sentiment detection in social networks and in collaborative learning environments.
2015	Intercultural Talent Management Model: Virtual communities to promote collaborative learning in indigenous contexts. Teachers' and students' perceptions.
2015	Collaborative learning in environments with restricted access to the internet: Policies to bridge the digital divide and exclusion in prisons through the development of the skills of inmates.
2015	Collaborative learning based on associative models: Application to pattern classification in medical datasets.
2015	Cloud computing service for knowledge assessment and studies recommendation in crowdsourcing and collaborative learning environments based on social network analysis.
2015	Promoting academically productive talk with conversational agent interventions in collaborative learning settings.
2015	Efficiency of learning environment using GeoGebra when calculus contents are learned in collaborative groups.
2015	Lessons learned from the design of situated learning environments to support collaborative knowledge construction.
2015	The impact of individual and shared clicker use on students' collaborative learning.
2015	Facilitating critical thinking using the C-QRAC collaboration script: Enhancing science reading literacy in a computer-supported collaborative learning environment.
2015	Reflection-in-action markers for reflection-on-action in Computer-Supported Collaborative Learning settings.
2015	What's the difference? Learning collaboratively using iPads in conventional classrooms.
2015	Online collaborative learning activities: The perspectives of African American female students.
2015	Online computer supported collaborative learning (CSCL) for engineering students: A case study in Malaysia.
2015	From face-to-face to distance LMS-mediated collaborative learning situations with GLUE!
2015	Student activity and profile datasets from an online video-based collaborative learning experience.
2015	Object tracking via collaborative multi-task learning and appearance model updating.
2015	An Application Framework to Systematically Develop Complex Learning Resources Based on Collaborative Knowledge Engineering.
2015	Mobile Learning: A Pedagogical Framework to Facilitate Distributed Learning through Collaborative Approach for Enhancing English Language Communication Skills.
2015	Learning Effect of Collaborative Learning between Human and Robot Having Emotion Expression Model.
2015	Business process oriented learning: a collaborative approach of organisational learning.
2015	Effectiveness of Collaborative Learning with Complex Tasks Under Different Learning Group Formations: A Cognitive Load Perspective.
2015	Collaborative Learning Using Social Media Tools in a Blended Learning Course.
2015	Sketchpad: A Learning Tool Supporting Creativity in Collaborative Learning Activities.
2015	Students negotiating and designing their collaborative learning norms: a group developmental perspective in learning communities.
2015	Mobile collaborative learning: The role of individual learning in groups through text and video content delivery in tablets.
2015	An emerging - Social and emerging computing enabled philosophical paradigm for collaborative learning systems: Toward high effective next generation learning systems for the knowledge society.
2015	Exploring the antecedents of collaborative learning performance over social networking sites in a ubiquitous learning context.
2015	Enhancing students' learning process through interactive digital media: New opportunities for collaborative learning.
2015	A recommender agent based on learning styles for better virtual collaborative learning experiences.
2015	Human-Computer Collaboration in Adaptive Supervisory Control and Function Allocation of Autonomous System Teams.
2015	A framework to study requirements-driven collaboration among agile teams: Findings from two case studies.
2015	Designing e-Coordinator for improved teams collaboration in graduation projects.
2015	What Women Want: Analyzing Research Publications to Understand Gender Preferences in Computer Science.
2015	The Role of Microblogging Capacities in Knowledge Sharing and Collaboration in Virtual Teams.
2014	Collaborative Deep Learning for Recommender Systems.
2014	Learning From Ordered Sets and Applications in Collaborative Ranking.
2014	Cloud K-SVD: A Collaborative Dictionary Learning Algorithm for Big, Distributed Data.
2014	Collaborative Recommendation with Auxiliary Data: A Transfer Learning View.
2014	Efficient Model Learning for Human-Robot Collaborative Tasks.
2014	Utilizing the Active and Collaborative Learning Model in the Introductory Physics Course.
2014	Building active and collaborative learning environment in introductory physics course of faculty of technology education.
