Analyzing and Presenting Interaction Data: A Teacher, Student and Researcher Perspective

Abstract: Students' actions within a CSCL environment are recorded and stored as interaction data. The availability of such data offers new opportunities for support: the data can be accessed and analyzed automatically. Teachers, students and researchers may benefit from such an analysis. They have access to information about students' performance in the CSCL environment. The support gives teachers and students immediate feedback about performance indicators and it can help researchers to identify meaningful patterns in the interaction data. In the symposium we explore three issues with regard to this kind of support: 1) how can we extract meaningful information from the interaction data, 2) how can this information be used in practice, and 3) how should this information be presented to the user? We examine these issues from three perspectives, that of the teacher, the student and the researcher.

Introduction

Computer Supported Collaborative Learning (CSCL) refers to those situations where the interactions between the students are mediated by computer tools. Characteristic for computer tools is that the actions of the students are recorded and stored as interaction data in log files. These log files contain data about the ongoing actions and interactions of the students. The availability of this data offers new opportunities for support: the data can be accessed and analyzed automatically. The results of these analyses may provide the teachers, students and researchers with valuable insights about the learning processes. In the symposium we will address three issues with regard to this kind of support: 1) how can we extract useful information from the interaction data, 2) how can this information be used, and 3) how should this information be presented to the user? We make a distinction between three types of users: teachers, students, and researchers. The *first paper* focuses on the *teacher* as the user of interaction data. It presents a study where teachers were asked what kind of information they needed about students' performance while they are moderating an electronic discussion (e-discussion). These requirements where used for the development of awareness tools that provide the teachers with feedback about the group processes. In the *second paper*, two awareness tools that *students* use during their collaborative activity are discussed. This paper describes how awareness of group process – degree of participation and agreement – affects the performance of the students. Finally, the *third paper* takes the perspective of the *researcher* and describes how the researchers use log-files to identify patterns of interactions.

The three papers for the symposium differ with regard to the intended users but they have three themes in common that will be highlighted in the symposium.

- A *first theme* is a strong focus on the *user*. The use of the information is examined from the perspective of the user. In the case of teachers and students, the results of the analyses act as a form of immediate feedback. This feedback informs teachers or students about the group performance in the CSCL-environment. As such, this support may function as awareness tools (Dourish & Belloti, 1992), which may help students to collaborate more effectively and efficiently, for teachers the support enables them to moderate an electronic discussion. In the case of researchers, the support helps them to analyze the large amount of interaction data and to interpret the collaborative learning processes.
- A *second theme* that is visible in the three papers concerns the question *which data should be analyzed and presented* to the intended users. A CSCL-environments 'produces' large quantities of data: some parts of this data may be relevant to some users, while other parts may be irrelevant. Which data should be analyzed and what kind of information should be presented to the user is an educational issue rather than a technical one. To answer these questions the authors of the papers examine what kind of problems the users face and what kind of information they need to solve these problems. The second paper, for example, discusses feedback about social aspects of the collaboration (group member participation and the type of discussion that is being held), because students often have difficulties collaborating productively (Salomon & Globerson, 1989).
- A final theme concerns *the use of visualizations to present the analyzed data to users*. As stated before, large quantities of information are available to users of CSCL environments. The interpretation of this information is a cognitively demanding task. Visualizations can make this information more accessible because "it is possible to have a far more complex concept structure represented externally in a visual display than can be held in visual and verbal working memories" (Ware, 2005, p. 29). By using visualizations, the cognitive demands placed on users of CSCL environments may be decreased.

The three papers have several themes in common and they address similar questions with regard to the analysis and presentation of interaction data. They focus of the symposium is on different types of users. The aim is to broaden the scope by discussion three different approaches for extracting information from interaction data. We will explicitly discuss the choices that the researchers made so that the participants of the symposium become more aware of the reasons behind similarities and differences between the approaches.

