RUNESTONE, an International Student Collaboration Project

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Abstract- *Our students will eventually work in a global market; what better preparation can we provide for international collaboration than … international collaboration? The RUNESTONE project is developing and evaluating the notion of incorporating international group projects into the undergraduate Computer Science curriculum. RUNESTONE adds new dimensions to student teamwork, requiring students to handle collaboration that is remote, cross-cultural, and linguistically challenging. RUNESTONE is a three year project, with the prototype version running in winter 1998 with students at Uppsala University, Sweden, and Grand Valley State University, Michigan, USA. The 1998 pilot study will be followed by a full-scale implementation in 1999 and another in 2000.*

Introduction

The RUNESTONE project involves students and faculty at Uppsala University (Sweden), and Grand Valley State University (Michigan, USA), and researchers from the Open University (UK) and the University of Texas at Austin (Texas, USA). The project's primary aim is to introduce real international experience into undergraduate Computer Science education in a way that has value for all participants. Group projects (typically 5-10 students per team, 5-10 weeks per project) will be incorporated into courses at Uppsala University and Grand Valley State University. These students will collaborate closely with their foreign counterparts using appropriate communications and computing technology to solve a given problem. Because the students come from different specializations (all CS majors), they have different knowledge to contribute to the project. Problems will be designed to cover the spectrum of backgrounds. RUNESTONE's secondary aim is to identify effective support structures for remote international collaboration, encompassing strategies for communication, management, and technology use. RUNESTONE will evaluate pedagogical and technical solutions for collaboration, will examine the costs, both in time and money, and will investigate how students learn in such a setting and what they learn. This paper introduces the RUNESTONE project, describes the support and pedagogic mechanisms used, and presents preliminary observations from the first, pilot year.

Further Aims

The RUNESTONE project aims to:

- Give students international contacts and experience with teamwork with people from a foreign culture.
- Give students experience of collaboration with a group having a different educational background.
- Encourage learning through peer-teaching.
- Give students experience with the use of Information Technology in problem solving.
- Use the foreign experience to aid students in producing a superior product locally.
- Benefit staff by close collaboration with other universities, giving insights to other departments and ideas for new teaching methods.
- Gain experience with use of new techniques in the running of a course.

Another goal is to create a well-organized setting with courses that, after the initially higher start-up costs, run at normal or lower costs. One example of cutting costs without compromising quality is the use of student peer-learning, which can reduce the demand for staff hours. Another example is that the costs for renewing the course can be distributed among the departments involved.

In carrying out the RUNESTONE project, we will establish results that address the issue of transferability to other departments and institutions. For this reason, the evaluation will aim to distinguish between domain-specific and general lessons, particularly with respect to the impact of international collaboration on group interaction and personal development, the extent of peer-learning, and the costs of using this form of education. For example, the project shall examine questions such as how much time is spent on becoming acquainted with new techniques for communication and in what ways (if any) using non-native language impairs learning.

Peer-learning

Based on anecdotal evidence from our own experience as teachers, we believe that having students explain concepts and solutions to one another is a powerful learning technique. Our conjecture is that there will be plenty of occasions for the students involved with the RUNESTONE project to help each other with activities such as explanation, clarification, sharing knowledge or rehearsal of ideas. Occasions for peer-teaching can be formal or informal. Formal occasions arise when students at site X present information for the students at site Y. Informal occasions include questions that arise during day-to-day e-mail or simple study sessions.

The RUNESTONE project will examine peer-teaching and -learning systematically by considering which settings tend to encourage or discourage peer-teaching as well as factors that contribute to the effectiveness of peer-learning in these situations. One of our hypotheses is that the rather different educational backgrounds of the two sets of students involved in the project will encourage peer-teaching and -learning. The differences in backgrounds should motivate the students to articulate their reasoning, rather than assuming that there is mutual tacit understanding between them and their foreign counterparts.

The pilot study

From early January through late March 1998, the RUNESTONE project ran a pilot study, which involved a group of eight students: four in Uppsala and four in Michigan. All of the students were in their third or fourth year of university studies. For the Swedish students, the group project was part of a course that started in September, whereas for the Americans it was the major part of a course that started in early January. The problem specified for the group project was fairly advanced, involving study areas such as real-time systems, networking, and distributed systems. (See the appendix for a detailed description of the group project.) A major goal of the RUNESTONE project is to examine the influence of the group project on learning, and espectially to identify how particular factors in the project set-up affect what the students learn and how they learn it.

