Review of Peer Feedback in Collaborative Tutoring Systems

Sehrish Abrejo[1], Shahnawaz Talpur[2], Amber Baig[1], Mutee-u-Rahman[1], Ahsanullah Baloch[1], and Saad K. Baloch[3]
[1]Department of Computer Science, Isra University, Hyderabad. Pakistan.
[2] Mehran University of Engineering and Technology, Jamshoro. Pakistan.
[3] Department of Electrical Engineering, Isra University, Hyderabad, Pakistan.
* **Correspondence**: Sehrish Abrejo, sehrish-abrejo@hotmail.com
Citation | Abrejo. S, Talpur. S, Baig. A, Rahman. M, Baloch. A, Baloch. S. K, "Review of Peer Feedback in Collaborative Tutoring Systems", IJIST, Vol. 6 Issue. 1 pp 98-114, Feb 2024
Received | Jan 06, 2024, **Revised |** Feb 10, 2024, **Accepted |** Feb 14, 2024, **Published |** Feb 17, 2024.

Introduction/Importance of Study:

Collaborative tutoring systems (CTSs) allow students to communicate from different geographical areas to learn, share, and explain ideas related to a particular problem.

Novelty statement:

Many CTSs employ peer tutor evaluation to offer feedback to students as they solve scenarios. When they receive similar questions, the students utilize the feedback to enhance their thinking. The accuracy of peer feedback is important because it helps students to enhance their learning skills. If the student serving as a peer tutor is unfamiliar with the topic, he or she may suggest incorrect feedback. Considering peer feedback's importance in learning systems, this study's primary goal is to critically examine various collaborative tutoring systems and evaluate the strategies they have created to enhance group learning. Numerous reviews have been published in the past, but none of them have taken into account the methods by which these systems deliver or assess peer feedback.

Material and Method:

This article critically reviews different CTSs based on the proposed evaluation scheme to investigate their design and methods that support peer collaboration.

Result and Discussion:

Through this study, it was found that there are few attempts in which the feedback sent from one student to another student is evaluated by CTS. The peer feedback accuracy is important, because a student who gets inaccurate feedback may reach the wrong conclusions, which would affect the learner's knowledge.

Concluding Remarks:

It is concluded that all of the CTSs provide chances to boost student's learning gains. Fortunately, the entire degree to which these advantages can be realized is subject to further investigation.

Keywords: Collaborative Tutoring Systems; Peer Feedback; E-Learning.

Introduction:

Because of the fast advancement of networking technology, universities, and corporate training programs may now reach out to students who would otherwise be unable to take advantage of numerous educational opportunities due to scheduling or geography restrictions [1]. Tutoring Systems use innovative technological advances such as the web, digital media, and augmented and virtual reality to provide tutoring to individuals as well as to groups of students in a collaborative learning environment [2]. On the other hand, the single student interacting with the system directly is called One-to-one computer-supported tutoring which also attempts to tailor the tutoring to the student's specific requirements [3]. In a one-to-many collaborative learning environment, on the other hand, the system interacts with a group of students and uses a collaborative learning technique to teach subject knowledge [4]. When compared to other tutoring models, collaborative learning promises to allow students to learn in more realistic, cognitively engaging, and socially enriching learning situations. Students can use Computer Supported Collaborative Learning (CSCL) [5][6][7][8] to discuss strategies with a group of peers who can criticize, compete, encourage, and guide them toward a greater understanding of the subject matter.

The ongoing research over the past few decades has introduced many methods through which students can interact with each other or give feedback to other fellow students in the collaborative learning environment. Allowing students to offer constructive feedback on one another's solutions can have several benefits: students can practice giving constructive feedback, they can receive guidance on their solutions, and they can observe how other students have approached a problem. In the ITS interface, student feedback to peers can be provided by simply clicking on a button to indicate the degree of correctness [9] or through any graphical notation to indicate correct or incorrect steps/solutions [10]. Many collaborative tutoring systems allow students to interact by exchanging text messages with each other [11][12][13][14][15][16]. Through these text messages, they can share their ideas in more detail which makes students understand better. There are several research studies in literature and implemented systems available that emphasize the effectiveness of collaboration in learning environments where students are assigned different roles (i.e. Tutor or Tutee) [17][18][19][20]. These collaborative systems are categorized as Peer-to-Peer learning systems in which a peer can be a virtual peer (i.e. system acting as a peer [21][22][23][24]) or it can be a real user (i.e. student [25][26]).

The feedback that students receive should be correct and it should properly guide them to revise their solutions not to confuse them [9]. If the feedback received/given is not clear, then the student can create misconceptions about the solution. Many tutoring methods have been presented in recent years to encourage collaborative learning and improve student learning. Collab-ChiQat [27], CirCLE [9], and ITSCL [28] are examples of such systems. In such systems, a student may rate or comment on another student's solution. These comments or ratings can be misleading if they conflict with the solution. For example, a student may correctly solve a problem but receive a negative rating. Students may become confused as a result of negative feedback, and they will be unable to solve the problem. In ITSCL, each student can provide textual comments on the answers of the other students. They have the option of agreeing or disagreeing with the peer's answer, as well as suggesting improvements. If one student makes a false negative comment (correct answer, but students comment negatively) or a false positive comment (correct answer but students comment positively), the ITSCL will not consider these comments. Furthermore, textual feedback can be beneficial [29][30], but domain-related accuracy and relevance of natural language input need extensive use of NLP techniques [31]. Similarly, in the collaborative group diagram, Collect-UML does not prevent students from adding incorrect components. Students who use the group diagram for assistance may use incorrect elements in their individual solutions. There are few and limited methods that work on the correctness and relevancy of peer feedback related to the solution.

Novelty statement and Objectives:

Many CTSs employ peer tutor evaluation to offer feedback to students as they solve scenarios. On receiving similar questions, the students utilize the feedback to reflect and enhance their thinking. The accuracy of peer feedback is important because it helps students to enhance their learning skills. If the student serving as a peer tutor is unfamiliar with the topic, he or she may suggest incorrect feedback. Numerous researchers have reviewed different collaborative tutoring systems in the past, but none of them have taken into account the methods by which these systems deliver or assess peer feedback.

