

# Bringing Collaboration Front and Center in a Cross-Disciplinary Design Course

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**Abstract:** In this paper we examine the cross-disciplinary collaboration of students who took a learning technology design course at Stanford over a three year period (2003-2005). The course is a member of the TRAILS project, which has collaboration and cross-disciplinarity as learning principles. Many students come to the class believing that they know how to collaborate and that they can do it on autopilot. We discuss four areas – teamness, communication, joint problem space and learning environment – which we believe need to be attended to by the students to ensure that the cross-disciplinary design project is successful in terms of both the product and students learning. Through two case studies we illustrate how these areas have differentially affected two groups who took the course, and we discuss ways that instructors can facilitate attention to collaboration and steer students towards a successful collaborative experience.

## Introduction

The Stanford TRAILS course brings together students from the school of education, the computer science department and a variety of other disciplines. As discussed in detail in DiGiano et. al. (2005), the TRAILS project is a cross-institutional project that aims to develop courses that bring students from many disciplines together with educators, introducing the students to the design of technology curricula. Students range from undergraduate seniors to masters and Ph.D. students, bringing a variety of prior experiences and knowledge to the course. Over the period of a ten-week course, these students, in teams of between 2 and 4, design and produce a technology tool and a curriculum piece and field test it. All teams consist of someone with an education background and someone with technological skills. The groups are matched with a partner educator, either a K-12 teacher or an educator in a non-school educational setting, who helps them define a learning problem and guides the development of their solution. Thus, in a very short space of time, the students need to learn to work with both students from one or more different disciplines and an educator who faces the real world constraints of using technology in a learning environment. For the purpose of this paper, we focus on the ways that students collaborate with each other, as a team, and the ways in which, as instructors, we can help ensure successful experiences for all team members.

Many students who come to the TRAILS course believe that they know how to collaborate effectively and successfully with others. Yet, research on collaborative problem solving demonstrates that collaboration is far from simple, and success is not a simple result of putting people in groups. In her paper, *When Smart Groups Fail*, Barron (2003) discusses how variability in success between groups who are matched for prior achievement can be attributed to the different types of interactions that occurred within each group. She notes that, while there was no difference in the number of correct ideas proposed across groups, successful groups paid more attention to the correct ideas, and developed ideas further. Thus, the quality of the interaction rather than the quality of the ideas, predicted how well a group performed in the task, and how well individuals performed on a post-test.

Michalchik et al (2001) discuss the differences between two groups of ten students who were engaged in the creation of a website as part of an undergraduate course. The outcomes differed between the two groups, with one group receiving a higher grade for their website than the other group. Students in the high achieving group reported using a divide-and-conquer strategy, stating that they learned little from the process but were satisfied with their grade. The lower achieving group reported long, high-level discussions that were rich learning experiences. Yet, they felt that neither their project quality, nor the grade, represented the amount they learned while participating

in the project. Considering these results when thinking about cross-disciplinary design groups highlights the importance of respecting the skills and insight each group member brings to solve the problem, and acknowledging the value of the differences between groups members so that they can take advantage of the multiple viewpoints necessary to produce a “curriculet”—a technology-infused curriculum product.

Another key element of successful collaborative problem solving appears to be the creation of a shared problem space between group members. Roschelle (1992) argues that the creation of shared meanings is the crux of collaboration and that focusing on how groups interact and construct shared meaning will tell us more about the collaborative process. Hogan, Nastasi & Pressley (2000) found that the groups who reasoned clearly about the problem were the groups who identified and vocalized the elements which were causing them problems and the areas where they lacked knowledge. This indicates that students in successful groups create problem spaces within which they negotiate the problem and their understanding of it. We suggest that this is especially important for cross-disciplinary design groups, who need to talk across their different experiences and terminology to form a joint understanding of the problem.