2014	Collaborative Receptive Field Learning.
2014	Fostering of innovative usability testing to develop mobile application for mobile collaborative learning (MCL).
2014	Using multimedia and peer assessment to promote collaborative e-learning.
2014	yPBL: An Active, Collaborative and Project-Based Learning Methodology in the Domain of Software Engineering.
2014	Integrating Testing into Software Engineering Courses Supported by a Collaborative Learning Environment.
2014	Management of socio-cultural knowledge using an ontology-based socio-cultural user profile in a computer-supported collaborative learning environment.
2014	Incidence of group awareness information on students' collaborative learning processes.
2014	Exploring students' learning effectiveness and attitude in Group Scribbles-supported collaborative reading activities: a study in the primary classroom.
2014	CC-LR: providing interactive, challenging and attractive Collaborative Complex Learning Resources.
2014	Brief communication: Scalable Collaborative Infrastructure for a Learning Healthcare System (SCILHS): Architecture.
2014	Playful interaction for learning collaboratively and individually.
2014	Effect Of Robot Utterances Using Onomatopoeia On Collaborative Learning.
2014	Human Action Recognition Using Pyramid Histograms of Oriented Gradients and Collaborative Multi-task Learning.
2014	Assessment of collaborative learning experiences by graphical analysis of wiki contributions.
2014	Designing environments for peer-to-peer and collaborative learning.
2014	Pattern of non-task interactions in asynchronous computer-supported collaborative learning courses.
2014	Who Owns the Floor?: Examining Participation in a Collaborative Learning Scenario Between Student Teachers and Active Professionals in Second Life.
2014	Classroom Orchestration: Balancing between Personal and Collaborative Learning Processes.

2014	Investigating the Mediating Role of Affective Commitment in a Computer Supported Collaborative Learning Environment.
2014	Research of the blog platform-assisted collaborative learning model in the teaching of 'micro-controller principles and applications'.
2014	Collaborative learning via Web 2.0 tools in adult education: predicting learner satisfaction by off-task interaction and social feedback.
2014	Twitter's capacity to support collaborative learning.
2014	YELLing for collaborative learning in teacher education: users' voices in the social platform LearnWeb2.0.
2014	Collaborative Language Learning in Immersive Virtual Worlds: Competence-based Formative Feedback and Open Learner Modeling.
2014	A multi-agent system for enabling collaborative situation awareness via position-based stigmergy and neuro-fuzzy learning.
2014	A generalised framework to support field and in-class collaborative learning.
2014	Collaborative Work and Learning with Large Amount of Graphical Content in a 3D Virtual World Using Texture Generation Model Built on Stream Processors.
2014	Designing interaction in digital tabletop games to support collaborative learning in children.
2014	Case-based reasoning approach for utilisation of past remarks as advice for collaborative learning.
2014	PC Med Learner: a personalised and collaborative e-learning materials recommendation system using an ontology-based data matching strategy.
2014	Design for Business & Business for Design: An E-Learning Platform for Collaborative Innovation.
2014	Development of a Collaborative Learning Game Using External Plastic Cards as an Input Device on an iPad.
2014	Integrating Collaborative and Decentralized Models to Support Ubiquitous Learning.
2014	An Experiment on Anonymity and Multi-User Virtual Environments: Manipulating Identity to Increase Learning from Online Collaborative Discussion.
2014	Using Activity Theory as Analytical Framework for Evaluating Contextual Online Collaborative Learning.
2014	A Framework for Collaborative Networked Learning in Higher Education: Design & Analysis.
2014	Wiring Role Taking in Collaborative Learning Environments. SNA and Semantic Web can improve CSCL script?
2014	Collaborative and Cooperative E-learning in Higher Education in Morocco: A Case Study.
2014	Collaborative M-Learning Adoption Model: A Case Study for Jordan.
2014	An e-Learning Collaborative Filtering Approach to Suggest Problems to Solve in Programming Online Judges.
2014	Implementing Advanced Characteristics of X3D Collaborative Virtual Environments for Supporting e-Learning: The Case of EVE Platform.