Data collection

Data in a variety of forms was collected during the pilot study. This paper draws on that data to make some preliminary observations about what occurred and how to run the collaboration in the coming year. Data collection was carried out throughout the group project and covered all types of interaction between the students except their informal face-to-face meetings (which were covered by the project logs kept by the students). For detailed exposition of these and other techniques see, for example, [1, 2 & 3].

• Entry questionnaires: All students were asked to complete a questionnaire covering their backgrounds, expectations for the course, attitudes, and learning styles.

• Video-conferences: The first meeting between the students on both sides of the Atlantic was via video-conference, with both ends recorded on videotape. While we had planned to hold a second video-conference with all of the students after the project was over, this meeting was abandoned due to problems in synchronizing schedules.

• Weekly debriefings: Each week, the teachers at both sites held a meeting with their local group of students, where they reflected on how the project had gone during that week. The debriefing followed a standard script, but was sufficiently flexible to allow the teachers to immediately explore the students' observations and any new developments. The meetings were audio-recorded. At the end of these meetings, each student filled out a quick, one-page questionnaire about the meeting. The questionnaire asked about the meeting organization and the outcomes (decisions, learning, conflict resolution, clarifications, etc.), as well as about the respondent's satisfaction with the proceedings, both overall and in terms of their own role in the meeting.

• IRC logs: The whole trans-Atlantic project group held weekly meetings using Internet Relay Chat (IRC). Logs of those meetings were collected.

• Electronic mail and Web documents: Much of the student interaction about the project was via electronic mail and documents shared on the Web. All student mail relating to the RUNESTONE project was collected, and the Web site was monitored.

• Weekly project logs: The students completed weekly project logs where they kept a daily log of their time on the project, their activities and interactions during that time, and the outcomes. Other students in the Swedish project course, i.e., those in groups that consisted of only Swedish students, were also asked to keep project logs, in order to provide a basis for comparison. (This was not feasible for the rest of the American contingent.)

• Teachers' journals: Each teacher kept a journal of their observations, particularly with respect to peer-teaching and -learning, culture clashes or developing sensitivities, collaboration, effective or ineffective procedures, and technology issues.

This collection of data will be analysed for emergent patterns such as decision strands, student roles, evidence of peer-learning, and cultural factors that affect outcomes. The analysis will be data-driven in the first instance, albeit with special attention to the stated topics, and will be used to generate an analysis protocol for the subsequent years. The value of the international project will be judged primarily in terms of students' experience, as reflected in their recorded behaviour during the project and their questionnaire responses. It will be judged as well in terms of teachers' experience (again, based on qualitative data) and in terms of observed costs.

Preliminary observations: Is the international project a good education form?

The fundamental question for RUNESTONE is whether — and in what respects — this is a *good education form*, meaning that:

• The syllabus is covered at least as well as through 'conventional' methods.

- The actual time the students spend on the course is related to the 'allotted' time.
- The time staff spend on the course is related to the course size and is comparable to other ways of delivering the course.
- The cost of running a class is not higher than other forms.
- The course contributes to students' personal development.
- The form is motivating to students.

We address each of these points below. Because the pilot study was just that — a pilot study — any observations we make are necessarily limited and preliminary. Moreover, detailed analysis of the data is not yet complete; the comments given below are based on on-going examination of the data and a first-pass, topic-based review of the material, as well as on a more extensive examination of the data generated on the Swedish side.

Performance (syllabus coverage)

The coverage of the syllabus is a special case here, because the primary aim of this part of the course in Sweden is to provide experience in the use of concepts covered in earlier, more theoretical parts. Hence, the completion of the project task is perhaps a better measure. Based on their performance on previous projects, the Swedish students involved in RUNESTONE are strong students.Under normal circumstances, their project would have been predicted to have been among the first completed and best produced by the class. This was not the case here and was, in our opinion, due to difficulties in coordination and synchronization among the students involved.

Time spent on task

The project logs of the Swedish students in the international group showed that they spent roughly the expected number of hours on the course: the equivalent of three weeks of full time studies, i.e., 120 hours. The American students spent on average somewhat less, i.e., roughly 100 hours, but this was in line with the expectations for the course the American students followed. It was interesting to see how these hours were actually spent, especially compared to each student's individual estimates from the background questionnaire. One question had asked the student to estimate, for courses taken prior to the pilot study, the percent of their total course time they generally spent studying alone and in groups.

For these summary figures, emailing was considered as working alone. Recategorizing emailing as a group activity would make the focus on group work even stronger. The, on average, lower procentage spent working in a group among the Americans was due to a higher rate of local group work among the Swedes. This was not surprising, because the Swedes knew each other well before this course. Two students (one Swede and one American) provided incomplete data and so are not reported here. Swede 2's reported time included considerable time searching the web for useful information, which was both time-consuming and solitary.

