Student Teams in Search of Design Thinking

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Abstract The research explored student teams as they worked independently of instructors and coaches to understand how students learn the design thinking process. Two approaches to the research were explored: taking cues from team members' reflections on their working sessions; and, analyzing communication bids made by students using interaction analysis techniques. Teams from two design thinking classes at the Hasso Plattner Institute of Design (d.school) at Stanford were studied. Results indicate that groups struggled for sustained and focused talk and activity relating to their assigned tasks, yet ultimately, established ways to communicate and accomplish assigned tasks. The findings implicate course design, suggesting more attention to team process and communication.

1 Introduction and Background

The movement to teach design thinking in universities is in full swing. A quick search reveals that, in over 60 universities and colleges, design thinking is taught as workshops, supplemental training, courses, or degree programs. These programs are in addition to the teaching of design as part of engineering, architecture, and art programs. The growing enthusiasm for teaching and learning design thinking raises questions about how this complex set of ideas, processes and concepts can best be taught. The field needs a better understanding of what happens in existing courses in order to improve both teaching and learning.

Design thinking is complex. It is about concepts, processes and the development of dispositions that guide thought and actions in innovative problem solving. This complexity poses several dilemmas for course-based design education. What can be

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taught and what do we expect students to learn when we teach them design thinking? If the aim is to teach design thinking concepts, processes, practices, and dispositions, how do we set goals for what we expect students to learn, and how do we understand or assess their learning experiences? Should instruction focus on individual or team experiences?

Rittel and Webber (1973) used the term "wicked" to describe design problems. Cross (2006) extends that view to design thinking instruction, considering it as problematic as design is itself:

> It is also now widely recognized that design problems are ill-defined, ill-structured, or 'wicked' (Rittel and Webber 1973). They are not the same as the 'puzzles' that scientists, mathematicians and other scholars set themselves. They are not problems for which all the necessary information is, or ever can be, available to the problem-solver. They are therefore not susceptible to exhaustive analysis, and there can never be a guarantee that 'correct' solutions can be found for them. In this context a solution-focused strategy is clearly preferable to a problem-focused one: it will always be possible to go on analyzing 'the problem', but the designer's task is to produce 'the solution'.

In design thinking classes, instructors are trying to teach the components and process of design thinking, and also teach about the end game—transformations in the way the newly minted design thinkers think, act and intuit as they design novel and innovative solutions to problems. These ultimate educational aims set a high bar with observable and documentable outcomes, *and* with more subtle changes that are difficult to anticipate, define and document. von Thienen et al. (2012) liken the process of a group learning design thinking to engaging in group therapy and suggest that some of the processes, dynamics, and outcomes are comparable. Teaching and learning design thinking is a complex enterprise.

In teaching design thinking, courses aim to provide students with group learning experiences such as "radical collaborations," interdisciplinary experiences, and learning from deep exchanges with peers. Generally we teach students how to do design thinking and how to do it in teams. Instructors hope students have a productive team learning experience and, as such, rely on student teams to be proficient enough to carry the students through the process and projects that are assigned. The team process and practice is one of the sticky problems of design thinking education because courses are situated in educational systems that have emphasized and rewarded individual learning and achievement. It is not surprising then, that the team experience is in conflict with the individual achievement imperative, further complicating how we teach design thinking. Creating an effective and successful team learning experience is a sticky *wicked* problem.

As design thinking instructors and researchers, we aim to better understand the team learning experience and to find ways to better support it. When we began this research, we thought we would learn how to assess team learning in a design thinking course; when we finished, we learned that the teaching process might better address the student team experience. We were especially focused on the experience of groups during their out-of-classroom-time experiences, so we were able to capture how teams worked through the design process independent of their course instructors or coaches. The research taught us about how teams handle the

design thinking process as they are learning and enacting it. If class time was when students were introduced to design thinking processes and mindsets, team meetings were times to fulfill assignment tasks in practice and production runs. They were also the times when important components of design processes and solutions – point of view statements, brainstorming, and design solutions – were experienced and negotiated.

We set out to assess team learning by starting with the basics and examining what the student teams were doing and how they were interacting. Previous studies were of interest. Kress and Schar (2012) examined cognitive differences among group members, and Brereton and colleagues (1996) determined that team interaction affected design outcomes.

Conflicts among group members seem endemic in teamwork and surfaced in this study. From prior research we know that a sense of belonging and togetherness, and sharing joint goals are important to design group's abilities to apply itself to its class projects successfully (Mercier et al. 2009). Teams worked best at enacting and representing what they were learning when individual members could not accomplish the tasks alone. Divide and conquer did not work best on design teams. Katu contends that, "Harmonizing is about emphasizing differences together" (Katu 2012, p. 18), suggesting that the best functioning teams succeed at keeping the team together despite members' differences. In his account, the effective and successful team members share passion, common goals, and commitment to excellence.