During the first year of the TRAILS course at Stanford some basic supportive exercises were incorporated to help students organize their collaboration (e.g. student-developed standards for team participation and explicit declaration of learning interests and desired roles). Over the next two years our team developed more overt ways to indicate the importance of actively attending to collaboration, including a mini-lecture on what research indicates is important, short dramatizations of what has gone wrong in the past, suggestions for how students should address difficulties and assignment of a “coach” for each group. In this paper, we will use two case studies of groups to illustrate what interdisciplinary collaboration looks like in the TRAILS course, and will refer to other groups in an effort to triangulate our case findings. We will also indicate where we believe interventions are possible, and where we have effectively implemented interventions to promote successful collaboration in our course.

## Method

The TRAILS course at Stanford has been taught three times since the Spring of 2003. Data was collected from all courses, although this paper focuses primarily on the first two years. Our team members observed throughout of all courses. The team consisted of the course instructor, a teaching assistant (the second author) and a research assistant (first author). The first author also attended many of the group meetings for one project group each year – groups 1, 4 and 7 – and received copies of the majority of the emails between these team members.

The four students who were in the Team 1, and all the students, who took the course in years 2 and 3, were interviewed individually after the course ended. The students were asked to reflect on their experience during the course, specifically their collaborative experiences and their team’s interactions. The interviews also aimed to get the students to reflect upon and discuss key events during the project. The interviews lasted about one hour and were audiotaped.

	Number of students	Educational setting
<b>Spring 2003</b>		
Group 1	4	High school
Group 2	3	High school
Group 3	4	Middle school
<b>Winter 2004</b>		
Group 4	3	Museum
Group 5	2	Elementary school
Group 6	2	High school
<b>Winter 2005</b>		
Group 7	2	High school
Group 8	2	Elementary school
Group 9	4	Middle school
Group 10	3	Middle school

**Table 1:** Distribution of students in groups and educational settings from Spring 03 to winter 05.

All students were required to submit three journal entries during the course. The first journal was due in the week after groups formed, the second, half way through the course and the final one was due on the day teams turned in their final product. Journal entries were prompted with guiding questions, but students also had the option of addressing whichever issues were most interesting or pressing to them at the time. Journals were focused on documenting the collaborative process and, in particular, the students' experiences participating in their respective collaborative teams.

Table 1 shows the number of students in each of the 10 groups who have participated during the past 3 years and the educational setting in which they worked. The case study groups are group 1 and group 4; throughout the paper we will refer to groups according to the numbers indicated in this table.

## Results

There were three students in group 1; Tyler, a senior computer science major and three Learning, Design and Technology (LDT) master's students from the school of education, Zoe, Catherine and Jake. The master's students knew each other well, and had worked together on previous occasions. In Zoe's first journal she reports confidence in her group because they "*know the collaborative design drill*". None of the students had met Tyler before the course. Their product, while fulfilling all the requirements for the course, is one of the less successful of the 10 products that have been developed by students in this course.

Group 4 consisted of three students; one masters computer science student, Jack, and two LDT students, Paul and Johnny. Again, the LDT students had worked together prior to the course, and neither had met Jack before the course. Their project met and exceeded all requirements for the course, and was highlighted on the TRAILS website as an exemplary project.

## Teamness

One of the fundamental differences between group 1 and group 4 that we have observed through their interactions, journals and interviews is a differences in their concept of themselves as part of a team and their understanding of what is important for a team to function. In his first journal, Jake states that "*in order for a cross-disciplinary team to function well, each person must have his or her own goals met*", indicating that he imagines a team as made up of distinct people working to fulfill their own goals, rather than creating a single goal for the team. In her final entry, Catherine also noted that "*the trouble with team-work as I see it is we all want to please the others so we enthusiastically commit to doing X, Y and Z even if it isn't at all realistic with the available time and resources*", indicating that she sees the team in terms of individual, socially-mediated commitments.

While neither Jake nor Catherine seem to view a team as the sum of its parts, Tyler expressed how he did not feel like he belonged within the team, saying in his interview "*I think the group would have run smoother if it had three people...and that might have excluded me*", a striking comment from someone who spent 8 weeks working with a group of people to complete a project.

