

Who Is On My Team: Building Strong Teams in Interdisciplinary Visualization Courses

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Abstract

While it seems that interdisciplinary collaboration in a visualization course is (theoretically) a very good idea, the practical undergoing is problematic: in a single semester course students need to find project partners out of a group of students they do not know at all, establish a “common ground” with their new partners and create an expressive and effective solution to a visualization problem. This paper reports on a one semester course given to 48 interdisciplinary students (29 computer science, 14 business information systems, 5 non-technical¹), the strategies chosen to support interdisciplinary collaboration, and expectations and feedback on the collaboration as experienced by the students.

CR Categories

I.6.9. [Visualization]. K.3.2 [Computers and Education]:
Computer and Information Science Education – *computer science education, curriculum, information systems education*.

Keywords

Interdisciplinary collaboration in visualization, forming interdisciplinary groups, transdisciplinarity, breadth-first, computer-generated visualization course.

1. Why Interdisciplinary Collaboration is a Good Idea

My motivation to teach interdisciplinary courses is based on my belief that interdisciplinary collaboration skills are important soft skills for our computer science students. Furthermore, I have personally experienced how important interdisciplinary collaboration is for finding solutions to complex visualization problems. This first chapter backs up my belief with relevant literature and experiences.

Computer Science students acquire a substantial body of knowledge [Computing Curricula 2001] during college time. But they will – typically - *not learn to collaborate with other disciplines*. This might be a setback in their professional lives if they encounter real-life problems whose solution needs knowledge of other disciplines in a depth that can not be easily

acquired on their own [Derry and Fischer 2005], [Campbell 1969], [Fischer and Redmiles 2008].

Teaching computer science students to collaborate with students of other disciplines involves interdisciplinary courses. But how do interdisciplinary courses affect the “body of knowledge” students need to learn to gain sufficient depth in their own field? It seems that depth in one discipline can not be acquired in courses where several disciplines are taught together. However, [Cunningham 2008] and [Case and Cunningham 2009] formalize what many graphics educators already do: teaching computer graphics or visualization “in context”. Using a context (one or several application areas) might further motivate computer science students in learning rendering techniques and make the collaboration to students of these application areas very fruitful. Hence, computer science students need not loose depth over a productive collaboration with students of other disciplines. Students of other disciplines will obtain (breadth) knowledge on graphics technology, and it seems there is plenty of interest for that [Rushmeier 2006].

An example of my own work over visualization problems may be used to back up the need to closely collaborate with other disciplines over visualization problems: In 1980s I worked with NASA experts for about six years. While I was a computer science graduate, my NASA colleagues came from the geosciences, mainly geography, geology and geodesy. We supported our analysis of air- and spaceborne radar data of planet Earth with digital elevation models (DEMs). Data were visually enhanced via color and visual context, such as color scales, direction arrows, distance bars. Depicting DEMs, I often used a color mapping code of blue-cyan-green-yellow-red-white to visualize increasing heights (the white was a synonym for snow-covered peaks of high mountains). Toward the end of the '80s I started to work with astrophysicists, where I used, among other visual attributes, again color to depict (in this case) emission. It took three months of working with astrophysicists, until one scientist exclaimed “You are using the wrong color codes - because yellow is *higher* than red!” Even the constant reminder of the color scale on the side of each picture had not prevented the scientists to see “their” color mapping of “red – yellow – white” for increasing emission values. In my visualization courses I now make sure students learn about the discipline dependent “hue ranking”, assigning hues to an increasing scale. What I teach students is not so much the meaning of hues, but rather that computer scientists know little of how other disciplines interpret visual clues unless they try to find out. Another interesting fact to learn was that interpolation of data does not always mean linear interpolation – as expected by computer scientists – but might be

¹ The five non-technical students are media science and literature students.

a black body curve in appropriate cases. And while computer science students learned in their graphics courses the efficient shading by Gouraud, and tend to use it in over 90% of all shadings, a student of archaeology might rightly ask to have the visual representation of their data verified (“Why should I trust your picture of my data”, reported by A. Chalmers in [Domik et al. 2008]) – leaving the computer scientist with a novel way of thinking of their algorithms. In unidisciplinary visualization courses computer science students do not get imposed to a real-world attitude of data-owners.