The main objective of this study is to investigate different collaborative tutoring systems critically to review the approaches that they have developed to support collaborative learning. Furthermore, this study aims to critically analyze previous systems based on three dimensions that will be used to discuss the structure of collaborative systems, namely Techniques, Group Formation, and Peer Feedback Evaluation.

Collaborative Tutoring Systems:

There are several researches in literature and systems available that emphasize the effectiveness of collaboration in learning environments where students are assigned different roles (i.e. Tutor or Tutee). These collaborative systems are categorized as Peer-to-Peer learning systems in which a peer can be a virtual peer (i.e. system acting as a peer) or it can be a real user (i.e. student). The following section describes some of the Peer-to-Peer learning systems being the main focus of this research.

Know Cat:

Know Cat (Knowledge Catalyzer) [32] is a non-supervised system that was developed in 1998 and was used in some universities. It encourages several students to write some documents on the topics they are interested in, these documents can be accessed through their knowledge sites. These sites are accessed in three ways. 1) Using a knowledge tree, which is a hierarchical structure of topics, 2) Through a document set contained in each topic, and 3) Through annotations in each document. The participating students in the community can perform different tasks discussed below:

Add Document:

The students can add documents related to any topic which is then competed with already present documents. With this competition, the documents receive ratings to become the best among all.

Voting Document: The users can show their degree of satisfaction by rating the document.

Adding an Annotation to a Document:

This is a kind of note that is added within a document to suggest changes or to give an opinion on the document. The author's students read these annotations and try to improve their documents. The screenshot of Know Cat is shown in Figure 1, which displays the knowledge tree, the documents with a rating, and the users participating in the community.

Circle:

Circle [9] is an abbreviation for Circuitously Collaborative Learning Environment, which is intended to improve metacognitive awareness of the learning process using mathematical word puzzles. The primary goal of this study is to get students to reconsider their concepts after examining the solutions of other students. To begin, each learner is assigned one problem, which is subsequently submitted to the system. After the first submission, the Peer Inspector role is assigned to students, which requires them to evaluate and provide feedback on other students' solutions. After obtaining adequate remarks and considering various solutions, the inspector may reconsider their solution (Metacognitive awareness). The interface of CirCLE is shown in Figure 2, which has 2 parts.

Inferential Diagram: Where students are encouraged to use an interface to design their solutions.

Peer Interface:

Where Peer Inspector can rate the student's solution by clicking on the provided buttons, Disagree, Excessive, Insufficient, Incomplete, or can comment by clicking on the others button.

APTA:

Walker [10] proposed an Adaptive Peer Tutoring Assistant in which one student with similar potential instructs another student. The students take on the roles of tutee (for solving the problem) and tutor (for assessing and marking tutee's erroneous actions). If the tutor makes any mistakes, such as incorrectly marking the proper step, the system prompts and shows the tutor's error. The main focus of this tutor is to give feedback that is relevant to the current interaction between students. The relevant feedback and prompts from the tutoring system help peer tutors elaborate more on the concepts, problems, and issues in the given scenario. The students can solve a given mathematical equation, they can chat with each other, where they receive adaptive feedback from the tutoring system. This feedback is generated according to the dialogues they exchange with each other which encourages peer tutor and tutee to respond accordingly.

Collect-UML:

Collect-UML [33] is a constraint-based intelligent tutoring system through which students learn object-oriented analysis and design using Unified Modeling Language (UML). This tutor was designed for a single user and then it was extended to support a collaborative environment where multiple students take part in solving one problem together. This strategy may be used by students to tackle issues both alone and collaboratively. First, students create UML class diagrams on their own using input from the system. They then divide into small groups to brainstorm group solutions. When the system is in collaboration mode, it compares the group's overall solution against each member's unique solution. It offers feedback on the group solutions along with recommendations for collaboration.

The collect-UML has two parts, one is used by a single user (individual diagram) and the other is for a group of students (group diagram). The students can chat with each other to share their views, elaborate, and comment on the diagram solution. The tutoring system also gives hints to single users to help them to reflect on their thinking.

Expresser:

Expresser is a system developed by Dragon [34] that allows students to discuss their thoughts, explanations, and perceptions on microworlds (Algebraic Equations) using the LASAD discussion tool. Expressers can be used to solve simple algebra problems by designing patterns by using colored square tiles for building blocks. The colored tiles indicate equation variables. While students work independently on the problem, Expresser monitors their progress and interferes if it detects that one student is stuck while others have passed that point. For instance, Alice and Bob are trying to solve a microworld problem and Alice has solved a part of the problem while Bob is having difficulty. The system realizes that Alice can assist Bob, so rather than letting Bob work on the issue indefinitely, the system sends Alice a message. The system also alerts Bob's teacher, who can intervene to assist or further promote Alice's assistance. This sort of intellectual assistance benefits both Alice and Bob since Alice learns by attempting to teach Bob, thereby benefiting both the tutor and the tutee.

In any situation, the students are encouraged to engage in a discussion that will assist Bob in grasping the notion of a general rule through an example (see Figure 1). This activity is aided by the inclusion of specific boxes in LASAD that allow students to express their concerns about challenges they are encountering in their microworlds. A picture of the student's work is included in these boxes, as well as a "Go to Microworld" button that allows anybody to view and alter the shared model. In the example presented, Bob uses LASAD to build one of these "Microworld Issue" boxes to represent his problem (Figure 1 Box 1). After making several recommendations and responding to his inquiries, Alice attempts to assist him and finally clarifies problems using an example from her Expresser work (Figure 1 Box 20).

The system can detect nodes that demand response in general, such as a "Microworld Issue" node (Figure 1, Box 1) or a "Question" node (Figure 1, Box 18). The algorithm identifies that Alice is reacting to these nodes by creating her nodes and linking them to the issue and inquiry nodes in the scenario above. There is no need for additional assistance because there is active engagement. The system may poke students or warn the teacher if there is a lack of reaction.