In meetings, group 1 awkwardly discussed the issues and their work. Frequently Zoe mediated the discussions between Jake and Tyler, who rarely spoke directly to each other, while Catherine sat slightly apart from the group, computer in front of her, attending to her own work rather than to the group. When asked about high and low points during the group process, Jake described the group meetings as the low points and said "*we just never had fun in our meetings.... meetings weren't quick and productive and they weren't very enjoyable, but they weren't bad, they just weren't fun.*" Catherine described the first meeting as filled with "*slightly awkward silences*" and Tyler noted "*I didn't like meetings.... I hated having meetings when nothing had happened since the last meeting*". This was not a group of people who wanted to be together, or who saw their interactions and efforts as necessary for joint achievement and success.

In contrast, group 4 became a team very quickly. In Johnny's first journal entry, right after the group had formed, he expressed his enthusiasm for the group, saying, "*I am excited about the prospect of working with this team.*" Their meetings were interspersed with jokes and laughter, and, as the quarter progressed, the group became more cohesive and enthusiastic. In his second journal Jack comments "*Our group is fantastic. We have a wonderful group dynamic, great ideas and each of us has different strengths we're contributing to the project.*" In his final

journal, Paul noted that “*without our team’s collaboration I don’t believe we would have had such a complete and considered product*”. There was the combination of an appreciation for each other’s strengths and a joint understanding that they were part of a team who needed to cooperate in order for the whole team to be successful. This outlook distinguished this group from team 1, and enhanced both the learning experience of the students (see below) and the quality of their product.

## **Communication**

Open communication between group members is essential for effective collaboration. In his first journal, Johnny reports a frank discussion with Paul and Jack about their desire to work in an informal educational setting. He notes that “*in that initial interaction, I saw the value of directness within the group*” and the team continued to openly discuss their project and concerns throughout the project.

In contrast, when Team 1 ran into interpersonal problems, they chose to ignore them, rather than deal with them. From their prior experiences Zoe and Jake had an unspoken acceptance of the low-level of work they expected Catherine would bring to their group, and they had developed a strategy for dealing with her. Jake described it during his interview as “*If that person [Catherine] is in our group we just ignore that person, or not ignore, we don’t expect that that person will do as much as other people.*” This strategy caused resentment within the group as others had to pick up the slack when Catherine did not do what she had agreed to do and also an supplied an excuse for both Jake and Tyler when they had not advanced with their part of the project. Zoe expressed frustration with Catherine, who was responsible for the curriculum development, and annoyance that she did not make it happen, although she did not confront Catherine about it.

This strategy was also employed when dealing with Tyler when he did not attend classes or meetings, and did not complete the sections of the programming he had agreed to. In her final entry, Zoe, the official group leader, noted that she had considered dealing with Tyler directly but she decided “*it was just more efficient to continue on with our process and just take his contributions when he was willing to make them*”, thus letting him off the hook, and letting resentment about his lack of contributions fester and grow within the group.

During the same quarter, Group 3 also experienced communication problems, but, after speaking with the teaching assistant and instructor, one member called a group meeting to address the issues and her concerns. While this was difficult at the time, the group made appropriate adjustments and managed to develop an effective product and to work together.

As we have continued to develop the course, we have made efforts to remind the students that they need to be aware of communication challenges and to foster open lines of communication between all group members so that concerns can be addressed as they arise.

## **Problem Space**

The creation of a joint problem space, which has been shown to be important for collaborative problem solving, is essential if a cross-disciplinary design group is to function effectively. Trying to persuade students of this has become a key element in our course design; from the beginning we remind them that all members of the team need to be aware of what is going on in the project at any given stage, and they all need to make an effort to ensure that the language they are using is understood by the other members of the group. This is reinforced in class through story-writing activities that ask the students to share and align team-member visions for the project outcomes.