Percent of studytime spent alone vs. in group

	Alone		**In a group**	
	estimated	*reported*	*estimated*	*reported*
Swede 1	70	23	30	77
Swede 2	30	57	70	43
Swede 3	80	30	20	70
averages		*38*		*62*
American 1	90	53	10	47
American 2	70	53	30	47
American 3	95	50	05	50
averages		*52*		*48*

Staff time and costs

Because this course required new development, staff time spent on the course cannot be considered typical. The greatest development cost was in setting up the project, which is standard overhead for any project course. This offering certainly involved fewer lectures than usual and less involvement from teaching assistants. There were some special costs, for example running the video-conferences and obtaining special hardware for the project. None of the costs was discouraging.

Student development

It is too early to say much about the effect of recent project work on students' personal development. It is likely that the project outcomes for the students were *not* what they would have been had the project been individual or purely local. In either case, the students would have expected to complete the project, and some of them to excel. Hence, we speculate that the outcomes in personal development are likely to be *different in kind* from those of a 'conventional' project. Our experience as teachers suggests that the experience and frustration of working in a relatively large group with unknown persons is likely to be counted as a key lesson in the long term. The students have had to deal with problems that were different, and in many cases more inter-personal, than usual. Each student appeared to reflect on his or her individual responsibility for communication or other problems with the project. For some, insurmountable frustration and failure to complete a project were new experiences.

After the course, both the American and Swedish students talked about lessons in project and time management, ideas for improving the experience included alternative group structures, more milestones, and better indicators of progress. The American students described a 'lack of closure': they knew some parts of the project worked, but they hadn't seen it working and didn't know if it worked. (The Swedish students, on the other hand, were certain that it didn't.) The students all realized the value of communication skills (including how to conduct a meeting and set an agenda); perhaps the clearest lesson for the students was the need to acknowledge all email and to answer promptly. All of the students rated the project as being more successful in terms of acquiring knowledge and experience than in terms of producing a product. Hence, the early indicators are that the project did contribute to students' personal development.

Student motivation

Three factors enhanced the initial motivation of students in this international group:

- There was a project to do.
- The team was international.
- The international project was part of an 'experiment'.

In the initial meetings, some students stated that the real challenge was to make the group work as a team, and to demonstrate the viability of the experiment; others cited both the teamwork and the challenge of the project itself. During the project, motivation was neither constant nor evenly distributed; students cited differences in expectations and motivation within the groups as one of the main problems. At times the awkwardness of physical separation and different time zones impaired student motivation and enthusiasm. Nevertheless, seven of the eight students report that they would be willing to participate in such a project again.

Additional observations

Discrepancies between the groups

Much of the observed frustration can be attributed to discrepancies between the two groups of students, in terms of expectations, sense of urgency, time available, local cohesion (and hence local group dynamics), technical skill, and access to a key, charismatic lecturer (an American working for the year in Uppsala). The American students felt that they were "a step behind all the way". The Swedish students felt that the American students lacked "passion". One American student expressed regret at not being able to contribute to the extent wanted, for the reason that there was too much else (i.e., job and family commitments) going on. The American students perceived the RUNESTONE project as bigger than those they normally undertake; they felt that future international projects should make clear that *all* students must participate fully in order for the project to succeed.

Student-identified problem areas

• Motivation, commitment: The Swedish students perceived the discrepancies of commitment and motivation as the biggest problem; everything else, they believed, would have been surmountable had all the students been working with the same "passion".

• Technical issues: The American students thought that technical issues were the biggest problem, especially writing code for hardware that was located on the other side of the Atlantic. Testing was difficult when the local platforms differed from the target platform.

• Communication: The American students didn't perceive communication as a problem, while the Swedish students identified communication as one of the biggest problems. All the students were frustrated by slow or lacking responses to email messages and IRC questions. The students cited multiple missed deadlines as a major problem, although they argued that this might not have happened had the communication been really effective.

• Programming language knowledge: All students mentioned that some extra programming language competence (C or Java) would have been desireable.

• Problem definition: All students said that understanding the problem to be solved in the project was something that caused extra work. The American students rarely used opportunities to ask the Swedish-based teachers for clarification; the Swedish students were unable to diagnose the misunderstandings of the American students quickly.

• Single physical version of equipment: There was only one physical version of the equipment, which was located in Sweden. This, and the fact that the teachers most involved in the course were in Sweden, put the American students at a disadvantage. (This will be changed next year.)