Collab-ChiQat:

The enhanced version of a single-user, non-collaborative computer science intelligent tutoring system designed to facilitate paired programming with two students in a group is called Collab-ChiQat [27]. Collab-ChiQat is intended to support students in their collaborative learning of linked list data structures.

One student can take turns playing the role of driver (the role assigned to the person writing the code) and the other student must wait for their turn to write the code. ITS gives domain assistance to help control students resolve a specific problem, while other students may contribute relevant comments utilizing peer feedback rewards from the collaboration board interface. Both students can monitor their classmates' collaborative engagement and problem-solving through charts and graphs in the collaboration panel and can communicate via audio calls.

Collaborative CTAT:

Collaborative CTAT [35] is the extended version of CTA (Cognitive Tutor Algebra), which is an existing Intelligent Tutoring System that is used in primary school classes to teach mathematical fractions. Among the improvements is intelligent collaborative support for concurrent networked cooperation. The cooperating students use their computers on their own, but they comprehend the problem they are trying to address in a shared, yet distinct, way. The system has an audio chat function that lets students who are working together talk to each other. The method asks students to respond to a subject individually, shows them what their peers have to say, and then allows them to respond to the problem as a group in an attempt to develop cognitive group awareness.

The overall learning activity is divided into two parts, in the Tutored problem-solving phase, all students learn and solve problems individually using a CTAT tutor. In the erroneous example phase, students check their peer student's solutions, try to find the errors in the original solution, make corrections and provide advice to the student to avoid repeating similar mistakes in the same types of problems in the future. CTAT contains a Tutored Problem Solving interface where students compare fractions by finding the least common denominator converting all fractions using the least common denominator and sorting fractions from smallest to largest. Once the students have submitted their solution, the solution is viewed by a peer student in a collaborative erroneous interface.

ITSCL:

[28] proposed the ITSCL (Intelligent Tutoring Supported Collaborative Learning), a combination of CSCL and an ITS. ITSCL allows students to get engaged with the system through three levels. Individual learners communicate with the ITS tutor without cooperation at the initial level of interaction. One learner utilizes ITS one-on-one at this level of participation, answering ITS's questions and having to respond to its inquiries. If a student is unable to answer or needs assistance somewhere in the middle, ITS will give intelligent hints. The second and third stages of interactions in collaborative learning enable learner-to-learner (two peer students) and tutor-group interactions, respectively.

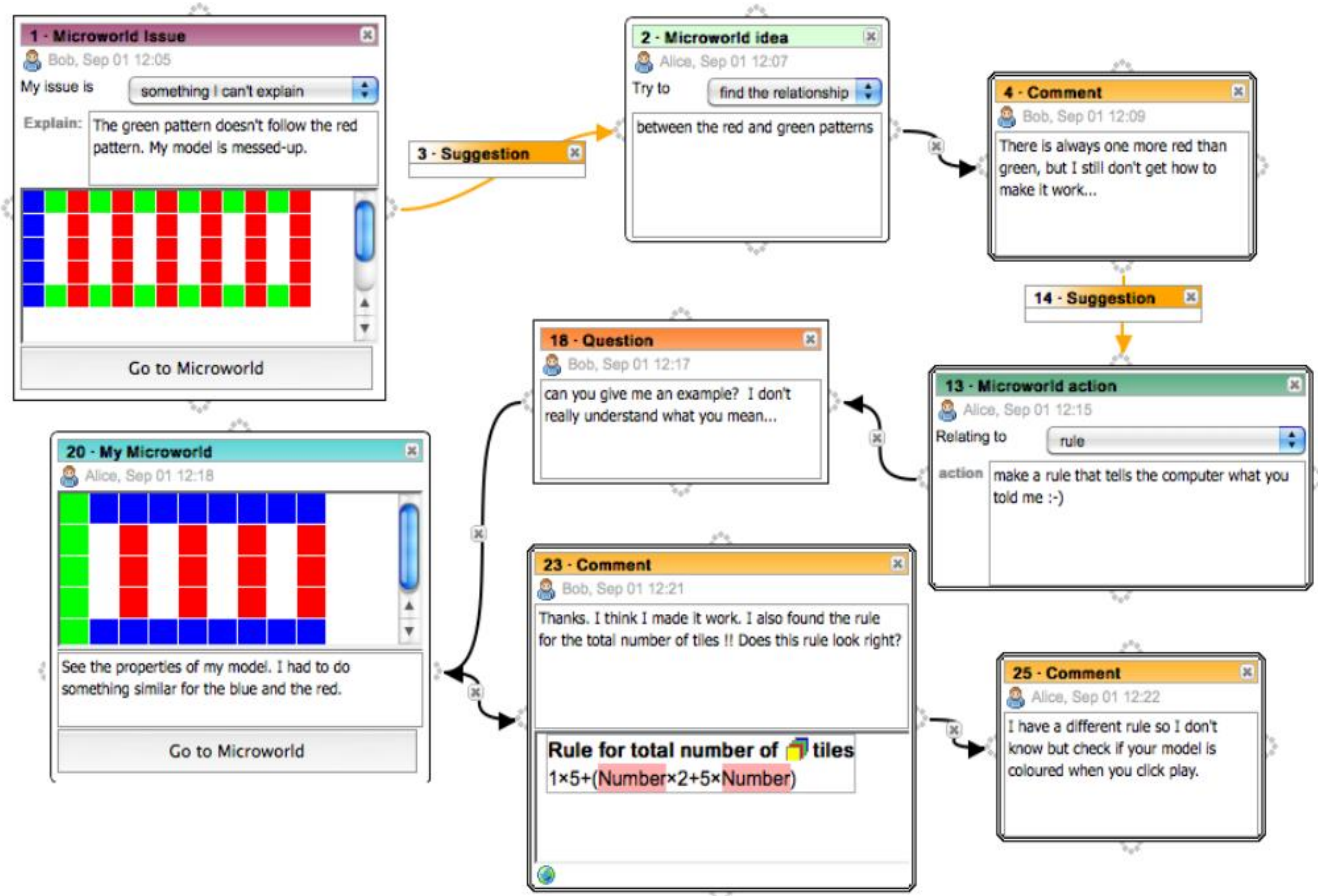

Figure 1: Alice and Bob's discussion using eXpresser [34]

Two students interact over chat to answer the questions at the second level of participation. ITS provides hints based on students' answers. The third stage of interaction permits tutor-group learning, in which numerous students submit a collective response to the ITS's problems. In this type of interaction, each student responds to the question posed by ITS individually, and ITS shows each student's response to all other students in the group. After reading the responses of other students, each student can revise his or her response twice. Students finalize their responses after updating. The ITS applies natural language processing (NLP) to finalized replies and compares them to answers recorded in the database. The response that most closely fits the stored database answer is chosen as the group answer, and the system subsequently provides ITS suggestions on the chosen group answer.