Computer science students often complain to be held as “code slaves” in interdisciplinary projects. They feel that their programming is seen as labour to be done without resourceful input. Surprisingly, they might learn from artists that *they* often feel like “art slaves”, designing an appropriate color code that computer scientists take credit for when filling in the appropriate OpenGL code. An experienced educator will be able to use these misunderstandings to set both groups straight on the background knowledge and abilities computer scientists need for effective graphics programming and artists need to suggest expressive color coding.

Many classical examples of interdisciplinary, collaborative visualizations exist, probably best known from the past is [Cox 1988] with her Renaissance Teams.

2. The Meaning of “Interdisciplinary Collaboration” in a Class Room

2.1 Multidisciplinary – Interdisciplinarity – Transdisciplinarity

Interdisciplinary collaboration is a group process between individuals trained in different disciplines, e.g. astrophysicists, computer scientists, biologists, designers. Educators often do not distinguish between the terms multidisciplinary, interdisciplinarity and transdisciplinarity, though these teaching modes are well defined and distinguished by [Klein 2006], [Rosenfield 1992] and [Nicolescu 1999]. There is no sharp distinction between those terms, but rather a continuum rising above unidisciplinarity that describes the collaboration between educators, experts and students. In short, *multidisciplinary* means that several disciplines are being involved either in a sequential or juxtaposed mode; *interdisciplinarity* implies integration or blending of knowledge from different disciplines, while *transdisciplinarity* places the highest demand, namely forming new knowledge from available unidisciplinary awareness.

We can see that interdisciplinarity is sandwiched between multidisciplinary and transdisciplinarity. It places higher demands on educators and students than multidisciplinary but lower demands than transdisciplinarity. To give a practical example of this, let us assume a visualization course hosting computer science, physics, astrophysics and math students. In a multidisciplinary course, each student might have a series of assignments to submit and/or present. No mandatory collaboration takes place, though students, on their own, might observe dissimilar approaches by different disciplines. In an interdisciplinary course, students will form interdisciplinary

groups to solve assignments and/or work on projects. They will need to collaborate with members of other disciplines and expand their knowledge in breadth (into other disciplines) and depth (in their own discipline). They will present their best solutions to the class and will reflect on the benefits and struggles of their interdisciplinary collaboration. In a transdisciplinary course, collaboration will be longer and more intensive: during and after project presentations the students together with their advisors will discuss knowledge gained during the course that will now expand knowledge of their own discipline and how it might be used to solve further problems. Transdisciplinarity will therefore require access to educators or experts for each discipline involved. Being the sole educator in my visualization course (I am a computer scientist) I can only aim for interdisciplinarity in my courses, not for transdisciplinarity.

2.2 Collaboration

After explaining the use of the term “interdisciplinary”, it is now time to look at “collaboration”. A good reference is [Stokols 2006], who observes *transdisciplinary scientific collaboration*. Stokols finds circumstances that facilitate transdisciplinary collaboration:

- members` strong commitment to achieving transdisciplinary goals and outcomes
- interpersonal skills of team leaders
- history of prior collaboration among team members
- spatial proximity of team members` offices and laboratories
- schedule frequent face-to-face meetings for brain-storming of ideas
- establish electronic linkages among participants
- foster institutional supports for transdisciplinary collaboration

and factors that constrain transdisciplinary collaboration:

- substantial time required to establish common conceptual ground and informal social ties
- unrealistic expectations and ambiguity about shared goals and products
- conflicts among alternative disciplinary views of science
- bureaucratic impediments to cross-departmental collaboration.

