Facilitation of Online Student Group Projects with a Support Agent

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ABSTRACT
As more courses are provided online, consideration must be given to providing for group working, as an integral part of the learning experience. Present online provision, based on CAL, is aimed at individual study in the main, and CSCW products are aimed at business users. We propose student support agents to help with the maintenance aims of group working, providing support in developing group relations. Our initial prototype is built in Prolog, and is based on a whiteboard architecture. In this paper we describe the design work, based on analysis of traditional face to face group project work, through to developing the prototype for testing.

Keywords
Agents, Groupwork, Online learning.

INTRODUCTION
There is a drive towards making higher education accessible to a greater number of participants than ever before. It is agreed in some circles that modern technology should be able to provide applications to enable students to work at their own pace or in their own time, notably Computer Aided Learning (CAL) packages. However, CAL packages are essentially aimed at independent learners, and online students should be given the opportunity to develop group working skills as well. Various forms of Computer Mediated Communication (CMC) are being used for online courses, to allow for discussion between students and tutors, but their use in supporting some aspects of group work is limited. We propose a software agent that can support the maintenance aims of group project working, called a Guardian Agent.

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2. THE ROLE OF GROUP PROJECTS IN LEARNING
Traditional undergraduate and postgraduate courses incorporate a mixture of individual and group learning methods, and it is acknowledged that group learning offers several advantages to learners [4], [7]. Students learn from each other by exchanging ideas and resources, negotiating strategies and tasks, are able to comment on each others' work and contribute towards merging and redrafting of the final written work. A key component of undergraduate and postgraduate courses is group project work. This is because in undertaking group projects students are given the opportunity to develop and practice the task and the social aspects of team working.

The learning cycle by Kolb [8] gives a good summary of the stages in student learning, and this gives a starting point for thinking about how we approach course material design and presentation. The main feature is that students do not learn by simply being told facts. They need to be able to practice using the facts, and reflect on the way they are used in order to form connections in the brain, which can be regarded as knowledge. Further experimentation, experience and reflection leads to intelligence or expertise in a subject. Educated students should be able to formulate a set of facts into information within their own minds. If the students are able to talk about this information, then they can be said to have knowledge of the subject, and intelligence shows in their ability to apply the knowledge in a variety of situations. Group projects give students an opportunity to discuss their understanding of the subject with their peers, as they apply the theory to practice.

Experiential learning and problem-based learning have been used to encourage applying facts and skills learned to a real life situation, often using case studies. These give the opportunity for students to practice and reflect on the effect in a given situation, from which they are able to formulate patterns to determine which situations lend themselves to particular approaches. Some university courses have been run entirely using problem-based learning [2]. The best results have, however, probably been obtained where problem-based learning forms only a part of the course content, and it is used to build upon learned facts and skills.

3. COMPUTER SUPPORT FOR GROUP WORKING ONLINE

Successful group working requires that the maintenance roles as well as the task roles of the group are given attention [5]. Group dynamics play an important role in determining how successful the outcome of the project is, i.e. the ways in which the members interact with each other and how this changes with time as the group develops [1], [4], [7]. The most successful groups are composed of members with different personalities, so allowing students to choose their group members, as they often do in face to face projects, may not lead to the most successful outcomes, as the tendency is to choose similar minded friends. At work it is unlikely that a member will be able to choose their colleagues, so it is important that students can work with people they do not particularly like, and learn to be tolerant of others' attitudes in concentrating on the given task.

Learning by experimentation and making mistakes and by doing, which require immediate feedback and guidance by a tutor, are not easily accomplished within online courses. But advances in technology ought to enable us to design more adaptive CAL material, which exhibit some intelligence, called intelligent tutoring systems (ITS), and to allow for more rapid communication of feedback, so that future online courses are an improvement on correspondence courses.