Rashi:

Rashi [36] assists collaborative students in maintaining attention by limiting students to the essential content instead of providing an open discussion platform where they might stray from the subject. The algorithm correctly identified the discourse's domain content by using an Expert Knowledge Base (EKB). The current study is focused on the adoption of Rashi as a Human Biology Tutor. Students analyze and hypothesize the medical status of patients using interactive visuals, interview interfaces, video, and inquiry and information organizing tools. Students may successfully critique and comment on one other's work while staying on the topic due to the framework in place. Rashi encourages students to work together by recording statistics and allowing them to chat. In the first place, students keep track of their facts and hypotheses in their notebooks. Students can drag and drop content into their notebooks from other students' notes. Individuals who perform particular tasks within a group can collaborate, or a student can work alone yet use the sharing methods when confused. Second, Rashi provides a student chat feature that incorporates subject labeling. Subjects make it easy to sift previous conversations and connect subjects to notebook entries.

Wayang Outpost:

Wayang Outpost [37] is an Intelligent Electronic Math Tutoring Software that helps middle and high school students practice solving math word problems in the format of standardized tests like the SAT MCAS and CA-Star. It does this by using multimedia, animated characters, and animated adventures. The system utilizes an animated character, Jake, as the embodiment of the tutoring agent. The investigation of "natural partnerships" for tutoring systems is the study's main contribution. Natural collaborations happen when students study in a one-to-one learning setting yet collaborate with a collocated partner in some fashion. As a result, the notion that the tutoring system was designed for a "private" one-on-one session is trumped by the students' interactions.
It is aimed to improve standardized test results and assist instructors in assessing students' strengths and shortcomings. As the student proceeds through the curriculum, Wayang Outpost learns how much the student understands each math ability, as well as how much the entire class knows. Wayang Outpost has been demonstrated to help students enhance their exam performance. Students practicing how to answer standardized arithmetic problems can use a range of tools provided by the system. These include videos and animated worked-out examples, in addition to assistance aids. Wayang, like a human tutor, recognizes student capabilities and adapts their presentation to offer further practice on weak skills.

Methodology:

The study aims to investigate and analyze Collaborative Tutoring Systems that can handle diverse student roles while also fostering a collaborative learning environment where students actively contribute by providing feedback on each other's solutions. This approach goes beyond traditional one-way instruction, emphasizing the importance of peer interaction and engagement in the learning process. The selected CTSs are shown in Table 1: Column 1 under the systems heading.

A process of assessment is required for successful critical evaluation and analysis of any work. This is especially true when the effort, like in the case of CITS, encompasses numerous, wide fields of inquiry. As a consequence of the comparative examination of the selected works, a groundbreaking categorization scheme for CITS that combines the ITS and CSCL paradigms was developed. The categorization scheme is meant to aid in the understanding of design concepts employed by CITS in their emerging state. This work uses the following broad dimensions to critique previous work.

- **Techniques:** What system tools for interaction are used?
- **Group Formation:** How the groups are made and what roles are used?
- **Peer Feedback Assessment and Evaluation:** How the feedback from peer students are evaluated?

The classification scheme incorporates CITS's primary operational aspects. CITS are collaborative learning environments that use technological tools (technology) to provide systematic support to learners working within groups (group formation) aiming to send and receive domain-related information to achieve a learning goal (Peer feedback assessment and evaluation).

Our critical review started with the evaluation of tools that a CTS uses to support collaboration between students. A key focus was placed on identifying the interaction methods utilized by students to engage with one another as this assessment allowed us to know how students are bound to the systems' interface-provided options. Table 1 under Technology section shows the review of interaction methods that targeted systems have used. Furthermore, it was also crucial to know whether the system allows student to justify his/her review. Lastly, our review also focused on whether system allows student to update/change their review or not. Finding out how CTSs were intended to create student groups was the next step. In a group consisting of just two students, one student receives feedback from one peer. Understanding how the system facilitates cooperation amongst numerous students in a group was important. Table 1 under Group formation section shows the methods that different CTSs have used to form groups. Finally, the study's primary goal was to find out how the system helps a peer student who is giving feedback to other peers. This investigation is crucial in determining whether the feedback provided by students to their peers will be assessed by the system or not. The details are provided in Table 1 under Peer Feedback and Evaluation section.

Every CTS underwent a thorough examination based on its provided descriptions to identify and assess any potential errors or inaccuracies. This process involved detailed scrutiny of the information available to ensure a comprehensive understanding of each CTS and to catch any discrepancies or flaws that might be present. Subsequently, we categorized the identified issues based on the predefined evaluation criteria that we had established. This systematic grouping allowed for a structured and methodical approach to addressing and analyzing the concerns within the context of our established evaluation framework. Figure 2 depicts the overall evaluation procedure.