Though Stokols` research is on *transdisciplinary scientific collaboration*, [DiGiano et al. 2008] describe in a well documented education experiment very similar obstacles in *interdisciplinary education* (between biology and computer science students). Similar to [DiGiano et al. 2008] I am transferring Stokols observations on *transdisciplinary scientific collaboration* to the *interdisciplinary collaboration* in my university course.

3. Background on the Visualization Course

The University of Paderborn has 14.000 students and is divided into five faculties. My current visualization course has 48 participants: 29 computer science students (Faculty of Computer Science, Mathematics and Electrical Engineering), 14 business information systems students (Faculty of Business Administration and Economics), 5 non-technical students (media science students and literature students – all from the Faculty of Arts and Humanities). Students from different faculties typically do not know each other on a private level. All students are at the Master level. The title of the course, of which I am reporting here, is “Data and Information Visualization”, and includes 90 minutes of lecture and 45 minutes of lab time per week over a course of 15 weeks. Students receive 4 ECTS² for the course, which translates to an expected effort of 100-120 hours on the student’s side. Lab time is being used to create visualizations or visualization concepts; the assignments over the first three weeks had to be completed individually and submitted to the educator. Assignment four through ten is submitted by each project group.

While the project work in this course is still ongoing, the group selection process was finished weeks ago and work experience in project teams could be observed in the meetings and in the minutes of the meetings.

4. Supporting Students in Finding Project Partners for Interdisciplinary Collaboration

One major obstacle in interdisciplinary courses is that of building project teams over the first week of a course, while students of different disciplines are still unfamiliar with each other.

Based on

- Stokol’s claims on transdisciplinary scientific collaboration (section 2.2),
- Fischer’s work on transdisciplinary and Long-Tail education [Derry and Fischer, 2005; Fischer 2005; Fischer 2007],
- experiences from previous courses with students from multiple disciplines (of which I reported in [Domik and Goetz 2006] and [Domik et al. 2008])

a strategy was developed for supporting students in forming interdisciplinary teams that were both technically and conceptually strong. This strategy contained:

1. students get the opportunity to find out about private interests of other students;
2. each project group is required to include students of as many disciplines as possible;
3. students learn a “common language” suitable for all disciplines that they can use to define the goals of their project, discuss characteristics of data, aims and tasks of users, and quality criteria for good visual representations;
4. weekly meetings of project teams are enforced, but also supported.

Detailed explanations on how this strategy was implemented follows next.

4.1 Students Find Out About Private Interests of Other Students

Inspired by discussions on “Long-Tail Education”, e.g. [Fischer, 2007; but see also Acknowledgement] I wanted the students to get to know each other on a private level before committing to join a project group. Here is a very short elaboration on Long-Tail education, necessary to understand the following procedure used in my course:

The basic idea of the Long-Tail in the distribution of product sales is described in the book “The Long Tail” [Anderson 2006]. The long tail is the shallow end of a distribution that starts out with a high population in the origin (“head” of distribution). If storage space is limited, a business will only keep products that relate to the head of their sales distribution in store. If storage space is (almost) unlimited – e.g. with digital products – the long tail of sales distribution can contribute in a large amount to the sales of the business. Long-Tail education is a strategy of teaching promoted in [Fischer 2007] for higher education to aid the collaboration process by *passion*. In the case of a visualization course with interdisciplinary collaboration, the head of the knowledge distribution is basic knowledge on visualization methodology and technology to be taught by the educator. Passions and hobbies of course participants make up the Long-Tail of the knowledge distribution in the course. If we therefore support students to find common passions within interdisciplinary groups, there will be enough intrinsic motivation to find commonalities and make an extra effort to understand each other. The desire to collaborate for success on the project will strengthen the group process.