Observing Group 4 was an invaluable lesson for our team in how a joint problem space can be created and maintained within a group that has diverse backgrounds and roles on a project. The group consciously located each of their meetings in a room with one or more white-boards and started each meeting by laying out an agenda (and respecting time limits in each section). As they worked through the agenda, the team members took turns writing or drawing on the white-board to illustrate what was being said – either by the person writing to help illustrate a point or by another member of the team to ensure they understood the ideas being expressed. As the board became full with notes, they took digital photographs, which were later posted on the group’s website, before erasing the less important elements. At the end of each meeting, a list of decisions and deliverables was generated – something

which had been assigned time in the original agenda – to ensure they all agreed on what had occurred during the meeting, and what deliverables were expected by the next meeting.

This technique would have soothed huge problems with other groups who have participated in the course. Unbeknownst to the course team until after the course, Group 5 suffered from not creating a shared problem space due to language difficulties. One of the members, Louise, spoke a heavily accented English, which the other team member, Julie, had great difficulty understanding. Instead of mentioning anything to course instructors, however, she would nod and agree with Louise, and leave the meeting having no idea what she had agreed to. At subsequent meetings, Julie would arrive without having completed what she had agreed to, and Louise became increasingly frustrated at her teammate's apparent lack of commitment to the project and the way she seemed to ignore all their discussions. The simple act of using an external form of expression would have saved this pair a huge amount of stress and would have helped make their interactions more enjoyable and effective for both team members. This example again points to the challenge groups face in acknowledging and addressing potential barriers in the group.

As Group 4 had a process through which they could make their thinking visible to each other, they remained aware that sharing a problem space is an issue for interdisciplinary groups. In his second journal, Paul commented that *“often our idea may mean, or represent, slightly different things to each one of us, and our visualizations of those ideas may vary. Creating drawings and visual representations of our ideas seems to help solidify a consensus amongst group members as well as further crystallize our thinking.”* This is in direct contrast to the members of Group 1, who made little effort to ensure all members knew what was going on, and in many ways, saw the project in distinct parts that should not concern all of the members. During an early brainstorming meeting to consider possible project options, Tyler presented the third idea of the day, one that he was very excited about. Zoe and Catherine responded positively to Tyler's idea, and without fully exploring it or attending to the fact that there was no definition of what would be learned through its use, the idea was adopted by the group. The LDT students had all expressed their belief that having Tyler's commitment to the project would be essential for success, and seem to have used this, rather than reasoned discussion, to decide to adopt his proposal. Jake was present for this meeting, but he did not engage in discussion. Instead, he sat back from the group and only presented technical issues when pushed for a comment. He finally said he wasn't sure that this would help their teacher-client, but his concern was not addressed, and he did not raise it again.

As the quarter progressed, there were moments when it was clear the group hadn't created a joint problem space. While each individual might have felt they were not sure about an element of the project, they did not concern themselves too much as they imagined someone else would have it under control. In her second journal, Zoe noted that she was concerned about *“reinventing the wheel”* with a product that many have tried to create before them. But she did not bring this to the group's attention, missing an opportunity to clarify a clear learning goal for what students would learn from their product – something, which they never really developed.

During his final interview, Jake acknowledged that *“I would have liked a more interesting curriculum but I think their goal, well, I wasn't the curriculum developer”*. We were well aware that the group's curriculum was not well developed and followed a very standard worksheet format, and so his disappointment is understandable. However, this lack of clarity in the product's learning goals, and the fact that he excuses himself because he was not the curriculum developer, points to a group who did not develop their ideas together, even though the course stressed the necessity of integrated curriculum that is deeply connected with the technology.

## **Learning Experiences**

When students complete design projects as part of a course, it is all too easy to examine only the quality of their final product and to ignore the quality of the learning that students experienced during the project. However, in design courses, we would argue that the collaborative experience and process is paramount.