Paper 1: Supporting e-moderation of synchronous discussions: Awareness tools for teachers

Argumentative discussions can be a powerful means for substantial learning. It may lead to significant individual gains in conceptual knowledge acquisition in, for example, Science, Mathematics or History. However, collaborative argumentation is not easily elicited. Therefore, argumentative design (Andriessen & Schwarz, in press), that is: the design of a learning environment that may lead to productive argumentation is an important yet complicated precondition. One way to facilitate productive argumentation is to provide students with a synchronous CSCL environment with a graphical tool that enables students to co-construct an argumentative discussion map.

Research from classroom discussions emphasizes the central role of the teacher as an important mediator for productive student argumentation (e.g., Yackel, 2002). However, moderation of synchronous e-discussion is highly complex: The dynamic flow of overlapping interventions may overwhelm the computer screen. It means that the teacher has tremendous difficulties reading the interventions, understandings their interweaving, and evaluating how to intervene in relation to such a flow. Teachers' attitudes towards moderation are n often negative and they consequently leave discussants without substantive interventions (Gil, Schwartz & Asterhan, 2007).

In this paper we describe research that has been conducted to identify teachers' preferences concerning information about features of the interaction and discussion that may help teachers to improve their moderation practices. Some of these features can be extracted from interaction data obtained during the e-discussion. They are operationally detected and are translated into tailored awareness indicators for moderators. In further research we studied how teachers evaluate the awareness tools and appropriate the different features *during* actual and simulated electronic moderation (e-moderation) practices, in co-located as well as distant learning settings.

A system for moderating e-discussions

The aim of the research that is discussed in this paper is to develop computerized system that supports moderators in their endeavor to increase the quality of synchronous e-discussions. We capitalized on the various tools that already have been developed (for a review, see Soller, Martinez, Jermann, & Muehlenbrock, 2005), and, at the same time, developed a system that is adapted to teachers' needs, beliefs and expectations. The most salient features of the system, which is currently at a stage of refinement, are among others: (a) awareness tools that provide immediate representations of aspects of e-discussions; (b) automatic alerts visualizations; (c) a remote control intervention panel from which the moderator can send textual comments and imagery to targeted students or the whole group; and (d) tools for off-line reflection (annotations and keyword searches). These aids are envisioned to help the teacher to monitor, evaluate and direct the discussion without disrupting the flow of the on-going collective argumentation. The design of the tools is based on a participatory user-centered design approach, involving teachers, tutors and (high school and university) student discussants. Currently the system supports moderation of e-discussions within two different platforms, but the system could also be relevant for other synchronous discussion tools as well, particularly graphical tools. One of these platforms that the system supports is Digalo (see figure 4). The Digalo provides its users with a shared workspace based on a concept-mapping interface. The tool enables synchronous, textual talk through mediation of geometrical shapes that represent different dialogical moves (see a/o Schwarz & De Groot, 2007).

Since research on moderation is sparse, the aim of the research is: 1) to describe and identify different moderation practices and relate these to certain discussion features (e.g., Gil, et al, 2007), 2) to describe teacher motivations during interventions, and 3) to assess teacher, tutor and student expectations, beliefs and needs concerning e-moderation of collective argumentation (Asterhan, Schwarz & Gil, submitted).

Awareness tools

In this paper we focus on one particular aspect of the system, namely the awareness tools. The term awareness is defined as "an understanding of the activities of the others which provides context for your own activity" (Dourish & Belloti, 1992). A great variety of tools for e-discussion and e-collaboration are available today, many of which offer awareness features for participants or moderators of discussions Awareness feedback is based on various properties of the discussion, such as social interaction patterns, participation information, temporal stages and text analysis. Yet, a systematic integration and combination of structural, process-oriented, and textual aspects has only recently been discussed in initiatives such as the Interaction

Analysis project in the European Kaleidoscope network. The awareness tools that are developed for our research are derived from structural, process-oriented and textual elements of Digalo discussion maps. The *structural* elements are the direct or computable attributes of each shape or arrow object (such as type, creator, and number of characters) and any combination using these attributes as building blocks. The *process*-oriented elements are comprised of user actions on the discussion objects, and sequences thereof (stressing the dimension of time and the process of discussion rather than the end product). The *textual* elements are the free text contributions typed within each shape.