Communications technology

None of the students considered the communication media as problematic. We tried a number of different forms of collaboration; IRC and email were the preferred modes of communication. [4 & 5] report experiences with tools that support project-based learning.

• IRC: All of the students felt that IRC was the best way of communicating with their counterparts. It contributed a 'liveness' to the communication and often left the students feeling that they had made progress. They appreciated being able to have different conversations going simultaneously and to review the log. Other benefits of the IRC were that it allowed time to think before answering, and that silence wasn't awkward compared to more direct forms of collaboration, e.g., video and audio.

• Email: As one of the students observed: "Email is great — it's as good as you make it." The American students observed that email would have been their main medium even if the project were American-only.

• Web pages: The students used Web pages to share documents and to keep records. However, they rejected other possible Internet-based communication tools; electronic whiteboards and 'CUSeeMe' were discussed but not tried.

• Video-conference: The initial video-conference was not particularly useful, largely because the connection was quite poor. The fact that the students requested a project-end video-conference shows that they found some value in this medium. Experience reported elsewhere [6] indicates that an initial 'social kick-off' helped subsequent communication.

• Audio-conference: Provision was made for weekly audio-conferences between the students (using speaker phones). The first try was not useful, and no further attempts were made.

Language

Language *per se* was not a barrier for these students. The Swedish students are highly competent English speakers (with 8-9 years of study and English usage required in many university courses), although they are not necessarily fully confident. The students' email and IRC logs are full of jokes

— but the students expressed low confidence that their jokes were understood. Everyone was fiercely polite.

National culture

The students noticed a few cultural differences between the two groups, specifically in these areas:

- Educational background (e.g., lack of knowledge of C and use of functional programming)
- Age (the Swedes being older: 23-24 vs. 20).
- External obligations; the Americans perceived that they had more job and family obligations, although some of the Swedish students work as consultants, i.e., the groups actually worked under similar conditions.

Nevertheless, the students were emphatic that culture was 'a non-problem'; each group described their counterparts as being "just like" or "pretty much like" them. It seems likely that the pilot study simply did not reveal sufficient clues here to indicate the role which culture plays; it is difficult with a small sample to distinguish between individual differences and group trends.

Team coherence and roles

The American cohort was a collection of individuals, whereas the Swedish cohort worked in concert as a team. The American students described a sense of working on an individual basis.

While roles were assigned rather late, there was a good international distribution of responsibilities. The groups recommended that in the future we appoint a student at each site as local project leaders. Designated responsibilities for these two students would include acting as principal liaison and watching for problems within the local cohort or the overall interaction. This monitoring function might catch problems earlier and help to defuse them; for example, this year the Swedish students helped one another with programming and technical difficulties, preventing these factors from becoming problems.

Social interaction

There was relatively little social interaction between the cohorts; the students felt that they didn't know their counterparts very well, and the project didn't help them to get to know each other. Some interactions would probably have been more efficient if the participants had known each other better. Social interaction — jokes and talk about personal topics — increased toward the end, during the hectic efforts to make the project fly. Yet, for each of the students, some part of the process or of their counterparts' actions or interpretations remained mysterious.

Peer-learning

Peer-learning between the cohorts was limited; it was largely related to craftsman skills, e.g., better technical solutions. This may be accounted for by the lack of familiarity between the students and possibly by the nature of the project, which could be sub-divided in a way that avoided the need to learn about what the others were doing. Some of the Swedes reported peer-learning within the Swedish cohort, but this occurred largely in face-to-face interactions about which no data was collected.

Conclusion

No reliable conclusions can be drawn from a small pilot study. However, this trial does suggest changes for the next phase in the RUNESTONE project. Some example changes include having equal resources at the two sites, incorporating a clearer technical and project management briefing in order to achieve a faster and appropriately structured project start, making clearer suggestions about targets and milestones, and recommending a different team management structure.

Before next year, we will investigate other means of collaboration. For example, we are intrigued by the "CoWeb" (Collaborative Website) concept from Georgia Tech (see http://pbl.cc.gatech.edu:8080 /myswiki). In a CoWeb, any page (including both text and graphics) can be edited by any user.

There is still much to understand about how international collaboration influences the learning process. We hope that the more detailed analysis of the full data will reveal more about factors that affected the nature of the social interactions within the team and will provide examples of peer-learning opportunities taken and missed. The data collection schemes themselves will be evaluated, with the goal of introducing new methods that are faster to carry out and more attuned to this particular project. Scaling the project up to include the whole class in Uppsala next winter appears feasible.