Online courses can be solitary affairs, unless Summer schools, Saturday workshops etc. are included in the programme. However, these reduce the self-paced element of online courses, as students must prepare for a group tutorial on a particular date. Management of such courses to incorporate a group project will require considerable negotiation of availability and readiness, in order to gather together an appropriate number of students capable of working together for a given period of time. A number of problems arise when adapting a conventional approach to group projects for students working online:

- students are working at their own pace and in their own time, so a timetable must be imposed either by the group itself or by the course leader;
- organising conventional meetings is not possible, but a substitute is necessary, probably aided by technology;
- sharing information must be enabled by technology, students must be able to express their opinions online, which may require different skills;
- assessment is probably not possible on an individual basis, but a group mark may not be acceptable if students recognise that members of a group are not pulling their weight;
- tutors may experience difficulties monitoring the progress of groups of students.

An important area of CSCW research is into improving the support provided for online work. Distance learning is a growing market and as higher education institutions strive to provide online learning experiences, consideration should be given to providing an interface which gives a level of support comparable to that provided on campus based courses. Social inclusion is an important aim of online provision, and these learners often have individual and specific additional requirements, not readily provided by Groupware products, which are specifically aimed at business users. New technology as a means of communication has actually changed the ways in which people communicate and collaborate, e.g. email has meant that traditional working boundaries have been removed as communication between lower and higher levels of staff is now acceptable.

3.1. Experiences of working in a group online

One of the authors took part in an exercise to work in a group to produce a report on the assessment of Key Skills online. The group worked online over a period of two months, in which time they used email predominantly to communicate, and occasionally used the virtual classroom provided in Blackboard for synchronous discussion. At the end of the exercise reflection on the group processes was recorded, which can be summarised as follows:

- we found ourselves able to communicate, but not necessarily understand the meaning of what was said;
- it was difficult to get a concensus;
- at times the communication can seem aggressive;
- it is even more difficult online to agree meeting times;
- we found it difficult to achieve a fair distribution of work;
- the group discussion process allowed each one to identify one's own perspective
- we were using different platforms and some members had difficulty opening others' files.

At the same time two other groups were working on similar reports, but mainly working face to face, with CMC used as an adjunct. When individual opinions were sought, using a questionnaire, after the exercise it was apparent that the online group experienced more difficulties than the other groups, including:

- the face to face groups tended to find the progress meetings helpful and found it easiest to get started,
- the online team tended not to trust each other as much as the others, experienced less support from each other, they also felt they learned less by working in a group and learned less by discussing and explaining ideas to each other.

3.2. Comparisons between online and face to face working

Computer mediated communication (CMC) tools, such as conferencing, email, discussion forums support the communication needs for the task roles of group projects, examples include studies of co-operative learning in a virtual university [3] and groupwork in mathematics teaching [6]. Student support using commercial groupware products enables communication between group members and instructors. BSCW has been used as support for group projects and was found useful for information sharing, offering greater flexibility in students' face to face communication, but offered limited support for the maintenance roles of groupwork [11].

Table 1 – A comparison between online and face to face methods of communication

Stage of project	Traditional use of face-to-face	Online
Getting established: introductions, personal abilities and preferences, brainstorming, agreeing rules.	Main function of intitial meetings.	Email, video-conference, bulletin board, groupware, guardian agent.
Anticipating problems: awareness of problems.	These might be apparent by non-attendance at meetings, non-verbal cues etc.	Non-contribution to bulletin board or lack of response to email may be recognised by group members, or by guardian agent.
Getting off to a good start: agreeing ground rules.	Face-to-face agreement to these is in a sense binding.	Email, video-conference, bulletin board, groupware, guardian agent.
Managing time: agreeing a time plan.	Again face-to-face agreement is binding. Problems will become apparent at each meeting, and action agreed.	Email, video-conference, bulletin board, groupware, guardian agent.
Allocating tasks: equal distribution of tasks to individuals and sub-groups.	Some discussion essential, which may take time. Sub-groupings are spontaneous. Final agreement of allocation is binding.	Email, video-conference, bulletin board, groupware, guardian agent.
Choreographing activities: bringing it all together.	Individuals will bring hard copies of their work to explain to each other. An individual is responsible for collating the work.	Email, video-conference, bulletin board, groupware, written post or fax, guardian agent.