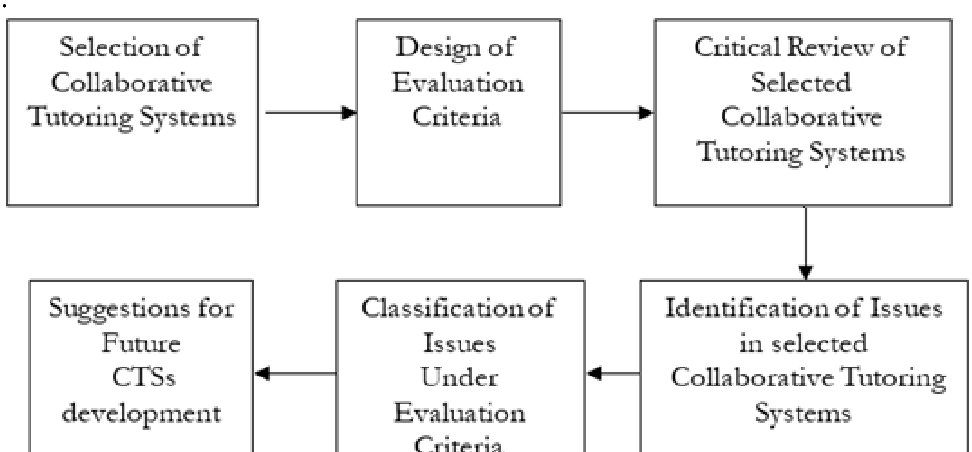

Figure 2: Evaluation flow of different CTSs.

Techniques:

Techniques are essentially the methods or procedures employed for the creation and upkeep of programs and applications. In this survey, the attention is directed towards the tools that previous systems have utilized to offer support for collaboration among users. These systems impose limitations on collaborators, requiring them to utilize designated tools for effective collaboration and communication. The commonly integrated features in targeted systems encompass private or shared workspaces, textual or audio-based communication channels, and mechanisms for providing feedback, often in the form of ratings or comments on solutions contributed by other users, serving as a means to foster collaboration among students or users. Table 1 shows the list of techniques used by selected CTSs.

Group Formation:

The process of forming groups plays a crucial role in influencing the overall collaborative learning experience. Properly selecting members for a group can contribute to the creation of conditions that encourage meaningful interactions, ultimately fostering robust learning and intellectual progress. The research indicates that many systems mentioned in the study form groups consisting of two members, with strictly assigned roles as outlined in Table 1. However, it is noteworthy that KnowCat and ITSCL deviate from this trend by supporting groups with more than two students. The majority of systems employ the titles of tutor, inspector, or reviewer to designate students responsible for overseeing and evaluating the work of their peers. Assigning simple peer roles to students implies that they have the ability to offer feedback on each other's solutions without the need for specific role names.

Feedback Assessment and Evaluation:

Peer assessment, commonly referred to as peer review, is a structured educational approach where students evaluate and comment on each other's work. This process not only instructs students in evaluating and enhancing their own work but also trains them to analyze and provide constructive feedback to their peers. Conversely, the recipient of the feedback strives to make adjustments and improvements to their work based on the received comments. The majority of the systems explored in this research study heavily depend on the practice of peer review as a valuable component of the learning process. Nearly all of these systems enable students to offer feedback on their peers' solutions in various ways. However, it is worth noting that APTA stands out in its capability to identify errors within the feedback provided by the tutor. This unique feature sets APTA apart from the other systems, as it not only facilitates student input on solutions but also actively identifies and addresses potential inaccuracies in the guidance offered by the tutor.

Techniques:

Techniques of any system are development methods or procedures for designing and maintaining programs and applications. In our scenario, the focus is on the tools that previous systems have implemented to provide collaboration support to the users. Students are given limited rating options in CirCLE, which they can use to evaluate the solutions of other students. There is no mechanism for students to defend their ratings on the solutions. The system's lack of restricted communication strategies in core components of the CSCL architecture puts it at a major disadvantage when it comes to providing effective collaborative support because students often need to know or explain why certain ratings were given. In KnowCat, a user adds an annotation (also known as a note) to a document to express recommendations, comments, or views. Unlike KnowCat and CirCLE, all of the other systems investigated in this research either include a textual chat facility or link students via audio communication. Furthermore, it is unclear whether or not the rating given on other students' solutions in CirCLE, a KnowCat annotation, the class component in Collect-UML and comments in boxes in eXpresser, may be changed. Students should have this flexibility in the system so that they may adjust their feedback if it is inaccurate.

Group Formation:

The formation of groups is a complicated and crucial phase in the design of effective collaborative learning activities. It strongly influences the collaborative learning process in CSCL [38]. In APTA, Collab-ChiQat, CTAT, eXpresser, and Rashi, the group formation is left to the teacher's preference. Students in KnowCat and CirCLE are allocated roles based on the tasks they complete. In KnowCat, for example, if a student uploads a document, he or she acts as an Author; otherwise, they are Peer reviewers. In CirCLE, however, all students are initially allocated to the role of basic student, and then they are assigned to the role of Inspector, who evaluates the solutions of other students. The students in Collect-UML and ITSCL work as simple peer students and they are not assigned any role. Students develop collaborative relations outside of the teacher and system in Wayang Outpost. Within their collaborative interactions, students pick the roles they want to play. These roles, as well as the collaborative relationships themselves, are unknown to the system.

Feedback Assessment and Evaluation:

Peer assessment, often called peer review, is a structured learning process in which students' critique and remark on one another's work. It teaches students how to assess and improve their work as well as analyses and offers feedback to others. On the other hand, the peer who receives comments will endeavor to adjust and improve their work. Most of the systems discussed in this research study rely on peer review. Feedback is given in the form of ratings on documents or solutions in KnowCat and CirCLE. Students acting as Peer Reviewers or inspectors can rate the work of other students using any of the system's rating choices. Despite taking all of the correct steps, the inspector in CirCLE might disagree with the students' solutions and issue unfavorable feedback. The method does not assist in informing the inspector of the student's correct solution.

APTA allows tutor students to assess each step tutee student takes in solving a mathematical problem. The tutor can mark each step as correct or incorrect which is in turn evaluated by ITS if the correct step taken from the tutee has been marked as incorrect (or vice versa). The tutor's feedback evaluation by ITS is also visible to the tutee student which is considered a design flaw. The tutors should provide correct feedback before damaging tutees' learning progress.