In order to find common passions, students needed to get to know each other. In the months before the start of the visualization course, I joined several social websites hoping to find one to support the exchange of private information between students. However, none of the major social websites suited my idea of a private exchange. As a consequence I asked each student (in the second assignment of the visualization course) to fill out a form of private questions. If a question appeared too private, students were allowed to skip it. It was also made clear that not handing in this assignment would not lead to a lesser grade, but would be an obstacle for others to find out about personal traits of this person. The questionnaire contained questions such as “Memberships in clubs or associations”, “degree program”, “favourite films/books”, “former high school”, or “my abilities for the project group”. We also asked for 1-2 pictures of each person and their first name. We created a PDF file of all the answers and made this document available on the web (password secured) for one week. Though I expected some reservations on the student’s side, this process was accepted almost unanimously. Every one of 48 students submitted this private profile.

4.2 Each Project Group is Interdisciplinary

It was made clear to the students that each project group would contain more than one discipline. As there were only five non-technical students, not each group would have members of all three different disciplines. In Assignment 3 (after discussing data,

² European Credit Transfer and Accumulation System

data models, data characteristics in the previous lecture), each student submitted a complex data set they desired to visualize. In a group effort between all tutors, we decided on seven data sets that were representative of the 48 data sets we had received. “Owners” of these data sets were notified that they should look again through the private information of their class mates because they would be allowed to start the project group selection process. During the next lecture, each of the seven data set “owners” presented their data set, their visualization goals for that data set, and selected one person of the remaining students (who did not belong to his/her own disciplines) into their project team. One by one the group was allowed to select among the remaining course members. Students sometimes declined their selection, if they wanted to be picked by another group. Such a declination was accepted, as the goal was to form groups that liked to work together and on a common visualization goal.

4.3 Students Learn a “Common Language”

Using a Breath-First technique for teaching visualization, as reported in [Domik and Goetz 2006], the concepts of visualization (e.g. issues of data; user and task; mapping from data to visual attributes; interactivity) were taught on a breadth level that students of all disciplines can comprehend. This helped to remove misunderstandings in the communication: e.g. while an “effective” animation might mean “real-time” for a computer scientist it might mean “aesthetic” to a student of the arts department. However, “effectiveness” for visualization has been well defined by [Mackinlay 1986] to mean that one visualization is more effective than another visualization if the information conveyed by one visualization is more readily *perceived* than the information in the other visualization. Therefore, within the first lectures, students learn a language to discuss their later project work in universal terms.

4.4 Support Communication in Teams

After project teams had been formed, future assignments (weekly) had to be submitted as a group. These assignments are in essence the meeting minutes of the group. To help students in starting up the communication process in their group, the assignment for the first meeting included a brainstorming session on the group project. This brainstorming session was a guided role play that made sure that each of the students had a communicative role in the discussion process. This assignment intended to dampen unrealistic expectations of team members, let everyone voice their understanding of the joint project and voice their concerns. Later assignments included time tables of the project work, the role of each group member in the project, conceptual data models, etc. The minutes of each meeting end with “action items” for each project member, and the place and time for the next meeting. I participate in the meetings from time to time and can therefore observe the groups working and discussing and can see the projects grow.

The following chapter offers a quantitative assessment of the situation.

5. A Survey of Students Participating in the Interdisciplinary Visualization Course

A voluntary assessment of students reveals more closely their interest and assessment of interdisciplinary work. Of 48 students, 30 students returned the survey: 18 computer science students (of a total of 29 computer science students); 9 business information systems students (of a total of 14 business information systems students); and 3 non-technical students (two media science students and one literature student). This seems like a representative return to my full course (as described in section 3) and I rather valued the voluntary act than a forced complete survey of all course members. The percentage is rounded off to integers, but when more precision was needed one digit after the decimal point was used.

5.1 General Questions about Interdisciplinary Course Work

The following questions concerned the participation of interdisciplinary courses.

Question: “Have you participated in interdisciplinary courses at our university in the past?”

Answers: 10 students (33%) had already participated in interdisciplinary courses, 20 students (67%) had not. Looking closer at *who* had experience with interdisciplinarity, we could see that only 4 (22% of) computer science students, but 5 (56% of) business information systems students had this experience. See Figure 1.