In order to see how new technology can be applied to group projects, it is necessary to analyse the stages of a group project, to determine the particular problems encountered at the different stages, and to determine whether new ways of working may be possible, rather than simply adapting a current traditional project, and where support in the form of a Guardian Agent might be appropriate.

This table identifies some of the tools that could be applied at the different stages of the group project. It can be seen that the meeting plays a prominent part in getting the group established, formulating ground rules and identifying individual talents. At face to face meetings non-contribution by members is implied by non-attendance, also disagreement and other negative feelings are often recognised by visual cues. Agreement between members at a face to face meeting might be more binding than agreement arrived at online. Hence an online project will require a considerable amount of support, if it is to be kept on track.

Typical problems with face-to-face meetings include: making sure that discussion is relevant, keeping to a reasonable meeting time, ensuring all members are present and keeping to the agenda. Email and bulletin board messages tend to be shorter and succinct, though it is possible to be sidetracked into discussion that is not relevant, and a member that suggests online that this is happening would be very brave. Obviously time is a critical factor in face-to-face meetings, but not so for online discussions which are asynchronous, though long waits for responses from group members may be unwelcome. Online discussions should be controlled by an agenda with time limits set, so that all group members know what stage in the discussion is current.

When problems arise it is often too late to do anything about them, but if a problem can be anticipated, the project can often get back onto schedule without wasting too much time. At face-to-face meetings individual worries may be aired that may or may not be significant. Problems, such as lack of skills, can often be resolved by explanation from other group members. When the time plan appears to be getting behind schedule it is often possible for group members to agree to a change of plan, by reallocating tasks. This means that a traditional time plan is likely to be more fluid than an online one.

Drawbacks with online technologies include:

- the time taken for a discussion and to reach collective agreement;
- the time it might take to recognise potential problems;
- getting all members to agree their responsibilities;
- knowing who can do which parts of the project;
- recognising when extra help with skills is needed;
- bringing the project together.

Some groupware products provide features which help with these problems, but these are designed for business use, and may not adequately help the students to acquire appropriate group working skills. There is also a need for tutors to be able to monitor the progress of the project. These difficulties represent the sort of capabilities that could be offered by a group support agent, however, a commitment to the group project by each individual is still an essential ingredient.

4. ARCHITECTURE OF A GUARDIAN AGENT

An agent is a self-contained, concurrently executing software process, which encapsulates the current state in terms of knowledge, and is able to communicate with other agents through message passing [13]. We propose an agent to support students, called a Guardian Agent, which works quietly in the background on each group member's workstation. The agent will autonomously monitor the progress of the group project, suggest ways in which the students can act to improve the progress of the project and enhance the communication between members of the group.

Each student working on the project will have an individual agent, operating in the background, watching progress, measuring it against the plan and taking remedial action when

necessary. The agents belonging to each member of the group are able to communicate with each other to exchange information and negotiate on behalf of the students.

The agent might recognise that lack of time is becoming a problem when monitoring the progress of the project against a plan of the work to be completed, and a variety of solutions might be suggested. Similarly, lack of skills could be recognised by the appearance of errors in the work, or the student asking how to do a particular task. The individual agent will support an individual student, but in addition this agent will communicate with the other students' agents to support the group as a whole to ensure that the project is completed satisfactorily. The student will also be free to work unaided by the agent if so desired, though monitoring will continue unobtrusively.

It is not proposed that such an agent will replace the tutor's input, but the agent will perform some of the mundane administrative tasks, which are usually performed by the group members during face-to-face meetings automatically, but which do not need to be performed by the students in order to fulfil the learning outcomes of the group project. The role of the tutor is different for online learning [10], and support for the tutor by an agent is an additional functionality to be pursued. Multi-agent systems can combine different types of agents, but in our architecture each individual agent will have a similar structure when the project begins. Each agent will have interfacing capabilities for communicating with its student, reasoning capabilities for monitoring and analysing the current situation, a knowledge base personal to its student and communication capabilities for communicating with other students' agents. The architecture for our agent system is shown in Figure 1, which shows that communication with other students'agents is by means of a whiteboard.

