Facilitating Argument in Physical Space

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ABSTRACT

We have created a ubiquitous computing application which will facilitate discussion. The system applies radio frequency identification (RFID) and tangible user interfaces (TUIs) to the World Wide Web. It uses TUIs to permit users to explore and construct both sides of a debate. While our initial evaluation focuses on school children, during our demo conference attendees use our interface to participate in the debate of pertinent Ubicomp topic; "Will ubiquitous computers replace paper?" Our interface moves beyond WIMP to bring argumentation and debate into the tangible realm.

Keywords

Computer Supported Collaborative Argumentation (CSCA), Tangible User Interfaces (TUI)

INTRODUCTION

A regular theme in Human-Computer Interaction research has been the development of systems that help people impose structure on complex interpersonal communication. Systems for Computer Supported Collaborative Argumentation (CSCA) [2], requirements capture [3], discussion thread management [16], and others provide interactive visualisations of human communication, in a way that assists users to address complex topics (such as system design), [5] or work through contentious issues (such as industrial relation disputes) [9]. Typically these systems work by helping users to focus on the structure of discussion, for example noting when new contributions are intended to clarify, support or rebut earlier statements.

One of the challenges in building systems like these is that they are typically implemented to run in a conventional computer environment, as an application under a WIMP operating system [2,3,4,5,9,10,16]. Although many such systems are designed for use by multiple users, each user sits in front of his or her own screen, contributing to the discussion by operating the keyboard and mouse at that screen. It is possible to augment the discussion via video or tele-conferencing (especially if some participants are remotely located), but this introduces many obstacles to effective collaboration. In particular, the introduction of a shared representation is only of value if it then supports *deixis* – semantic reference to a specific component of the discussion (e.g. pointing) [1]. The whole purpose of CSCA systems is to help structure argument through the provision of a shared representation that enables participants to make deictic reference to specific structural components of the argument.

Video and tele-conferencing systems are particularly poor at supporting *deixis*. Although many research attempts have been made, video-conference systems do not yet support gaze inference such that one participant can tell what another participant is looking at. Pointing is a key element of *deixis*, but it is very hard to create multi-user systems that allow participants to communicate by pointing at their screens. If the whole structure fits in a single screen with no zoom or pan, then it is possible to implement multi-cursor pointing systems. Alternatively, one user can be in control of a display that is broadcast to many screens. If each user is allowed to control their own view (i.e. true collaboration), and if the visualisation does not fit within one screen (i.e. truly complex argument rather than toy examples), then it is practically impossible to establish socially appropriate interfaces for collaborative argumentation.

These factors have motivated us to take a ubiquitous computing approach to the support of collaborative argumentation [17,18]. Rather than using conventional screen and keyboard interfaces, we have created a large scale physical interface that can be distributed across a room or over a board table. Participants in an argument can move freely about the room, pointing to, picking up or moving physical objects that represent elements of the argument structure.

While our departure from WIMP interfaces for computer supported for argumentation is novel, so is our approach to argumentation. In ancient times the study of rhetoric began with simple forms such as ranging from fables and storytelling and progressed through more complex forms to the sophistication of parliamentary debate and legislation[6]. There has been a considerable amount of work done on the use of ubiquitous computing in the support of narrative creation by children – the beginnings of rhetorical education [7,14]. Work in the field of computer-supported cooperative argument has focused on rhetoric in it's most accomplished forms of industrial negotiation and legal argument [4,9]. There has however been very little work which has focused on the first exercise in persuasive rhetoric that are used to lead the student step by step to the heights of rhetorical complexity. We have chosen to bridge this gap and focus on the classical rhetorical exercises of encomium and vituperation, where a student would praise or criticise a topic or individual. These exercises break down constructing an argument into a series of manageable step that ensures the participants cover all of the necessary ground and use their research effectively as possible.