We examined student teams using methods enabling us to capture and take an ethnocentric view. Specifically, we followed two teams, from two courses, as they met outside of class to work on their class-assigned projects. Each group had 2–3 weeks to work on their own.

Together, the two groups show a process of students becoming introduced to design thinking and working to become acceptably proficient at it. Our results indicate that teams did not necessarily stick to the tasks that corresponded to their immediate assignments or their current stage in the design process. For example, a team with the object of prototyping, often drifted back and forth to earlier and later stages of the process.

We decided to focus on student teams in their independent work outside of the classroom. We acknowledge the facilitator role instructors play in design teams. As instructors attempt to create environments where teams can accomplish their independent work and achieve success, they are the supporting cast to the design thinking team ensemble. This study focused instead on students and their emergent roles in this ensemble. Both teams accomplished moments of unease and eventual alignment, illuminating the dynamic nature of teams in collaboration. This research on student teams' collaborative experiences provides a more nuanced view of how we might design more effective courses, and seeks to answer several questions: What is the nature of team collaboration for new design thinkers? How does what we learn about student teams implicate how design thinking might be taught?

2 Research Methods and Analysis

As researchers of design thinking and team learning, we were guided by social views of learning and a theoretical rationale that is based in socio-cognitive views of learning. Vygotsky (1976 [1934]) described how opportunities to interact with others in a social environment are essential to learning. The human-centered focus of design thinking and the deep and radical collaborations that define the process provide a deeply social process for learning. Design thinking is an approach to learning that encompasses active problem solving by engaging with (Dewey 1916), and changing, the world. These perspectives lend themselves to analyses of team interactions.

Qualitative approaches and methods guided our data collection and analysis. Our exploratory studies took a student-centered, emic approach and were conducted with students who were in Stanford design thinking courses. We studied teams of students who were enrolled in two of Stanford's Hasso Plattner Institute of Design (d.school) classes: *Design Thinking Bootcamp* and *Innovations in Education*.

Our goal was to gain understanding of student teams as they engaged in design thinking work. Our focus was on how teams who were learning design thinking moved beyond the in-class collaborations to new, and possibly, shared conceptual spaces. Our general frame of interest included the nature of group process, catalyst events, cohesion and affirmation, and group dissension. We wanted to study teams as they engaged in the practices and processes of design thinking to understand how they put their classroom learning into practice. Our goal was to do that as naturally as possible, to minimize our researcher intrusion into the team, and to work from the perspectives of the team members to guide our analyses.

The data collection process was comprised of three main data sources. The first data source was videotapes of team meetings made by the group members setting up a stationery camera and letting it run throughout their sessions. The second data sources were "confessionals" by team members called in to a telephone number after their team meetings, and emails among the group that were shared with the research team. The third source were post-project interviews completed with students as an option if they did not want to make "confessional" calls by telephone.

We had several reasons for creating this research design. First, we were interested in seeing things from different participants' perspectives to understand the significance of what the team members saw as key events. We felt this would help us gain more grounded perspectives on a collaborative effort. Second, we felt that it would provide a sense of privacy for the students. Instead of the research team asking questions, students had an opportunity to reflect and respond at their own pace and in their own words. The third reason was that we thought we would be able to quickly follow up with relevant questions based on the students' responses. And fourth, we used the student reflections to point us to events or instances they thought were significant, providing us with directives for where a truly student-oriented analysis might be focused.