We address several levels and methods of processing these elements. The lower levels are those of simple statistics (e.g. average text length, distribution of contribution types, and the like) or the use of statistical relationships between elements as relatively simple composite indicators (e.g., using the ratio between the number of connectors and the number of shapes as a measure of connectivity). The higher levels may involve more complex units, combining several types of elements (e.g., a cluster of shapes with certain characteristics, a sequence of actions indicative of a certain phenomenon) and/or the use of artificial intelligence methods and intensive input from pedagogical researchers (e.g., machine-learning classifications, query by example, search for pre-defined patterns). For examples, we refer the reader to previous publications on these issues (e.g., Hever, De Groot, De Laat, Harrer, Hoppe, McLaren, & Scheuer, 2007).

What do teachers need?

As a first step, we gathered data on teachers' needs with regards to the different sources of information that could aid them in the moderation process. A total of fourteen teachers who have experience with conducting and/or moderating Digalo discussions, participated in one or more of the following three data collection activities:

- *Questionnaires*: Nine teachers were presented with 18 predefined sources of information and asked to rate the extent according to which they considered each one of them as helpful in supporting moderation of Digalo discussions (Likert scales with 4 values). Following they were asked to rank the same features (five most important and five least important).
- *Evaluation of screen shots of possible awareness indicators*: Twelve teachers were presented with a variety of screenshots of different information sources. They were asked to rate how important and useful the information it depicted might be to them when moderating a discussion. They also had room for writing down additional comments and suggestions and were encouraged to do so.
- *Teachers' evaluations of actual discussion maps*: Eight teachers were individually asked to reflect aloud and point out interesting phenomena in two discussion maps that would be important to them when evaluating the discussion or moderating it. An observer wrote down their comments and prompted them to be more specific when something was unclear.

Table 1. Indicators for the support of on-line moderation, indicated by experienced teachers (N=14).

Source category	*Details and possible indicators*
Presence	Who is online, who is active at the moment and for the last [time interval], who is lurking.
Participation	Number of contributions per discussant, by the different discussion ontology categories.
Responsiveness	The extent of interpersonal interaction and responsive to each other. For example: social network diagrams, numerical indicators of connectivity on discussion map-level, frequency of questions shapes within a map, or indicators of dialogicity based on machine learning classifications
Quality of reasoning: shape-level	Whether discussants use reasoned arguments as opposed to simple claims (based on machine learning classifications)
Quality of reasoning: discussion map-level	Whether the group considered multiple perspectives, whether they engaged in dialectical argumentation by considering both the pros and cons of a thesis. For example: ratio of supporting and opposing links, map-level classifications based on content analyses (different perspectives)
Impact of contributions	Identification of contributions that were neglected (i.e., without links) and contributions that catalyzed or opened up the discussion (i.e., with many links).
Textual length of contribution	Identification of particularly long contributions (indicating that a student wrote an essay-type of contribution, instead of engaging in argumentative dialogue)

Conclusions

The combined results of these three different data collection activities lead us to identify seven different categories of information sources that were recurrently mentioned by the teachers to be potentially helpful in supporting on-line moderation. They are presented in Table 1, together with a short description of how these features can be operationalized into awareness indicators. Certain features are automatically detected in the interaction data and are visualized in the awareness tools. Further research focuses on how teachers evaluate these awareness tools and appropriate the features *during* actual and simulated e-moderation practices

Paper 2: Visualizing of Collaboration and Coordination: Two Tools for Students

The research on the effectiveness of computer-supported collaborative learning (CSCL) and the processes that take place during CSCL, demonstrate that the collaboration in CSCL environments is not always free of problems. These include for example, lack of awareness of group members' activities, communication and coordination problems, and lack of quality discussions. The central issue in this contribution is how and why visualizations of the collaborative process affect group members' collaboration in CSCL environments. In order to tackle this issue, two different visualizations were developed. The effects of these visualizations were examined in two studies by giving one group of *students* access to the visualization, while the other group of students was not given access to the visualization. The two visualizations were implemented in the VCRI environment (Virtual Collaborative Research Institute, Broeken, Jaspers, & Erkens, 2006). Both studies worked with 16 to 18-year old participants in the fifth year of pre-university secondary education. Both studies were carried out in the domain of history.