Both the rhetorical focus of our system and our approach to ubiquitous computing were designed for use in schools, to facilitate part of the English national curriculum [11] that teaches argumentation and discussion skills to students (see Figure 1). It is particularly useful to see visualisations of argument structure in the classroom. Teaching argument demands that the teacher be able to refer explicitly to the argument structures being developed by the children, in order to provide relevant critique of a malformed argument, or explains ways the argument could be made more persuasive. In addition to this natural fit to the classroom context, we also believe that it is especially valuable to design ubiquitous computing systems that are constrained by a specific application domain. Many ubiquitous computing research projects have created products, middleware or technical architectures that have no clear application and may never find one. To avoid this trap, we voluntarily accepted the strict design constraints of the school environment, and of the highly prescriptive English National Curriculum, in order to guarantee the creation of a system that addressed a genuine need. We call this research strategy Curriculum Focused Design [12].

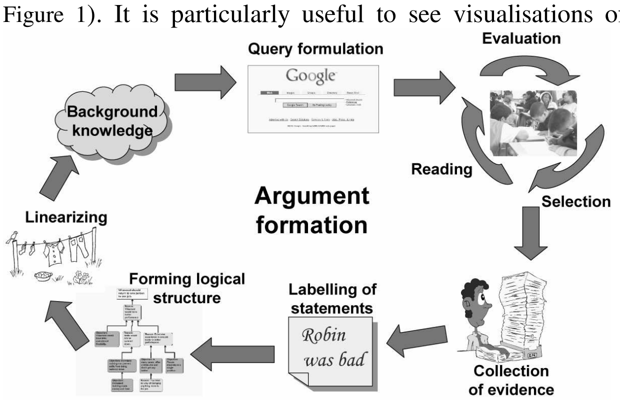

Figure 1. Argument Formation Cycle

We are however convinced that the classroom is not the only forum that will benefit from computer support for the learning of skills in argument and persuasion and intend to explore further the possibilities of using our system with older children and adults.

TECHNICAL APPROACH

One of the constraints imposed by the classroom context is that the technology base for the ubiquitous computing system must be extremely robust. The classroom is a physically demanding environment, with little tolerance for equipment failure. We therefore selected a well-established communications and sensing infrastructure, based on radio frequency ID tags and readers (RFID). The physical tokens of argument contributions are augmented with RFID tags, and the argument structure is represented by a series of RFID readers. The RFID readers are networked to a central server, which generates a real-time visualisation of the developing argument for projection onto the wall of the classroom.

Users interact with the application by placing statements which are augmented with RFID tags on the readers. Each reader has a prompt and together they form a trail which takes the user through an argument – either for a position, against it or showing understanding of both sides – in small and easily managed steps. Every time the reader places a statement on a reader this change in state in the TUI is reflected in the GUI. The aim is to use the GUI and TUI in combination to allow the user first to organise the statements relevant to an argument according to the loose structure provided by the prompts on the readers, secondly to deliver a speech for the point of view she has set out using both the TUI and GUI as visual aids. In our next generation of the TUI we hope to support the use of physical paper as a token, this would further support deictic reference to sources, and supporting the wide variety of individual affordances of paper documents that have been noted by Sellen and Harper [**Error! Reference source not found.**].

USAGE SCENARIO

Our system permits collaboration while developing an argument, by encouraging movement in physical space. Each piece of supporting evidence has a physical instantiation allowing it to be pointed to, or carefully considered with a neighbour. Information can be grouped arbitrarily in 3d to permit relationship building between the data. Users can place these physical instantiation on an RFID reader if users wish to gain more contextual information. This results in the information being projected so they can discuss it with a larger group. This same GUI permits teachers or facilitators an overview of what is going on, or can later be used in conjunction with the TUI to display visuals to support the users argument, letting them speak directly from the data.

EVALUATION

We have evaluated our design approach over a period of six months, with a range of prototypes exploring the technical approach above. Our iterative prototyping design method commenced with "low fidelity" prototypes that explored the use of the spatial interface within an actual classroom lesson, but only provided limited automated functionality through the use of RFID. Some automated functionality was simulated during these experiments via the "Wizard of Oz" technique [8] where a researcher controlled the computer interface to test alternative designs with minimal development effort. After ten generations of prototypes, we have developed an effective and technically operational system that has been evaluated under lesson conditions [15].