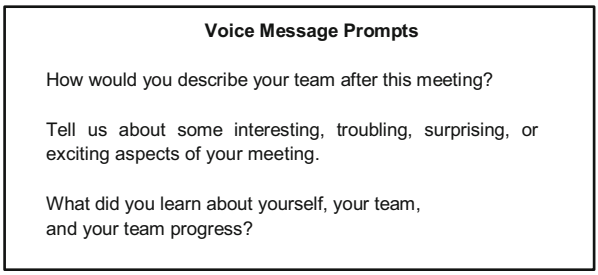


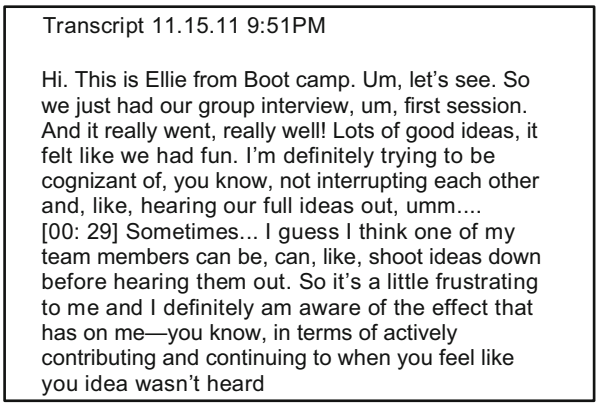
Fig. 1 The telephone voice prompts

The "confessional" data was extremely relevant, and we privileged it in selecting data for deeper analysis. The voice messages turned out to be a productive data source as they revealed meanings students were attaching to the experiences they had with their teams. After each session, individual group members called a Google Voice number and responded to a set of prompts (Fig. 1). The three prompts were designed to keep reflections broad while helping students organize their thoughts. The phone messages were recorded as digital audio files and auto-transcribed with Google Voice software. We retrieved the files and manually corrected any mistakes in the transcripts. Excerpts from transcripts of confessionals (see Figs. 2 and 3) show the kind of reflections that were shared, including reporting on the context for the meetings, conflict that arose, personal reactions to events, and frustration and excitement.

Megan and Ellie's phone responses (Figs. 2 and 3) were made after the same team meeting. Both were members of Team One and point to a moment of conflict between teammates at one particular meeting. Together, these responses provided a focal point for our video analysis. In general, Team One appeared to have unresolved frustrations that members aired in their voice messages. Their process of working through team issues resembled "confessionals" in which the inner workings of the team were revealed to outsiders. (Recall how confessionals are overlayed on video footage in documentaries and reality television shows). These monologues, although external to the team collaborative process, revealed the more internal functions and dysfunction of the team that teachers and coaches might not readily have access to. We wanted to investigate how these moments of conflict had arisen and how, if at all, teammates had worked together to resolve it. We believed this kind of analysis would also indicate elements of individual behavior during team collaboration that foster synergy or disruption.

Team One had more moments of conflict in their team meetings, yet they bigger risks and pushed their prototypes beyond the boundaries perceived by individual members. Unlike the confessional feel of Team One's communication with the research team, Team Two's reflections were more spirited. In Fig. 4, we excerpt some comments from Nora that illustrate how team spirit was built and maintained primarily through email exchange.

While the team members' comments portrayed a vibrantly positive team spirit, they were also often irresolute, with members expressing how well things went but being a little less certain they'd accurately perceived and characterized their team's


Transcript 11.15.11 9:51PM

Hi. This is Ellie from Boot camp. Um, let's see. So we just had our group interview, um, first session. And it really went, really well! Lots of good ideas, it felt like we had fun. I'm definitely trying to be cognizant of, you know, not interrupting each other and, like, hearing our full ideas out, umm....
[00: 29] Sometimes... I guess I think one of my team members can be, can, like, shoot ideas down before hearing them out. So it's a little frustrating to me and I definitely am aware of the effect that has on me—you know, in terms of actively contributing and continuing to when you feel like you idea wasn't heard

Fig. 2 Excerpts from transcript of an exemplary student phone response

performance. They had nothing to confess. In other words, members talked about enjoying the process and their team while having no sense of whether or not their teammates might agree. Team Two shared very extensive email exchanges with the research team. While both teams struggled to schedule times to meet, Team Two split up tasks as indicated in the email exchange in Fig. 5.

When asked about her views on perfectionism during her exit interview, Nora described the internal shift she had to make to adjust to her teammates' outlook on the design work at hand:

> So I definitely sort of let go between DP1 [Design Project 1] and DP2 [Design Project 2]. Like in DP1 I was highly perfectionist and kind of freaking out and frustrated and
>
> Just being like (to DP1 team members), 'You guys, we have to have a perfect final product.' And our final presentation wasn't perfect. There was just a lot of frustration or just lack – just total lack of communication. It was just so frustrating because I had invested all of this energy and then the output wasn't what I would have wanted it to be. So how I dealt with that going into DP2, I think, was putting less of myself into it so I had a lot less to lose. But not in a way that I completely divorced myself from this process, but sort of in a way that like, 'I'm going to be more balanced in my approach to this, and rely on my team members and if they don't do things the way that I would want to do it then that's okay.' You know, so striving for my own version of perfectionism less.

During this exchange, Nora, explains her team's interpretation of "embracing" design thinking as learning to let go of perfectionism, but misrepresents the potential gains inherent in a more critical approach to her teammates contributions. This meant that, a large part of their work was done individually with teammates later reviewing each other's progress and offering revisions. This approach to collaboration presented fewer opportunities for teammates to challenge each other, and influenced their team meetings (where all members were present) accordingly.