Study 1: Visualizing Participation

Study 1 describes the effects of the Participation tool (see Figure 1), which visualizes group members' relative contributions to the online discussion through the Chat tool of the VCRI environment. When working in CSCL environments, it is often difficult to determine what other group members are doing and whether everyone is contributing equally to the group task (Kreijns, 2004). The *Participation tool* gives an impression of the number of messages sent by each group member and the relative length of these messages. The tool thus gives feedback about group members' participation during the collaboration (e.g., is there equal participation in our group?) and allows them to compare themselves to other group members. This may raise their awareness about the manner in which they are collaborating and may stimulate group discussions about the collaborative process.

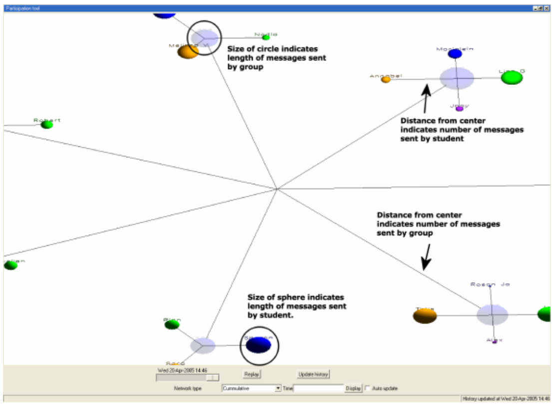

Figure 1. The Participation tool.

To examine the effects of the Participation tool, 17 groups of secondary education students (N = 52) were given access to the Participation tool while working in the VCRI environment, while 5 groups (N = 17) were not given access to the tool. We hypothesized that giving group members access to the Participation tool would increase their awareness of the group processes and activities taking place during their collaboration. This assumption was partly confirmed: group members with access to the Participation tool reported they knew better when another group member was taking a free ride. The Participation tool therefore enabled students to *determine free riding behavior more easily*. Additionally, the Participation tool was found to have an effect on participation: students who had the option to inspect the Participation tool had *higher participation rates*. Furthermore, the intensity with which the Participation tool was used by students was found to have an effect on equality of participation: *more equal participation was found in groups that used the tool more often*. Content analyses of the collaboration protocols furthermore showed that students who could use the Participation tool *engaged more in coordination and regulation of social activities*: they typed more statements that addressed the planning of their collaboration. This indicates that visualizing participation stimulates group members to devote effort to coordinating their collaboration. Finally, we expected that through stimulating participation and equality of participation, raising awareness, and facilitating coordination group performance would increase. To test this assumption, we examined the quality of the products made by the participating groups. *No effect of the Participation tool on the quality of group products was found*, however.

Study 2: Visualizing Agreement and Discussion among Group Members

A visualization called *Shared Space* was the focus of Study 2. The Shared Space visualizes the amount of agreement or discussion during group members' chat conversations (see Figure 2). To do so, the Shared Space analyzes all messages that students type in the Chat tool of the VCRI environment. The Shared Space uses discourse markers (Erkens, 1997; Schiffrin, 1987) to determine the communicative function of each message. Based on this analysis, the Shared Space moves the current chat topic to the left if it contains indications of disagreement (e.g., denials, negative evaluations) or to the right if it contains indications of agreement (e.g., confirmations, positive evaluations). Thus, the Shared Space gives feedback about the types of discussions group members are conducting (e.g., critical discussions or consensual discussions) and may raise their awareness about conversational strategies. Furthermore, by raising group members' awareness, groups may be stimulated to discuss how well their group is functioning and how the group process may be improved.