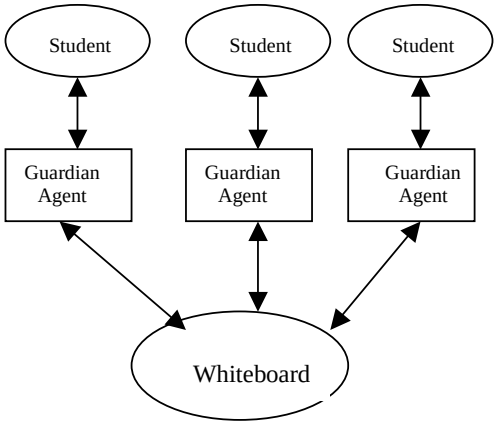

Figure 1 Architecture of Guardian Agent System

4.1. Development of the Guardian Agent

Students undertaking group projects in a traditional setting face several problems to a greater or lesser degree. The results of surveys on group projects have been considered closely when deciding what functions software agents should undertake in supporting group working [12]. Table 2 shows the stages of a group project and the roles we have identified for our agents.

Table 2 – Roles identified for the Guardian Agent at each stage of the group project.

Project stage	Potential areas in which GA can help
Planning	Introductions Setting ground rules Produce a project plan
Doing the project	Check the time schedule Ensure all members contribute Identify lack of skills
Completing	Collating the individual parts Preparing a report Appraising the group's performance

Our research is considering the project planning processes initially, including allocating roles, agreeing ground rules and producing a project plan (Table 2).

The process of allocating roles begins with finding out about each other's abilities. Students who have worked with each other previously will have a good idea about this already, but online students will have to explicitly describe themselves. The agent asks its student to identify the predetermined task areas he or she likes, is good at, dislikes and is not good at. These are filed as Prolog facts and posted to the whiteboard, where the other agents can access the information. One of the agents is given the role of allocating tasks to the students and, after checking that all the students have posted their abilities list to the whiteboard, this agent determines which students should be allocated which task, using the following rule:

> If studentA likes X and is able at X
> Then studentA should do X.

A series of allocation facts will then be posted to the whiteboard. If no student has been allocated to a particular task the agent looks again at the facts at its disposal and using the following rule, decides whether any student may be able to perform a task if given appropriate training:

> If studentB likes X, but is unable at X
> Then studentB should be offered training in X

A series of training facts are similarly posed to the whiteboard. It is likely that there will be some conflict to resolve, such as too many students being allocated to the same task, or no student allocated or offered training for a task. After informing the students of the conflict, the agents may negotiate on behalf of their student to solve the conflicts if the student does not choose to negotiate unaided.

The next planning task is to set the ground rules, identified as an important element in successful group projects [9]. Each student can suggest a rule, such as answering email messages within 48 hours, informing the other students in advance of non-

participation in a conference or when experiencing difficulties completing a set task on time. The ground rules are likely to be different from those for a face-to-face project, so the agent will be able to offer help to students, by suggesting rules, and collating the rules for agreement by all of the students.

An initial prototype has been implemented in Prolog, using the declarative features for handling facts and rules, which can be passed between each student's agent and the whiteboard. Evaluation of the prototype will give us valuable information as to the suitability of autonomous agents for supporting students undertaking group project work.

5. CONCLUSIONS

If online courses are to be regarded as an acceptable substitute for traditional campus-based courses, an element of group working should be incorporated into the scheme. However, online group projects require very different ways of working, though the learning outcomes should remain the same, for example to prepare the students for team working, and practice what has been learned on the course. In the future when global online team working becomes the accepted practice at work, the learning outcomes may need to be extended. Group workers experience a number of problems associated with the mainrenance aims of groupwork when working online with limited CMC support. Agents are suggested as appropriate to provide additional support which will overcome some of these difficulties.

In this paper we have reported on the initial design of agents to support students undertaking group projects, showing the chosen architecture for our prototype system. The implementation in Prolog uses an agent tool, which can be extended for a number of additional purposes.

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