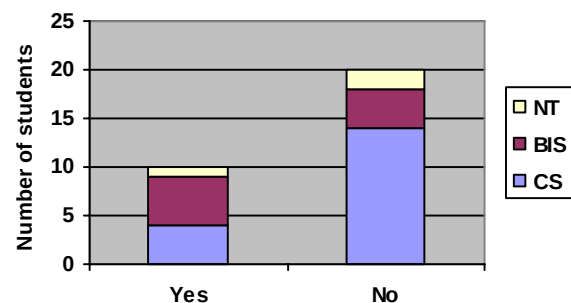


Figure 1: Answer to the question: “Have you participated in interdisciplinary courses at our university in the past?” (Number of students out of a total of 18 computer science (CS) students, 9 business information systems (BIS) students, and 3 non-technical (NT) students).

Question: “In your later job, would you rather work with interdisciplinary teams or with experts of your own discipline?”

Answers: 90% of all students later rather work on interdisciplinary teams. Of the 10% of students who marked the desire of working only within their own discipline, all of them belonged to computer science. Please note that this choice might not reflect the social competence of students so much as the typical job description of their discipline, as known to students. See Figure 2.

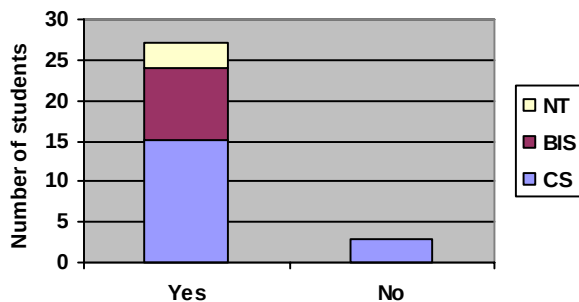


Figure 2: Answer to the question: “Would you rather work with interdisciplinary teams or with experts of your own discipline?” (Number of students out of a total of 18 computer science (CS) students, 9 business information systems (BIS) students, and 3 non-technical (NT) students).

It is interesting to note that 90 % of these students preferred interdisciplinary work in their later jobs, though two thirds of these students had as of yet no experience working on an interdisciplinary team. Students were at a Master level, therefore having spent a number of years already at the university.

Question: “For team work over the course of 8 weeks (as in our course project) what do you want to know about a person before asking them on your team? Please choose only one out of
 (a) private information about this person
 (b) the abilities this person brings to the project
 (c) strong interest on the team project
 (d) (none of the above; describe attributes you think are important).”

Answers: 3 students (10%) named “private information”, 16 students (53.3%) marked “abilities”, 4 students (13.3%) marked “project interest”, and 7 students (23.3%) their own attributes, usually a combination of above choices. See Figure 3.

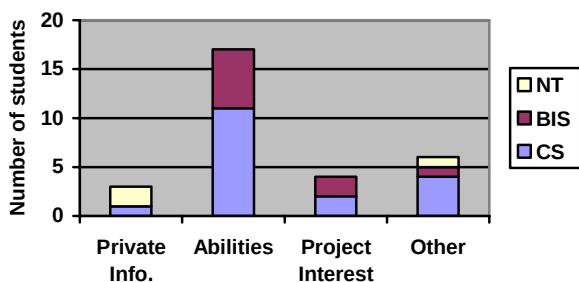


Figure 3: Answer to the question: “What do you want to know about a person before asking them on your team?” (Number of students out of a total of 18 computer science (CS) students, 9 business information systems (BIS) students, and 3 non-technical (NT) students).

5.2 Specific Questions about the Visualization Course

Question: “The “Common Ground” marks the commonalities of an interdisciplinary group. How do you find a common ground with others of your group?”

- (a) I find the common ground over the common language we learn in the lectures of the course.
- (b) I find the common ground over the data we want to visualize in the group.
- (c) I am looking for a private connection to other team members.
- (d) (none of the above; describe attributes you think are important).”