One important difference between the teams was the stage of the design process captured in the videos we analyzed. Recall that with Team One, we zeroed in on a moment of crisis indicated by a team member. In Team Two, we looked for a

Transcript 11.16.11 5:41 PM

Hi, this Megan from Team One. So we had a meeting earlier today with all of us, and we were going to do a prototyping session which I thought ended up pretty successful. We kinda didn't have all that much time so we really got to it and stayed focused.

[00: 27] One thing that I, ugh, thought was interesting was that, at one point, two of my other team members kind of had a disagreement about the approach of one of the prototypes and got into a little exchange – not heated by any means, but kind of expressing their different points of view. And I actually really appreciated it because, um because I feel like I'm usually one of the more expressive and vocal members of any of the teams that I am on. And, so it was nice to kinda not be in that and to be an observer and to not feel, like, particularly strongly either way about the issue, which was different for me. And I think, I think a lot of times when I'm in a team setting, I try to pay attention to, like, how I can tone down—like, if I have a strong point of view—how I can tone it down and I just thought that it was interesting for me to kind of just be an observer in that situation.

[01.50] One thing that I feel like...I feel like our team's doing really well and we're together, we have productive meetings. Something that I think has been like a little bit challenging has been coordinating schedules and also, like, not everybody being every meeting… the ideal would be obviously, if all of us were there at the same time. And I just think that like a significant amount of time is rehashing and getting everyone on the same page. Another observation. Umm...

Fig. 3 Sample transcript from a student phone response

similar moment of crisis and its subsequent resolution. Understandably, the team meetings we chose for our analysis had disparate design agenda and team imperatives. Team One's meeting was closer to the beginning of the design process, with members struggling over the transition from empathy work to defining a Point of View statement (POV). The conversation and activity in this meeting occasionally drifted to other stages in the process (for example, George brings up a POV that has good implications for a future prototype), and involved very little explicit

Fig. 4 Excerpt from student exit interview

Nora Smith(NS): Yeah, so if you couldn't contribute to one part that was fine, but then you made up for it later so… And I think everyone walked away from the project…my sense is that everyone walked away from the project feeling pretty good about what they had contributed and what everyone else contributed. And it was like a pretty positive team dynamic in general. Like we would send around emails…I would send something out saying (smiling and miming typing), "I'm going to do this." And Steve would respond (miming typing), "Way to go, Nora!" And it was very, like, "Go Team!"

And that really came from everyone, where we all sort of had a good team spirit—for the most part—moving through the project. That is good, that positive reinforcement: making other people feel really good about what they are doing, that worked out pretty nicely.

ZK (researcher): Did that come up organically because of the personalities or was there some sort of…norms that were set up in the beginning

NS: It was kind of weird. I think Steve actually was the one who initiated all the, "Way to go!" (laughing fondly) and the "Go us!"

ZK: How did it make you feel the first time he did it?

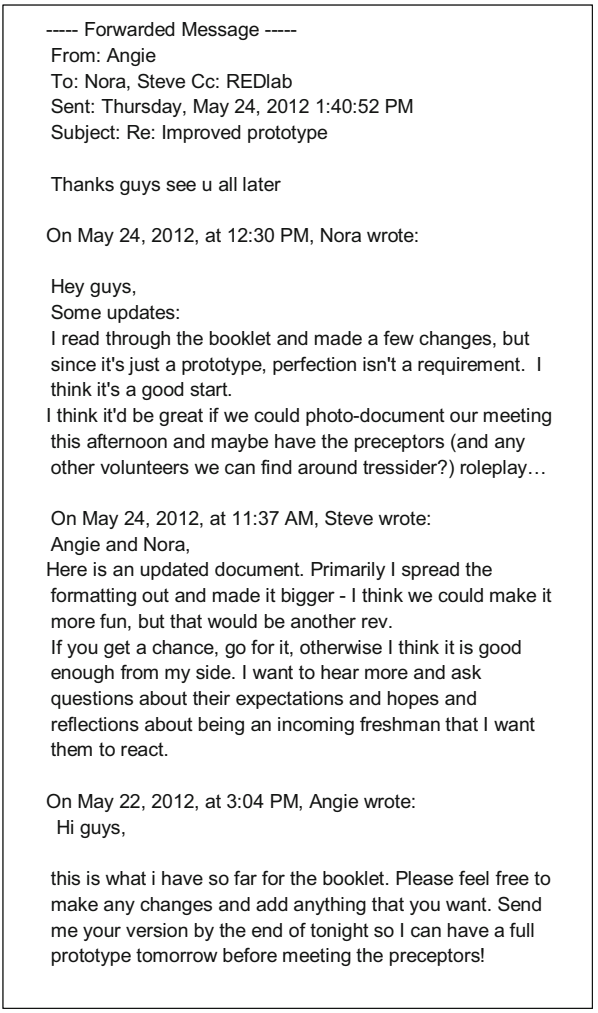
NS: It was great! It was also really unexpected because I also worked with him in DP1 [Design Project 1]. DP1 was just a very different project. We… it was me and Steve and Jane [another member of the class], and we kind of had our own… we had a lot of frustration with that process and project. And I think me, Steve and Angie…or Steve, Angie and *I* worked better together than Steve, Jane and I did. So having worked with Steve already and not having had that positive, [said enthusiastically] "Yeah! Way to go!" like that sort of attitude.