In Collect-UML, the students share a workspace and draw diagrams to support each other's private solutions. Each student takes ideas from a shared diagram that they implement in their solution as well. This technique has a flaw when it allows students to add incorrect class diagram components in a shared workspace. Hence, when students add incorrect components from a shared workspace into their private workspace, they will receive hints from ITS and their error will be logged as their own mistake. In Collab-ChiQat, the student acting as a peer can provide helpful bonus feedback using a collaborative panel interface. ITS provides hints on driver's solutions whereas the peer's feedback is not evaluated. Incorrect feedback would lead driver students to implement erroneous code.

Students in CTAT would not receive any help from the system on the individual solutions but they can guide each other's work. Similarly, in ITSCL, any student can leave a comment on the response of another student. They can either agree or disagree with the peer's answer, or they might offer revisions. If a student delivers fake negative comments (the answer is accurate, but students comment negatively) or false positive comments (the answer is incorrect, but students comment favorably), the ITSCL does not analyze these remarks. Furthermore, textual feedback can be beneficial [39], but domain-related accuracy and relevance of natural language input need extensive use of NLP techniques; otherwise, the system's capacity to offer meaningful feedback would be challenged.

The eXpresser maintains track of students' progress and intervenes if it discovers that one of them is stuck while the others have progressed. The two students may be stuck on the same problem. It's not apparent how the system will deal with this circumstance. Rashi allows students to make hypotheses regarding patient diseases in their notebooks. Peer students can review notebooks and offer advice or criticism on individual hypotheses. The system does not assess these remarks.

Lastly, pedagogical guidance regarding students' collaborative activities is not provided to them in Wayang Outpost. Students are allowed to chat with irrelevant content after choosing their communication subject [40].

Students with similar learning levels offer feedback to one another to improve their learning skills, according to studies reviewed in this research. Peer feedback does not always result in learning gains, and rather than confusing students, they should get meaningful comments as assistance to rethink their solutions [9]. Since the tutor is also a student, there is always the possibility that the peer will be confused about the topic and provide inaccurate information. On the other hand, a student who receives incorrect feedback may infer incorrectly, therefore influencing the learner's understanding. Any misinterpretation of peer input, on the other hand, may cause learners to become sidetracked and take longer to comprehend and solve the problem. Previous research that permitted students to participate by offering feedback to one another showed little or no evidence of peer feedback's relation to correct/wrong solutions. The overall evaluation of different CTSs under developed evaluation criteria is shown in Table 1.

Table 1: Summary of Collaborative Tutoring Systems, based on Evaluation Criteria.

	Technology			Group Formation		Feedback Assessment and Evaluation		
System	**Interactions**	**Express Justifications**	**Update Feedback**	**No. of participating Students**	**Students Roles**	**Peer Feedback Assessment Method**	**Feedback Evaluated by System**	**NLP Techniques Required**
KnowCat [19]	Knowledge sites, annotation on documents	No	No	More than 2	Author, Peer Reviewer	Documents are evaluated by peers. Peers' ratings are not evaluated by the system.	No	No
Circle [9]	Private workspace, inspectors' ratings on the student solutions.	No	No	2	Student, Inspector	Solutions are evaluated by peers. Peers' ratings are not evaluated by the system.	No	No
Adaptive Peer Tutoring Assistant [10]	Shared workspace, Chat, correct and incorrect marks on solutions.	Yes	Yes	2	Tutor, Tutee	Peer feedback corrects incorrect marks evaluated by the system	Yes	Possible
Collect-UML [20]	Shared and Private workspace, chat	Yes	Unclear	2	Simple peer	The system evaluates individual model solutions only	No	Possible
Collab-ChiQat [23]	Share workspace, Audio conversation	Yes	Yes	2	Driver and Peer	Audio conversations evaluated by authors. No evaluation of bonus feedback	No	No

Collaborative CTAT [24]	Private workspace, selected feedback answers, audio conversations	Yes	Yes	2	Student, Inspector	The system assesses group solutions, no individual solution assessments supported	Unclear	No
ITSCL [15]	Shared workspace, comments on a solution, ratings on answers, Chat	Yes	Yes	More than 2	Simple peer	Solutions are assessed by peer students	No	Possible
eXpresser [22]	Private Workspace, LASAD system for textual conversations	Yes	No	2	Tutor/ Tutee	Solutions assessed by tutor student.	No	Possible
Rashi [25]	Private and shared notebook, Comments on each other's notebook hypothesis	Yes	Yes	2	Simple peer	The hypothesis is evaluated by a group of students.	No	No
Wayang Outpost [26]	Private workspace, audio conversions.	Yes	No	Not mentioned	Simple peer	Solutions assessed by ITS.	No	No

Conclusion:

Because of their constant availability and simplicity of use, CTSs have grown in popularity. The use of CTSs in distance learning enhances the learning experience by providing personalized, flexible, and interactive educational opportunities, addressing the challenges associated with physical distance and varying schedules. Their considerable advancements over the previous decade have improved, but there is still tremendous room for development. This paper provides a detailed review of some collaborative tutoring systems with the help of an evaluation scheme that criticizes on design and techniques these systems used for supporting collaboration. When students work together, they provide feedback on their responses. Other students take this feedback to reevaluate their responses and reflect on their own thought processes. Since students act on feedback, its accuracy is critical. Through this study, it can be argued that there are very few attempts in the literature that work on peer feedback accuracy and solution correctness. Furthermore, it is reasonable to assume that the benefits of peer feedback evaluation will grow as the quality of peer feedback evaluation improves. As a result, as a potential improvement, peer feedback evaluation should be applied with upgrades in future collaborative and intelligent tutoring technologies. Much of the design, however, is dependent on how instructors, practitioners, and individuals like to arrange their learning and collaborative activities.

Future Directions:

The examined publications identify the following several prospective fields of study:

Virtual Peer Tutoring:

Using virtual peers as tutees might be a useful way to foster group learning. A virtual peer would be the perfect tutee since the tutor frequently benefited from features that are harmful to a real tutee (such as watching tutee blunders, answering tip requests, and correcting instructor faults). The tutor can still benefit from these experiences in this way.

Flexibility in Content Delivery:

CTSs can be designed to present a wide range of content formats, such as interactive activities, videos, text, and simulations. This adaptability will meet the needs of learners with varying learning styles and guarantees that distant learners have access to a wide range of instructional materials.