2014	Collaborative BIM Learning via an Academia-Industry Partnership.
2014	Use of Moodle as a Tool for Collaborative Learning: A Study Focused on Wiki.
2014	Technological support for the enactment of collaborative scripted learning activities across multiple spatial locations.
2014	Using the cloud to develop applications supporting geo-collaborative Situated Learning.
2014	Interaction-Rich Transfer Learning for Collaborative Filtering with Heterogeneous User Feedback.
2014	Learning collaborative team behavior from observation.
2014	Personalized recommendation of learning material using sequential pattern mining and attribute based collaborative filtering.
2014	Collaborative multi-agent reinforcement learning based on a novel coordination tree frame with dynamic partition.
2014	Mapping students' ideas to understand learning in a collaborative programming environment.
2014	Understanding collaborative learning activities in an information ecology: A distributed cognition account.
2014	Different leaders: Emergent organizational and intellectual leadership in children's collaborative learning groups.
2014	Perceptions and experiences of, and outcomes for, university students in culturally diversified dyads in a computer-supported collaborative learning environment.
2014	An evaluation of students' motivation in computer-supported collaborative learning of programming concepts.
2014	Where is the evidence? A meta-analysis on the role of argumentation for the acquisition of domain-specific knowledge in computer-supported collaborative learning.
2014	Group regulation and social-emotional interactions observed in computer supported collaborative learning: Comparison between good vs. poor collaborators.
2014	Structural model of team-based learning using Web 2.0 collaborative software.
2014	Exploring young students' talk in iPad-supported collaborative learning environments.
2014	Collaborative and role-play strategies in software engineering learning with web 2.0 tools.
2014	Using collaborative annotating and data mining on formative assessments to enhance learning efficiency.
2014	ALEF: From Application to Platform for Adaptive Collaborative Learning.
2014	Learning to Develop Learning and Teaching of CS: A Collaborative Example.
2014	A study of collaborative tool use in collaborative learning processes.
2014	Estimating Collaborative Attitudes based on Non-verbal Features in Collaborative Learning Interaction.
2014	Analysis of Team Characteristics of Project-Based Learning Based on Performance Factors of Collaborative Learning.
2014	Didactic Support of Diversity of Learning Styles? Potential Analysis of Three Collaborative Learning Methods within e-Business Education.
2014	The Impact of Different Roles on Motivation, Group Cohesion, and Learning Performance in Computer-Supported Collaborative Learning (CSCL).
2014	A Module-Based Learning Analytics System for Facebook Supported Collaborative Creativity Learning.
2014	Personalizing Learning Analytics to Support Collaborative Learning Design and Community Building.
2014	Using mobile devices and internet technologies in problem-based learning: Design of a suitable active and collaborative learning environment in engineering education.
2014	Social Collaborative e-Learning in Higher Education: Exploring the Role of Informal Learning.
2014	Model for collaborative and adaptive multimedia content delivery in a collaborative m-learning environment.
2014	Students' perceptions of self-directed learning and collaborative learning with and without technology.
2014	A quasi-experimental study of a blended course integrated with refined web-mediated pedagogy of collaborative learning and self-regulated learning.
2014	Case-based learning in virtual groups - collaborative problem solving activities and learning outcomes in a virtual professional training course.
2014	The Management and Construction of Knowledge as an Innovation Strategy for Collaborative Learning Through the Use and Creation of Learning Communities and Networks.
2014	Collaborative Learning: Group Interaction in an Intelligent Mobile-Assisted Multiple Language Learning System.
2014	Supporting online collaborative learning in small groups: Teacher feedback on learning content, academic task and social participation.
2014	Designing computer-supported collaborative learning at work for rural IT workers: Learning ensembles and geographic isolation.
2014	A Learning Method for Product Analysis in Product Design - Learning Method of Product Analysis Utilizing Collaborative Learning and a List of Analysis Items.
2014	Supporting collaboration of heterogeneous teams in an augmented team room.
2014	Tracing the Development of Ideas in Distributed, IT-Supported Teams during Synchronous Collaboration.
2014	Exploring the social-technological gap in telesurgery: collaboration within distributed or teams.
2014	Effects of cohesion-based feedback on the collaborations in global software development teams.
2014	Task models for human-computer collaboration in supervisory control of teams of autonomous systems.
2014	Mission critical: building community to engage young women in computer science (abstract only).
2014	Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades.