Evidence Selection

Our early prototypes focused on the collection and labelling phases of the Argument Formation Cycle. We had observed that children read source webpages, they then evaluated and selectively highlighted, and then grouped together relevant pieces of *evidence.* These groups were then named (e.g. 'trust', 'sightings', 'evidence and backing up') and claims or *statements* on each theme used to structure the argument. We gave children small stands incorporating a whiteboard on which to write a statement, and a set of clips to attach collected evidence supporting that statement (Figure 2). We intended that RFID tags in the documents would be recognised by an RFID reader in the stand, so that the logical relationships between statements and collections of documents would be recognised by the system.

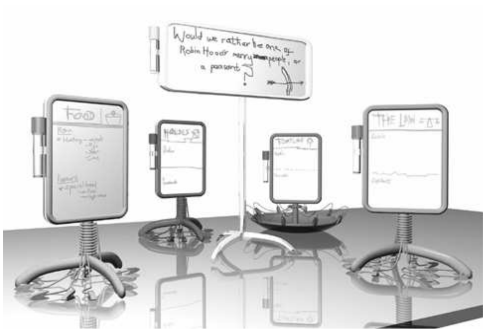

Figure 2. Iteration #3 prototypes for grouping selections

Argument Construction

For each stage in the argument an "Activity Square" was produced – a large card stating what the student should do at that stage of the argument – e.g. "Evidence and backing up" (see Figure 3). Then we used statements produced in earlier stages of the Argument Formation Cycle as counters in a rhetorical board game (see Figure 4). Children placed labels with these statements on suitable activity squares in order to structure their argument using evidence found in their research .

Figure 3. Prototype providing rhetorical structure

Figure 4. Selection tags each with a RFID & LED

Argument Presentation

The final stage of argument formation is linearization: the argument structure turned into a linear form which can be delivered as a speech. By arranging the TUIs the users have to construct an argument which is also represented on a projected display. Users can use the TUI to trigger the GUI to display content relating to the specific section of the argument they are verbally presenting.

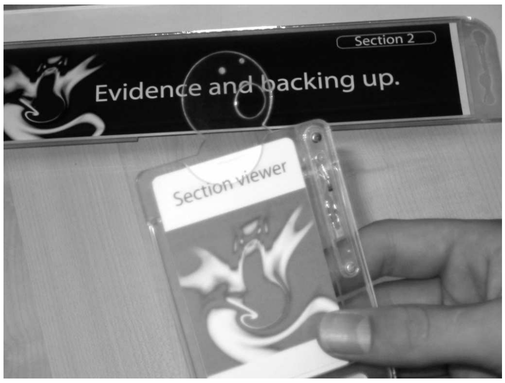

Figure 5. Triggering a transition in the GUI by placing the 'section viewer' on the activity square.

Observations

During the course of our evaluations we have spent upwards of twenty hours observing children in schools debating three different topics. All of these children succeeded in using the TUI to construct an argument which satisfied their teacher. A few of these arguments the teacher found surprisingly articulate. Students who used the TUI were able to interact better with their audiences while presenting. We have formed a number of preliminary gender-related observations: our female students seem to lead in the coordination and structure of the argument, whereas our male students have focused much of their energies on understanding the relationship between the GUI the TUI.

We learned that making many small changes through multiple iterations allowed us to isolate the effect of the physical affordances vs. the effect of technology. We were forced to switch from low to high frequency RFID tags to allow for clear grouping of multiple statements on an activity square. These trials have driven our technological roadmap. We observed how children enjoyed stacking the early box-shaped statements as well as how it helped with argument presentation. This resulted in our plan for a future box-shaped prototype that will permit stacking by containing both a RFID reader and a tag.

Further evaluation work will implement the system in more schools, in museums, with children who have behavioural disabilities, and with adults in professional settings.

CONCLUSION

We have developed an approach to locating conversational argument processes within a physical space through the use of ubiquitous computing. This provides a far richer outcome from ubiquitous computing than previous attempts to integrate video and screen-based visualisation. This argumentation system, while a novel use of technology, also provides a good example of user-centered design. Careful iteration and attention to the needs of users will help ensure a socially appropriate interface for collaborative argumentation which will more likely to be adopted by potential users. Our system will promote natural interaction with evidence as a TUI and as paper documents, and lends itself well as both demonstration and a case in point of whether future ubiquitous computers wills still include paper.

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