Students' Domain Learning Progression:

When learning remotely, the person interaction is not feasible therefore, these tracking tools assist both students in evaluating performance and pinpointing areas in need of improvement. Most of CITS use marking or grading method to monitor other student's progress. The CTSs should be implemented to add more features through which students can track progress of other students.

Author's Contribution: All authors have contributed equally.

Conflict of Interest: The authors have no conflict of interest in publishing this manuscript in IJIST.

Project Details. NIL

References:

[1] N. Hernández-Sellés, Pablo-César Muñoz-Carril, and M. González-Sanmamed, "Computer-supported collaborative learning: An analysis of the relationship between interaction, emotional support and online collaborative tools," Comput. Educ., vol. 138, no. February, pp. 1–12, 2019, doi: 10.1016/j.compedu.2019.04.012.

[2] A. A. K. Awais Khan Jumani, Waqas Ahmed Siddique, Asif Ali Laghari, Ahad Abro, "Virtual Reality and Augmented Reality for Education," Multimed. Comput. Syst. Virtual Real., 2022.

[3] J. Lu, Y. Tao, J. Xu, and M. Stephens, "Commognitive responsibility shift and its

visualizing in computer-supported one-to-one tutoring," Interact. Learn. Environ., vol. 31, no. 1, pp. 270–281, 2023, doi: 10.1080/10494820.2020.1777167.
[4] K. J. Yoo, "Effects of One-to-Many Tutoring Mathematics Cooperative Learning on the Cognitive and Affective Domains of High School Students," Commun. Math. Educ., vol. 34, no. 2, pp. 161–177, 2020, doi: 10.7468/JKSMEE.2020.34.2.161.
[5] H. Jeong, C. E. Hmelo-Silver, and K. Jo, "Ten years of Computer-Supported Collaborative Learning: A meta-analysis of CSCL in STEM education during 2005–2014," Educ. Res. Rev., vol. 28, no. February, p. 100284, 2019, doi: 10.1016/j.edurev.2019.100284.
[6] A. Piki, "Re-imagining the Distributed Nature of Learner Engagement in Computer-Supported Collaborative Learning Contexts in the Post-pandemic Era," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 13316 LNCS, pp. 161–179, 2022, doi: 10.1007/978-3-031-05064-0_13/COVER.
[7] L. Lipponen, "Exploring Foundations for Computer-Supported Collaborative Learning," Comput. Support Collab. Learn., pp. 72–81, Jan. 2023, doi: 10.4324/9781315045467-12.
[8] H. M. Armin Weinberger, Frank Fischer, "Fostering Computer Supported Collaborative Learning with Cooperation Scripts and Scaffolds," 2023, [Online]. Available: https://www.taylorfrancis.com/chapters/edit/10.4324/9781315045467-114/fostering-computer-supported-collaborative-learning-cooperation-scripts-scaffolds-armin-weinberger-frank-fischer-heinz-mandl
[9] T. S. and M. I. T. Dangal, B. Suntisrivarporn, "Circuitously Collaborative Learning Environment to Enhance Metacognition," Proc. Int. Conf. Comput. Educ. Japan Asia-Pacific Soc. Comput. Educ., pp. 1–4, 2014.
[10] E. Walker, N. Rummel, and K. R. Koedinger, "Adaptive intelligent support to improve peer tutoring in algebra," Int. J. Artif. Intell. Educ., vol. 24, no. 1, pp. 33–61, 2014, doi: 10.1007/s40593-013-0001-9.
[11] F. Su and D. Zou, "Technology-enhanced collaborative language learning: theoretical foundations, technologies, and implications," Comput. Assist. Lang. Learn., vol. 35, no. 8, pp. 1754–1788, 2022, doi: 10.1080/09588221.2020.1831545.
[12] S. Strauß and N. Rummel, "Promoting interaction in online distance education: designing, implementing and supporting collaborative learning," Inf. Learn. Sci., vol. 121, no. 5/6, pp. 251–260, Jan. 2020, doi: 10.1108/ILS-04-2020-0090.
[13] G. A. G. Mendoza and I. Jung, "Understanding immersion in 2D platform-based online collaborative learning environments," Australas. J. Educ. Technol., vol. 37, no. 1, pp. 57–67, Mar. 2021, doi: 10.14742/AJET.6106.
[14] A. Bhati and I. Song, "New Methods for Collaborative Experiential Learning to Provide Personalised Formative Assessment," Int. J. Emerg. Technol. Learn., vol. 14, no. 07, pp. 179–195, Apr. 2019, doi: 10.3991/IJET.V14I07.9173.
[15] B. AL KALBANİ, V. R. NAİDU, R. R. GUPTA, and A. AL SAWAFİ, "TEACHING MATHEMATICS THROUGH ONLINE COLLABORATIVE ENVIRONMENT IN THE HIGHER EDUCATION CONTEXT," IJAEDU- Int. E-Journal Adv. Educ., vol. 6, no. 17, pp. 238–245, Sep. 2020, doi: 10.18768/IJAEDU.789432.
[16] C. Troussas, A. Krouska, E. Alepis, and M. Virvou, "Intelligent and adaptive tutoring through a social network for higher education," New Rev. Hypermedia Multimed., vol. 26, no. 3–4, pp. 138–167, Oct. 2020, doi: 10.1080/13614568.2021.1908436.
[17] S. Ubani and R. Nielsen, "Review of Collaborative Intelligent Tutoring Systems (CITS) 2009-2021," 2022 11th Int. Conf. Educ. Inf. Technol. ICEIT 2022, pp. 67–75, 2022, doi: 10.1109/ICEIT54416.2022.9690733.

[18] E. Seo and M. Kim, "The Effect of Peer Tutoring for College Students: Who Benefits More from Peer Tutoring, Tutors or Tutees?," New Educ. Rev., vol. 58, no. 4, pp. 97–106, Dec. 2019, doi: 10.15804/TNER.19.58.4.07.