So the first time he did it I was like [laughing], "Where is this coming from?"

ZK [laughing]: …"Who is this person?"

NS: Yeah…"Who *are* you?" And you know, I thought maybe he was just having a particularly good day and wanted to send out a good email. But then it sort of…Angie and I started to pick up on that a little bit and it sort of became this *thing*, that in our email exchanges…we'd sign it like, "Go Team!" or whatever. [Laughter]

Or just be like, "Nice work guys, I think we really came together well on this one." Just nice things like that. And when you have a team dynamic like that…and I think it's a little chicken-and-egg-y, like maybe you have a good team dynamic and inspires comments like that or maybe you have comments like that and that inspires a good team dynamic. In this sense, we did start with a good team dynamic and good individual contributions that inspired us to send around positively reinforcing comments. Not necessarily that the positively reinforcing comments inspired the good individual contributions.



----- Forwarded Message -----
From: Angie
To: Nora, Steve Cc: REDlab
Sent: Thursday, May 24, 2012 1:40:52 PM
Subject: Re: Improved prototype

Thanks guys see u all later

On May 24, 2012, at 12:30 PM, Nora wrote:

Hey guys,
Some updates:
I read through the booklet and made a few changes, but since it's just a prototype, perfection isn't a requirement. I think it's a good start.
I think it'd be great if we could photo-document our meeting this afternoon and maybe have the preceptors (and any other volunteers we can find around tressider?) roleplay…

On May 24, 2012, at 11:37 AM, Steve wrote:
Angie and Nora,
Here is an updated document. Primarily I spread the formatting out and made it bigger - I think we could make it more fun, but that would be another rev.
If you get a chance, go for it, otherwise I think it is good enough from my side. I want to hear more and ask questions about their expectations and hopes and reflections about being an incoming freshman that I want them to react.

On May 22, 2012, at 3:04 PM, Angie wrote:
Hi guys,

this is what i have so far for the booklet. Please feel free to make any changes and add anything that you want. Send me your version by the end of tonight so I can have a full prototype tomorrow before meeting the preceptors!

Fig. 5 Sample email exchange between team members

discussion of team collaborative processes and no talk at all of logistics. In contrast, the primary objective of Team Two's meeting was to more clearly articulate their prototype and a considerable amount of team talk and activity was dedicated to team collaborative process and logistics, with team members dividing up tasks to be completed and even performing these in the meeting. Angie, who was in charge of editing the team's presentation, the final deliverable for the class, often brought the conversation back to how they could capture the design process and document their insights.

3 Analysis

With the videos, confessionals and interviews completed, analyses were conducted to make use of the student provided information and directives. Analyses started with open coding of the confessionals and interviews. We triangulated across data sources, finding instances on the video that were reported in voice messages, emails, or interviews. The research team watched video segments and chose one from each team for analysis. The selection process involved trying "see" the issues students described for us and identifying a beginning and an end to the respective events to which they referred. Once segments of the group in a topical event were identified, we created a content log that described what happened throughout.

The preliminary analyses and the emphasis on team interactions led us to look at how the groups attended to and accomplished their interactions. Since we were already rooted in the idea that talk and action were some of the building blocks of group work and learning, it made sense for us to look at the task the group was working on, the movements they made in talk and related actions, and how and when their interactions were relevant to the design thinking process they were learning. We concentrated our analyses on when "bids" were made in the group and how they were received and acted on. Bids are a struggle for control, attention, or for the right to speak within a group (Schegloff 1998, 2007). We considered bids to be requests/imperatives for action, type of work, adherence to process, and attention to relevant or irrelevant topics. They were requests for action from the team members, and we expanded the definition to include both verbal and non-verbal requests. A bid was as simple as requesting a turn to talk or building on another's idea, or as complex as entering a new topic into the conversation or suggesting the design solution to the challenge. Because bids were invitations or requests for interaction, we looked at bids offered by the students and subsequent responses. When we began watching the first group, we realized that the students were having a difficult time staying with their task to develop a POV and appeared to be all over the process map, pulling anything they knew with respect to design thinking into their activity. We decided to analyze the students in terms of their talk, focus, and action, the topics they were taking up, and the design thinking skills or processes they were invoking in the moment.