We examined the effects of the Shared Space by giving 20 groups of students ($N = 59$) access to chat-tool with Shared Space visualization, while 20 other groups ($N = 58$) had access to the regular chat-tool of the VCRI environment. Content analyses of the collaboration protocols show the Shared Space *facilitated coordination of the collaborative process*. Students with access to the Shared Space were less busy exchanging information and typed fewer messages aimed at reaching and maintaining mutual understanding. This indicates that for these students it may have been easier to understand their group members' contributions. In other words, the process of negotiation of meaning was facilitated. Furthermore, the Shared Space was found to have an effect on exploratory group norm perception. This indicates that groups that had access to the Shared Space *perceived their discussions as more critical and constructive* than did groups without access to the Shared Space. Additionally, students with access to the Shared Space reported more positive group behavior (e.g., helping behavior, positive group atmosphere) and more effective group task strategies than students without access to the Shared Space. In other words, they perceived their collaboration as more positive and effective. Lastly, we hypothesized that by stimulating students to adopt exploratory group norms and by decreasing communication problems, the Shared Space would also increase group performance. This hypothesis was partly confirmed as groups with access to the Shared Space only outperformed groups without access on one part of the group task (out of a total of three parts).

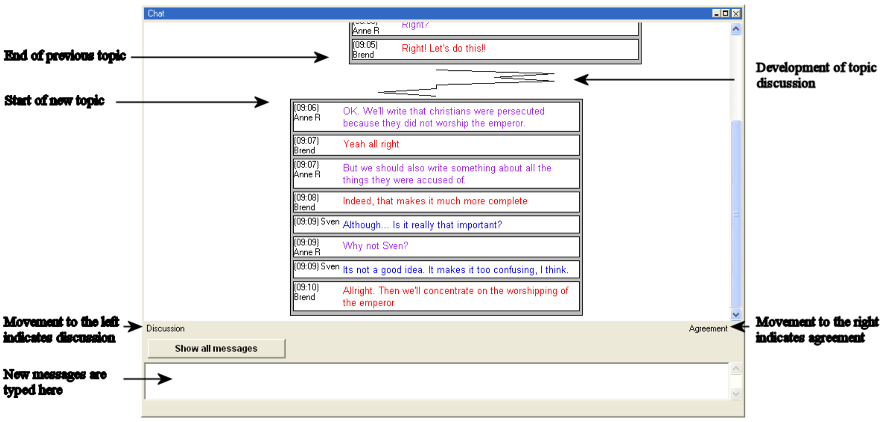

Figure 2. The Shared Space.

Conclusion

The results of the two reported studies show that analyzing the collaborative process in CSCL environments and visualizing the subsequent information for students can be beneficial. Students can use the information these visualizations provide to raise their awareness about group members' activities in the environment. Furthermore, students use the visualizations to coordinate the process of online collaboration: they use the visualizations to start discussions about the collaborative process itself and to facilite the process of negotiation of meaning.

Paper 3: Analysis and presentation of interaction data: A researcher perspective

CSCL environments record and store their actions as *interaction log files* (e.g. Börner, Hazlewood & Lin, 2002). Researchers have access to an extensive data set that focuses on the activities students carry out. Researchers have to make several choices how to access the data set. For example, a choice must be made whether to record private unshared tool use, in addition to recording actions that are carried out within the collaborative tool. From the researcher's point of view, this choice is guided by the research agenda. A research question concerning the role of private notes in cooperative text writing goes unanswered if the private space is not recorded. On the other hand, many research questions focus specifically on the collaborative processes (Lund, Rossetti, Metz, 2007; Overdijk & van Diggelen, 2008). The interaction log files contain events (private or shared) that occurred within the environment of the tools; they contain the textual and graphical contributions of the students as well as the separate chronological actions that the students performed. These extensive interaction log files — on which analytical choices have already been performed — form the semi-raw material on which researchers do their analyses. The first problem is extracting relevant interpretable data from these interaction log files; this implies translating the data into a readable and understandable format. Secondly, it does not follow that such an initial transformation automatically produces results. One of the goals of analyses of CSCL situations is to identify patterns of specific actions and interactions, perhaps associated with particular tool uses, and to relate them to learning outcomes or to the quality of student's productions (e.g. Lund, Molinar, Séjouné & Baker, 2007). If we can successfully relate a particular pattern to a desired outcome, then we can attempt to bring about the pattern in question (Ronteltap, Goodyear & Bartoluzzi, 2004). However, identifying such patterns in interaction log files that are so extensive and diverse is not self-evident.