Overall, the pilot study was a qualified success: the technology and interaction were demonstrated to be feasible. However, the project was not quite completed, and the students experienced frustration associated with group interaction (particularly with the international interaction). Nevertheless, the students all report that they learned a great deal, and all but one reported that they would volunteer again for an international group project. Interestingly, the frustrations were largely attributed to individual differences (style, personality, commitment, and expectation), and a perceived imbalance of resources (key resources being located only in Sweden), rather than language, technical, or cultural factors — although this perception in particular will require re-examination when more students are involved. The need for faculty on both sides who know the technical content of the project was apparent, but would be interesting to find ways around this in future offerings.

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References

[1] Isaac, S., and Michael, W.B. (1989) *Handbook in Research and Evaluation for Education and the Behavioral Sciences*. EdITS Publishers.

[2] Gall, M.D., Borg, W.R., and Gall, J.P. (1996) *Educational Research: An Introduction*. (Sixth edition) Longman.

[3] Denzin, N.K., and Lincoln, Y.S. (Eds.) (1994) *Handbook of Qualitative Research*. Sage.

[4] Kehoe, C., Guzdial, M., and Turns, J. (1997). What We Know About Technological Support for Project-Based Learning, In *Proceedings of IEEE Frontiers in Education Conference*. Pittsburgh, PA: IEEE.

[5] Guzdial, M., and Turns, J. (1997). Supporting sustained discussion in computer-supported collaborative learning: The role of anchored collaboration. *Journal of the Learning Sciences* (Submitted).

[6] Petre, M., Carswell, L., Price, B., and Thomas, P. (1997) Innovations in large-scale supported distance teaching for the Internet: transformation, not just translation. In *Proceedings of IEEE Frontiers in Education Conference*. Pittsburgh, PA: IEEE.

Appendix: The Group Project

The actual project in the RUNESTONE pilot study was to navigate a steel ball through a maze by tilting the maze in two dimensions with stepper motors. The user submits a navigation algorithm, defines a path for the ball to follow, requests the server to execute the algorithm, then waits for access to the game. When the user gains access, the game server resets the ball in the maze, executes the user's navigation algorithm, then provides feedback to the user on the result of the run. Feedback includes information on how the navigation code executed, and a graphical display of the path which the ball traced through the maze. The input to the navigation algorithm is the position of the ball. The output is the rotational positions of the motors as a function of time. Video images of the maze and ball are available from a black and white digital video camera.

The hardware components available for the projects were located in Uppsala. The central piece consisted of a desktop computer, with a black and white digital video camera attached to its parallel port and an Ethernet connection to a laptop computer (the Swedish students each had access to a personal laptop). One of the laptops was used to communicate with the two rotational stepping motors via its serial port. The camera was permanently mounted over the Brio maze game as was a light source. A second laptop, connected via Ethernet, was used to run as a client computer with a web browser for playing the game.

The software components included a C library of code to read video signals from the parallel port, control camera settings, Motif app (Ximprov) for viewing camera data, experimenting with camera settings, an example C program using camera data (Ximprov), an Apache HTTP server for Linux, and Linux JDK 1.1 with RMI support

The starting point for playing the game (running the maze) was a website. This website had to:

- Display the currently installed maze board.
- Allow user to define a path for the ball to follow.
- Accept user's navigation algorithm to execute.
- Give feedback to user during the run of the maze.

Optional extras were to:

- Provide information to a user on developing navigation algorithms.
- Notify a user about game queue, estimated waiting time, etc..
- Use RMI technology appropriately.
- Display graphical representation of a run, superimposed on selected path.
- Display a full video image of the maze.

The game server needed to be a concurrent system, either multiple processes or multiple threads, and had to:

- Maintain a queue of users who wish to play, insuring mutually exclusive game semantics.
- Accept navigation algorithms and selected paths from clients.
- Provide feedback to client on the success/failure of navigation code.
- Provide data to the client on the ball's movement during a run of the maze.
- Provide a framework in which navigation code executes predictably and safely.
- Be able to reliably reset the ball to the documented starting position.
- Drive the stepper motors via a serial port interface.
- Use priority to schedule the concurrent entities properly.
- Fetch ball position information from the video server and make available to navigation code.

Optional extras were to:

- Provide information to clients about game queue, estimated waiting time, etc..
- Provide a documented framework in which navigation code executes.

The video server had to consist of one or more processes which must:

- Read video frames from the camera as fast as possible.
- Reduce video data to an x,y location of the ball on the maze.
- Make ball position information available via a network connection.

Optional extras were to:

- Provide a grayscale video image of the maze via a network connection.
- Provide as many positions updates per second as possible.