4 Coding Categories

The research team developed a series of codes by which to analyze the video. We looked for verbal bids, non-verbal bids, and their responses in the interactional palette. The non-verbal included movements such as changing place in the workspace, grimacing, pointing, or writing on the board with a marker. By repeatedly watching the videos, we conducted an open coding process, allowing codes with corresponding numbers to be generated and defined. The codes were not

[Clip] Time	Ellie	Ellie Bid/Response (Verbal)	Ellie (Spatial)	Ellie (Objects of focus/Topics)	Megan	Megan Bid/Response (Verbal)	Megan (Spatial)	Megan (Objects of focu/Topics)	Megan bid short
0:00:19	[Crosses from bottom left to the table and uncaps a marker from the table and prepares to write] I just like that idea of like...	2	60		[Comes back onscreen. Wlks around table: from offscreen, along the left, to now directly facing camera. places white folder on the table and opens it]		30		1
			50						
					Yeah, that's actully really interesting	4	50		1
0:00:25	Like "Tv-Turn Off-Week"	4	10	103	[Pulls out folded chart which looks likes a spreadsheet. Chart rustles as George elaborates on the prototype]		50		3

Fig. 6 Segment with bid and response codes by number by team member

exhaustive of all possible codes, but did capture the range in these particular data. The codes established as *Verbal Bid Responses* are examples of this: "Acceptance" was defined as agreeing with the previous bid; "Building up" was defined as adding an additional action or idea to the previous bid; "Ignoring" was defined as not responding to the previous bid or responding with an unrelated action or idea. "Rejecting" was defined as explicitly disagreeing with the previous bid. Examples of *Spatial Bids* included, "Writes," "Proxemics moves," "Gestures," and "Attending to one's own person" (fixing hair, arranging clothing). *Objects of Focus* codes included "Design thinking steps," "Team collaboration," "Logistics," and "Social work." The preliminary code list was expanded and refined during the coding process.

From coding we realized that spatial and verbal bids and responses were being used to affirm or dissent in similar but distributed ways. Some team members would show agreement by leaning in and looking directly at their teammates when these teammates had the floor to speak. At other times, they would verbalize their agreement with "Umm, hmn" and "Sure! I think that's great!" In both cases the bids proposed by their teammates were *accepted* (Fig. 6).

In Team One, Ellie used her spatial responses for expressing dissent more often than other teammates: walking offscreen to a different whiteboard; opening a can of soda in response to a direct question; rifling through a stack of post-its while her teammates were looking over a chart together; these were all examples of how she *ignored* her teammates bids. These forms of ignoring and accepting were more nuanced and passive forms of dissenting and affirming, respectively. In Team Two, Angie was often offscreen, or documenting somewhat unrelated material on the whiteboard, or preparing for the next stages of the design process on her laptop.

Angie's teammates tended to overlook these dissenting spatial bids so that the bids interrupted the flow of ideas less often than Ellie's did. In Ellie's team, the team members on the receiving end of passive bids were highly attuned to them, stopping what they were doing in response to disruption of spatial synergy, and in these instances dissent appeared harder to resolve.

There were "idealized" and active forms of responding to bids, such as when a teammate responded to another's bid by elaborating on it. There were also passive forms that could be affirming, disregarding, or dissenting. When Steve copied down Nora's comments on the board, this was a move to *build-on* her points. When Megan responded to Ellie's bid with a counterargument this was a move to *reject* the bid made. Often, build-ons and rejections were complex and compounded, with spatial and verbal sub-bids embedded in them. For example, George, in response to a bid Megan makes, nods then pauses before adding,

"I think 'why' is more interesting. . .[Walks over to the board. Takes his time skimming it.]