In what follows we present an analytical tool called TATIANA (Trace Analysis Tool for Interaction ANAlysts) that supports researchers in the analysis of interaction log files obtained from various CSCL situations. We then present the general principle and show for two specific cases how TATIANA can analyze and visualize patterns of individual student actions and relate them to patterns of collective student interactions. Hereby we open up the way to correlating patterns with outcomes. Finally we conclude and discuss further work.

TATIANA (Trace Analysis Tool for Interaction ANAlysts)

TATIANA (Dyke *et al.,* 2007) attempts to help researchers represent their data in ways that are meaningful to them. We call these representations *replayables*. For video this simply entails opening it with a media player. For interaction log files, TATIANA supports the creation of different forms of replayables: Excel™-like tables in which each row corresponds to an event and visualizations in which each event is shown as a graphical object. Researchers describe how each event will be represented (fields of a row, appearance of a graphical object) through the use of filters, allowing them to select only the relevant facets of the data and represent them in an understandable form. TATIANA also treats categorization and annotation as being the creation of a new replayable. TATIANA allows replayables to be synchronized: navigating to a certain timestamp in the video will highlight the corresponding event (row for tabular replayables, graphical object for visualizations); selecting an event in visualization will highlight the corresponding row in the table and navigate the video to the timestamp of that event. Finally, TATIANA allows replayables to be combined to create new replayables, for example importing a categorization into an existing visualization or combining aspects of two visualizations to create a new visualization which is better suited to the researcher's current needs.

Visualizing the different facets of student actions and interactions: the general case

A microanalysis of the collaborative learning process begins with the identification of individual actions within a given interaction between students. However, the interpretation of the form and content of these individual actions is undertaken by the analyst in the context of the interaction between students. Indeed, verbal interactions in a face-to-face discussion are often described by local principles of turn taking and adjacency (Sacks, Schegloff & Jefferson, 1978). The coherence of a discussion is based on the assumption that each act is an appropriate response to a previous act (Littlejohn, 2002) and meaningful patterns are searched for on that basis. However, the timely order of actions within a CSCL environment is often hidden - for different reasons - of which the following two are examples:

1. The actions of one student in a particular collaborative tool may overlap in time with the actions of another student in another tool (e.g. one student types in a chat, while another enters text into a shared text editor);
2. Students can both act separately within the shared environment of a single collaborative tool (e.g. write simultaneously in different parts of a shared text editor, or construct different argument sequences simultaneously in different areas of an argument grapher).

Visualizing various graphical representations of situations like the ones mentioned above enables researchers to display the relationship between actions for which adjacency is not immediately apparent. Researchers thus create a logical representation that reflects meaningful student actions and interactions. TATIANA proposes a general visualization of such graphical representations called an *interaction score of actions* (based on the notion of a musical score) where different facets and sub-facets of a participant's action (participant's name, tool, particular use of tool, type of action, etc.) can be displayed in relation to time and in part, automatically generated and then merged, based on research goals. In the next section, we illustrate representations that fall into the two categories presented above; others are possible.