Answers: 4 students (13.3%) chose the “common language”, 7 students (23.3%) chose “data”, 12 students (40%) chose “private connection” and 7 (23.3%) chose their own attributes – usually a combination of choices above. See Figure 4.

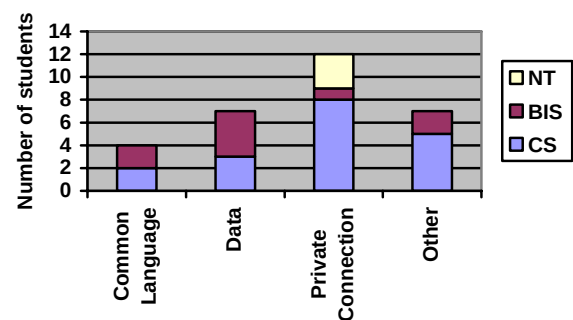


Figure 4: Answer to the question: “How do you find a common ground with others of your group?” (Number of students out of a total of 18 computer science (CS) students, 9 business information systems (BIS) students, and 3 non-technical (NT) students).

Question: “How many face-to-face meetings per week are necessary to further team work in your project group” were answered to almost a hundred percent by “1-2 meetings per week”.

Answers to the

Question: “How do you communicate between meetings?”

and

Question: “What electronic communication linkage would be ideal for your group communication?”

were answered almost identically: Email, ICQ, mobile phones, Skype were used in many groups; Wikis and SVN (a version control system) was still desired by some, but also already implemented in several other groups. An electronics calendar was the only item that could only be found on one “ideal” list but had not been implemented yet. So it seems that used electronic linkage matches ideal conditions in most cases for our students.

Question: “Have you used the private information of other students made available to you (Assignment 2) to familiarize yourself with your course mates?”

Answers: 20 students (67%) did check out private information about other students, 10 (33%) did not. A closer look at *who* was interested in private information of other students reveals 7 students of business information systems (78% of BIS students) and 10 computer science students (56% of CS students) and all three NT students. See Figure 5.

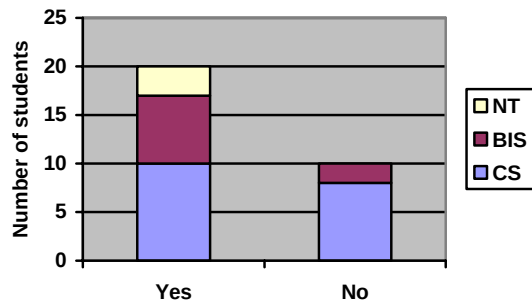


Figure 5: Answer to the question: “Have you used the private information of other students?” (Number of students out of a total of 18 computer science (CS) students, 9 business information systems (BIS) students, and 3 non-technical (NT) students).

6. Summary

A visualization course with approximately 50 Master students of three different faculties is being described and assessed for their interdisciplinary collaboration. All project groups of the course were interdisciplinary. Students received support in getting to know each other before team selection, in establishing a common ground for project discussions and in meeting frequently as a group. A survey revealed that two thirds of the students had never experienced interdisciplinary team work before, though 90% wished to work in an interdisciplinary team later. Many students look for a private connection with other students to find a “common ground” for project work; two thirds of students looked up private information on other students that was made available to them. Somewhat surprising was also the positive answer to electronic linkage used for communication within project groups. Most groups established a linkage consisting of Email, Skype, Mobile phone and (even) Wiki or SVN within the first two weeks and found this satisfactory for their work.

7. Acknowledgement

Many thanks to the members of the Center for LifeLong Learning & Design at the University of Colorado at Boulder for providing me with background information and inspiring debates on transdisciplinary and interdisciplinary education. Especially discussions with Professor Gerhard Fischer, director of the Center, during my semi-sabbatical in 2007/2008 and my summer stay in 2008 led to valuable input used for this paper.

And special thanks to Ingrid and Steffi Fischer, who – again – supported my family life during my research stay so I was able to keep some of my mind on the interesting work.

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