Why is this the center of his life? [Approaches the circled "center of his life" and taps it with this finger]"

In this instance, the nod is a spatial acceptance. The comment, "I think 'why' is more interesting. . ." is a verbal challenge that modifies Megan's comment and shifts the team's focus in a dramatic way. This bid is a verbal build-on. When George walks over to the board, he offers a new spatial bid by demanding the attention of his teammates, who in turn accept his bid by following him with their eyes. He uses this to build-on his own question, "Why is this the center of his life?" and spatially builds-on what Ellie had written on the board "center of his life." With this compositeness in mind, we recoded the transcripts for both teams, this time condensing bids and responses to one of four categories: (1) accept and (2) build-on, the two affirming activities; and (3) ignore and (4) reject, the two dissenting activities. Figures 8 and 9 show the distribution of the four categories in Team One and Team Two, respectively.

Figure 7 indicates a fairly evenly distributed use of talk-space by the three members of Team One. George built-on bids more than he rejected, ignored or accepted them. Megan, rejected more than she built-on, accepted or ignored. Ellie rejected and built-on less than she accepted and ignored.

Figure 8 illustrates that while Nora contributed the most to the team talk space, she built-on far less frequently than she accepted, ignored and rejected her teammates bids. Steve on the other hand, took up the least talk-space and most of it was accepting and building-on (his distribution is widest for these two forms of bid response). Angie ignored far more than she accepted, but also built-on more than she rejected.

In the following series of graphs, we show how these patterns of individual behavior related to uptake of ideas. In our coding scheme, we cross-referenced the bids and responses of each member. For example, for all of Georges bids, we counted how many times either Megan or Ellie responded by elaborating, whether