Two specific cases

The example shown in Figure 3 illustrates overlapping student and teacher actions. The x-axis shows time in the form of intervention numbers and the y-axis shows the participant and the tool he or she used. The legend lists the uses observed for each tool. We see that student A chats from intervention 0 to 10 during which she introduces herself in the text editor. She takes notes in the chat around intervention 40 and participates in dialogue periodically throughout most of the interaction. During this time, student B participates with student A in the chat and the text editor, but also carries out other actions (e.g. writes a synthesis in the text editor). It's possible to pinpoint areas of interaction during simultaneous use of a particular tool, but also across different shared tools (notes in chat for Student A and synthesis in text editor for Student B). The researcher may now ask how content is treated during those times.

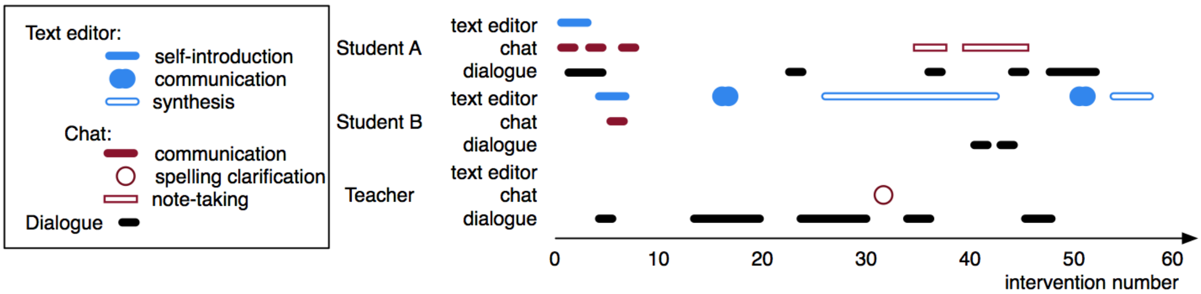

Figure 3. Overlapping actions of two students and a teacher.

Figure 4 shows how students can act separately within the shared environment of a single tool. The x-axis of the right-hand figure shows time; the y-axis of the same figure illustrates the quadrants (Q1, Q2, Q3) of an argument graph tool in which students constructed elements. The quadrants and students' constructions can be seen to the left. Taking student A, we see he begins constructing in Q1 with box 8, then moves to Q3 to construct box 12, goes back to Q1 to construct box 15 and so forth. The researcher may now consider the relations between boxes (possible interactions between students) and examine argumentative content.

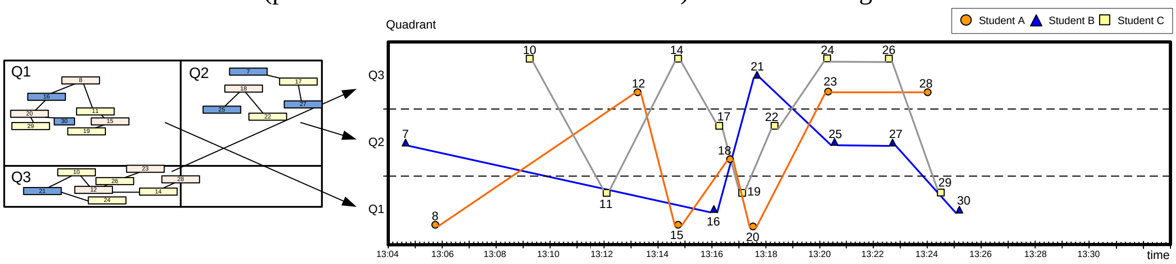

Figure 4. Argumentative sequences constructed by three students within an argumentative tool.

Conclusions and further work

We have shown how the researcher can be assisted in analyzing complex interaction log files, issued from CSCL situations, with the help of TATIANA (Trace Analysis Tool for Interaction ANAlysts). We introduced the notion of *interaction scores of actions* — based on the concept of a musical score — that illustrate how different facets of students' actions move though time during a given interaction. We illustrated with two examples how the researcher is thus assisted in identifying patterns of individual action and group interaction. Further work will augment the types of corpora analyzed with TATIANA in order to explore the possible visualizations of different facets of student actions and interactions.

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