[19] A. Thurston, M. Cockerill, and T. H. Chiang, "Assessing the differential effects of peer tutoring for tutors and tutees," Educ. Sci., vol. 11, no. 3, pp. 1–12, 2021, doi: 10.3390/educsci11030097.

[20] S. Hawkins, N. Fogg, C. Wilson, and J. Browne, "Establishing a tutoring and academic support center: Collaborating with nurse educator students," J. Prof. Nurs., vol. 39, pp. 19–25, Mar. 2022, doi: 10.1016/J.PROFNURS.2021.12.014.

[21] S. Feng and A. J. Magana, "The Effect of ElectronixTutor on Undergraduate Students' Acquisition of Conceptual Learning, Problem Solving, and Model Building of Electronic Circuits," Proc. - Front. Educ. Conf. FIE, vol. 2021-October, 2021, doi: 10.1109/FIE49875.2021.9637314.

[22] A. Lippert, K. Shubeck, B. Morgan, A. Hampton, and A. Graesser, "Multiple Agent Designs in Conversational Intelligent Tutoring Systems," Technol. Knowl. Learn., vol. 25, no. 3, pp. 443–463, Sep. 2020, doi: 10.1007/S10758-019-09431-8/METRICS.

[23] I. Šarić-Grgić, A. Grubišić, S. Stankov, and M. Štula, "An agent-based intelligent tutoring systems review," Int. J. Learn. Technol., vol. 14, no. 2, pp. 125–140, 2019, doi: 10.1504/IJLT.2019.101847.

[24] S. Hobert and R. Meyer Von Wolff, "Say Hello to Your New Automated Tutor-A Structured Literature Review on Pedagogical Conversational Agents", Accessed: Feb. 07, 2024. [Online]. Available: https://publikationen.as.wiwi.uni-goettingen.de/getfile?DateiID=739.

[25] Z. H. Ma, W. Y. Hwang, and T. K. Shih, "Effects of a peer tutor recommender system (PTRS) with machine learning and automated assessment on vocational high school students' computer application operating skills," J. Comput. Educ., vol. 7, no. 3, pp. 435–462, Sep. 2020, doi: 10.1007/S40692-020-00162-9/METRICS.

[26] C. Wankiiri-Hale, C. Maloney, N. Seger, and Z. Horvath, "Assessment of a student peer-tutoring program focusing on the benefits to the tutors," J. Dent. Educ., vol. 84, no. 6, pp. 695–703, Jun. 2020, doi: 10.1002/JDD.12135.

[27] R. Harsley, B. Di Eugenio, N. Green, D. Fossati, and S. Acharya, "Integrating support for collaboration in a computer science intelligent tutoring system," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 9684, pp. 227–233, 2016, doi: 10.1007/978-3-319-39583-8_22/COVER.

[28] I. Ul Haq, A. Anwar, I. Basharat, and K. Sultan, "Intelligent Tutoring Supported Collaborative Learning (ITSCL): A Hybrid Framework," Int. J. Adv. Comput. Sci. Appl., vol. 11, no. 8, pp. 523–535, 2020, doi: 10.14569/IJACSA.2020.0110866.

[29] G. Polito and M. Temperini, "A gamified web based system for computer programming learning," Comput. Educ. Artif. Intell., vol. 2, p. 100029, Jan. 2021, doi: 10.1016/J.CAEAI.2021.100029.

[30] A. N. Kumar, "Allowing Revisions While Providing Error-Flagging Support: Is More Better?," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 12164 LNAI, pp. 147–151, 2020, doi: 10.1007/978-3-030-52240-7_27/TABLES/1.

[31] S. Abrejo, H. Kazi, M. U. Rahman, A. Baloch, and A. Baig, "Learning from Peer Mistakes: Collaborative UML-Based ITS with Peer Feedback Evaluation," Computers, vol. 11, no. 3, 2022, doi: 10.3390/computers11030030.

[32] M. Pifarre and R. Cobos, "Promoting metacognitive skills through peer scaffolding in a CSCL environment," Int. J. Comput. Collab. Learn., vol. 5, no. 2, pp. 237–253, Jun.

2010, doi: 10.1007/S11412-010-9084-6/METRICS.
[33] Nilufar Baghaei & Antonija Mitrovic, "From Modelling Domain Knowledge to Metacognitive Skills: Extending a Constraint-Based Tutoring System to Support Collaboration," . Corfu, Greece", Proc. 11th Int. Conf. User Model., 2007, [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-540-73078-1_25
[34] T. Dragon, B. M. McLaren, M. Mavrikis, and E. Geraniou, "Scaffolding collaborative learning opportunities: Integrating microworld use and argumentation," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 7138 LNCS, pp. 18–30, 2012, doi: 10.1007/978-3-642-28509-7_3.
[35] J. K. Olsen, N. Rummel, and V. Aleven, "Learning alone or together? A combination can be best!," Comput. Collab. Learn. Conf. CSCL, vol. 1, pp. 95–102, 2017.
[36] T. Dragon, M. Floryan, B. Woolf, and T. Murray, "Recognizing dialogue content in student collaborative conversation," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 6095 LNCS, no. PART 2, pp. 113–122, 2010, doi: 10.1007/978-3-642-13437-1_12.
[37] C. collaborations while learning mathematics with an intelligent tutoring System, "Casual collaborations while learning mathematics with an intelligent tutoring system".
[38] I. U. Haq et al., "Dynamic Group Formation with Intelligent Tutor Collaborative Learning: A Novel Approach for Next Generation Collaboration," IEEE Access, vol. 9, no. Cl, pp. 143406–143422, 2021, doi: 10.1109/ACCESS.2021.3120557.
[39] W. Dai et al., "Can Large Language Models Provide Feedback to Students? A Case Study on ChatGPT," Proc. - 2023 IEEE Int. Conf. Adv. Learn. Technol. ICALT 2023, pp. 323–325, 2023, doi: 10.1109/ICALT58122.2023.00100.
[40] R. Harsley, "When Two Heads are Better Than One : A Critical Review of Four Collaborative Intelligent Tutoring Systems," 2014.