2014	Women in computer science: Survey on the perception of the women's participation in STEM studies.
2013	PeTEX@Work: Designing CSCL@Work for Online Engineering Education.
2013	Massively Multiplayer Online Role-Playing Games: A Potential Model of CSCL@Work.
2013	The Role of Communication and Facilitation for CSCL@Work.
2013	Technologies of Participation: A Case Study of CSCL@Work in Mammography.
2013	CSCL@Work for Practitioners.

2013	Learning User's Characteristics in Collaborative Filtering through Genetic Algorithms: Some New Results.
2013	Gameful Pedagogy and Collaborative Learning a Case Study of the Netsx Project.
2013	Exploratory Study on Collaborative Interaction through the Use of Augmented Reality in Science Learning.
2013	A method to form learners groups in computer-supported collaborative learning systems.
2013	How elementary school students evaluate the learning strategy of collaborative projects using ICT.
2013	Collaborative System for Learning Based on Questionnaires and Tasks.
2013	Facilitating Collaborative Learning in TaaS: A Mobile Cloud System for Enhancing Teamwork Performance.
2013	Designing and supporting collaborative learning activities.
2013	CoFiSet: Collaborative Filtering via Learning Pairwise Preferences over Item-sets.
2013	Accessible chats for computer supported collaborative learning environments in mobile devices: Doctoral consortium paper.
2013	Flexible tools for online collaborative learning: integration of adaptation patterns functionality in the WebCollage tool.
2013	Twin Bridge Transfer Learning for Sparse Collaborative Filtering.
2013	Sustaining Cognitive Diversity in Collaborative Learning Through Shared Spatially Separated Virtual Workspaces on Mobile Devices.
2013	Interaction patterns for assessment of learners in tabletop based collaborative learning environment.
2013	Evaluating landmark attraction model in collaborative wayfinding in virtual learning environments.
2013	Seek'N'Share: a platform for location-based collaborative mobile learning.
2013	A Wiki-Based Assessment System Towards Social-Empowered Collaborative Learning Environment.
2013	Model for interactive, collaborative and multimedia mobile learning environment.
2013	Learning-Based Modeling of Endovascular Navigation for Collaborative Robotic Catheterization.
2013	Visualization System for Analyzing Collaborative Learning Interaction.
2013	Advancing Collaborative Learning with Cloud Service.
2013	Scenarios for peer-to-peer learning in construction with emerging forms of collaborative computing.
2013	CAFCLA: An AmI-Based Framework to Design and Develop Context-Aware Collaborative Learning Activities.
2013	Towards Software Infrastructure for the Systematic Virtualization of Collaborative Learning Sessions.
2013	Building Intelligent Emotion Awareness for Improving Collaborative E-Learning.
2013	Extreme Learning Machine combining matrix factorization for collaborative filtering.
2013	Factors Influencing Hybrid Self-Regulated and Collaborative Learning for End-User Training: A Systematic Literature Review.
2013	A secure collaborative multimedia learning scheme in cultural environments.
2013	Utilization of Past Remarks of Similar Speech Pattern as Advice for Collaborative Learning.
2013	Facilitating Collaborative Learning on a Multitouch Tabletop.
2013	Collaborative Platform for Virtual Practice Enterprise Learning.
2013	A Genetic Algorithm-Based Multiple Characteristics Grouping Strategy for Collaborative Learning.
2013	E-PACAD: A collaborative learning environment based ontologies.
2013	Unrawelling the interaction strategies and gaze in collaborative learning with online video lectures.
2013	Learning collaborative decision-making parameters for multimodal emotion recognition.
2013	Improving the effectiveness of collaborative learning processes in Libyan Higher Education.
2013	Mobile Collaborative Experiential Learning (MCEL): Personalized Formative Assessment.
2013	Content-Orientation for Collaborative Learning Using Tabletop Surfaces.
2013	WeLEaD: collaborative toolkit for learning, engaging and deciding.
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