When asked during the interview what he learned during the project, Jake said, *“I don't think we learned from each other at all”*, despite the fact that he had helped teach Tyler to use Flash. This knowledge exchange had been fraught with difficulties from the start, as Tyler had wanted to take the lead on programming the product. But early on, Jake convinced the group that it needed to be programmed in Flash, a platform with which Tyler was not familiar. Jake did a lot of the programming, while spending a small amount of time trying to bring Tyler up to speed, and then leaving him to work the rest out. Tyler used his lack of knowledge as an excuse to participate minimally in the project development, and failed to take Jake up on his offers for further tutorials. To add to the Flash issues, at

the end of the quarter, Catherine mentioned that she had just finished coding her master's project in Flash. The group members were not aware that Catherine could use this platform, and in fact knew solutions to some of the development problems Jake had struggled with. While this is, in part, a symptom of their lack of a shared space to discuss the development of the project, it also indicates that there was problem between three of the group members when it came to sharing knowledge and learning from each other.

In contrast, Jack was happy to agree to code the entire project for Team 4. However, he spent an afternoon working together with Paul to show him how to code the project using Flash. Paul had expressed a desire to try his hand at animating some of his own designs even though both students acknowledged that they "*probably wasted a bit of time*" in doing this.

In his second journal Jack commented, "*I've been learning a lot from Johnny and Paul. Johnny is like an encyclopedia of teaching terms and standards...he's really open to learning about everything. Paul's great with ideas and I know he's going to come up clutch when it comes to our product looking sweet.*" This appreciation for the skills of all the team members comes through in both Johnny and Paul's comments also. In his second journal, Johnny notes how, separate from the project, Jack has helped him to set up his webspace, and, in his final journal, he told us that "*towards the middle of the project I began to need a little more variety, and said that I would like to try some of the more graphic work. My group was fine with this.... Jack used my prototype to make the finished Flash animation*" also indicating this was a group where trying new things was acceptable and where informal knowledge sharing was the norm.

The appreciation of each other's skills is seen in Paul's final journal, where he states that "*without our team's collaboration I don't believe we would have had such a complete and considered product. I think everyone put forth their best effort, both within and out of the area of their expertise.*" He, and the other group members, had a huge appreciation for the expertise each person brought, and coupled with their focus on creating a joint problem space, this allowed them to learn from each other and to produce a high quality product.

## **Discussion**

Through three iterations of the TRAILS course at Stanford, we have observed a variety of groups and collaborative behavior, and have seen how these effect the quality of the product and the students' learning experiences. It is clear that regardless or sometimes because of, students' perceptions that they already know how to collaborate, there are occasions when direct instruction is needed to help the groups to successfully communicate and develop their project.

During the second and third iterations of the course, we spent a significant amount of time during the early classes telling students about the experiences that previous groups had had. It became useful to talk to them about developing a shared problem space, and suggesting that they should have such a joint understanding of their project that everyone in the group feels that the group is taking up their idea. We also encouraged them to employ strategies such as meeting in places with a white board and taking the time to write down the goals and deliverables before the end of each meeting.

We have made a point of emphasizing the importance of getting to know teammates and developing a group culture where asking questions and learning from each other is the norm. It is all too easy for students to dive directly into the project work, feeling that they need to spend all their meeting time working on the project rather than being friendly with each other and building the social foundation for their collaborative relationship.

While we have distinguished four distinct elements in this paper – teamness, communication, joint problem space and learning experiences – in many ways they are inextricably linked. We suggest that there is a hierarchical order for these items, where it is essential that the lower items (teamness, communication) be in place before others are possible. At the top of this, therefore, would be learning experiences, the essential element if our courses are to be successful.

For learning experiences to be successful, we found that interventions such as lectures, dramatizations, coaches assigned to each team, a story-telling activity and focusing on attention to communication and shared problem space through externalization of the group's thought process has been essential.

Cross-disciplinary collaboration is complex, but we can draw on what is already known about collaborative problem solving, and use simple interventions to help students to attend to their collaborative process and ensure that students have successful, educational experiences within cross-disciplinary groups.

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