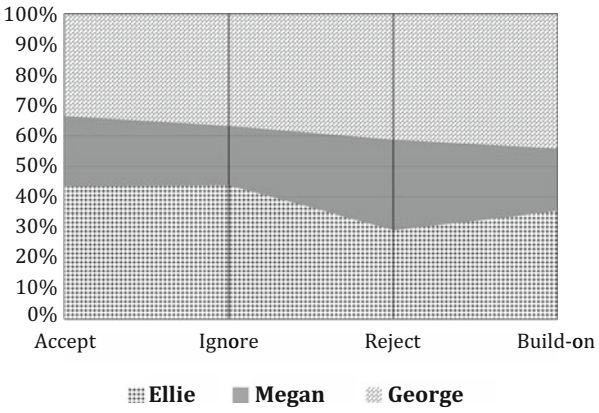


Fig. 7 Distribution of bids in Team One meeting

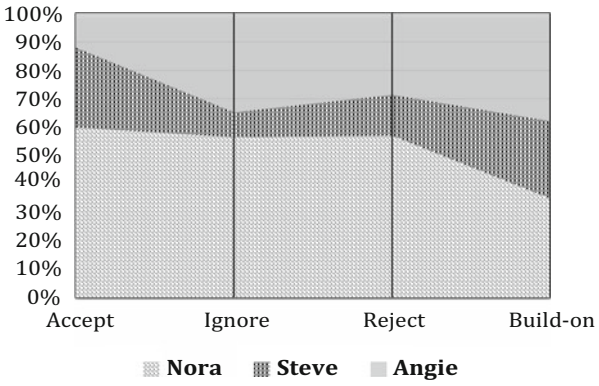


Fig. 8 Distribution of bids in Team Two meeting

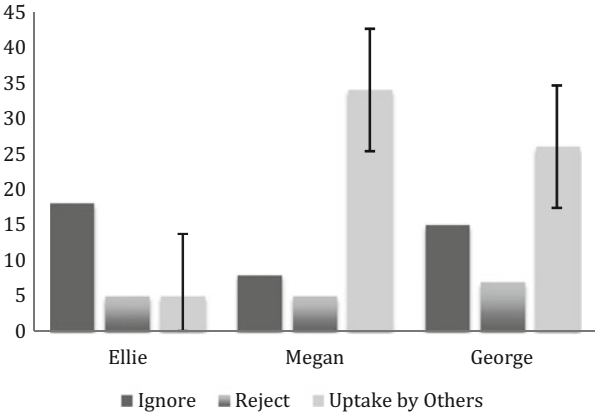


Fig. 9 Dissenting bids and uptake in Team One

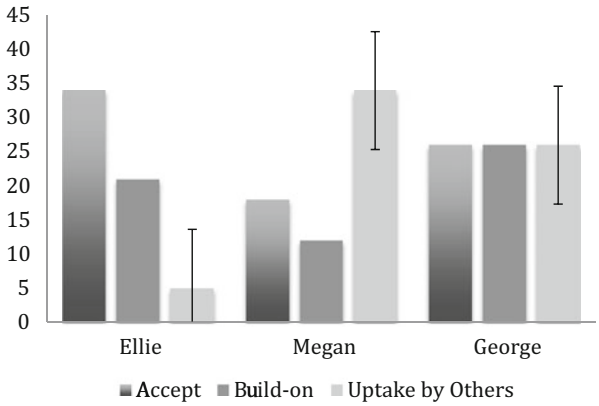


Fig. 10 Affirming bids and uptake in Team One

rejection or building on. We did this for each member of both teams, and came up with an *uptake* count that serves as a proxy for how *visible* that member was to their teammates. The more uptake one team member had, the more visible they and their use of talk-space were to their teammates. Was there a relationship between the visibility of team members and their tendency to affirm or dissent? Recall how Ellie's voice message influenced our foci for analysis. In Ellie's words, "So it's a little frustrating to me and I definitely am aware of the effect that has on me – you know, in terms of actively contributing and continuing to when you feel like you idea wasn't heard." This particular relationship between uptake (or visibility) and bid type would help us explore Ellie's claim about not being heard. Figures 9 and 10 show the relationship between uptake and the dissenting bids, and between uptake and the affirming bids for Team One. Each graph shows three bars for each team member: two bars for bid type, and the third for uptake count. In Fig. 9, Ellie, for example, ignored her teammates bids 18 times, and rejected them 5 times. Her teammates responded to these 23 combined dissenting bids only 5 times.

For Megan, who ignored teammates's bids 8 times and rejected them 5 times (a total of 13 dissenting bids), team members responded (by accepting, building on or rejecting) 34 times. George's total of 22 dissenting bids were responded to 26 times. Megan had, by far, the most uptake.

In fact, the difference between Megan and Ellie's uptake counts was statistically significant, as indicated by the Y error bars on Figs. 9 and 10. This indicates that Ellie's visibility was radically different and less than Megan's and George's during that team meeting, while Megan's and George's visibility was not significantly different from each other. Ellie was right! She wasn't being *heard* as much as Megan or George were. We mapped the relationship between uptake and type of bids for Team Two but the results were not significant, indicating that each member of the team was being heard (or had their bids taken up) by roughly the same amount.

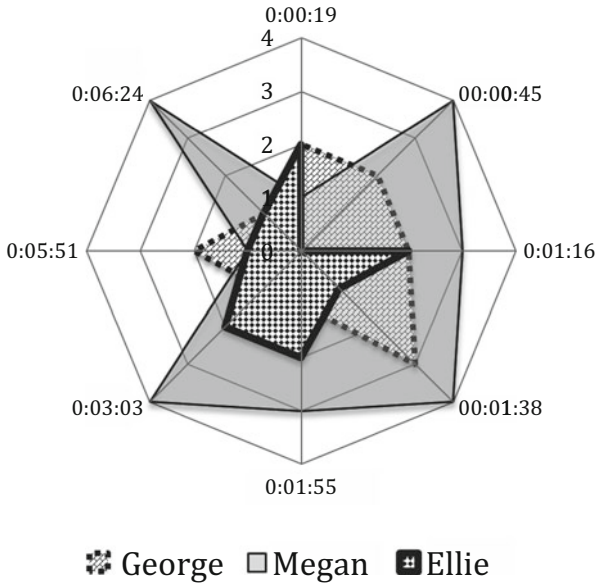


Fig. 11 Tension and alignment in Team One

We suspected this difference in visibility had something to do with how the teams dealt with dissent and affirmation or, more specifically, how they transitioned from one to the other. We identified one moment in each team where conflict arose, where all these members were spatially present, and where some resolution seemed to be achieved. In Team One, this moment arose when there was some dispute over who the user was and what his explicit and implicit needs were. In Team Two, the moment arose when one team member, Nora, suggested discarding a key component of the team's final product, the ePortfolio. In Team One, this moment occurred at the beginning of the meeting, from 0:00:19 to 0:06:24; whereas in Team Two it occurred at the end, from 0:37:17 to 0:44:10, with the meeting and video recording ending 30 s later. To examine this in more detail, we divided these portions of the meeting into eight smaller time segments, each corresponding to a bid made by one team member and the two corresponding responses to it from his or her teammates.

The two radar graphs, Figs. 11 and 12, indicate the flow of bid-making and bid-responses that took place over those eight time segments. These snapshots in time show the transition from bids that accept and build-on to bids that ignore and reject team members' contributions. Our data shows one team (Team One) is overly erratic and one team (Team Two) that is more linear. The radar graphs illustrate what moments of tension and moments of alignment might look like for both teams through the lens of offering and accepting bids. When bids are easily accepted and built upon, the team moves smoothly and cohesively. The bid-making patterns of

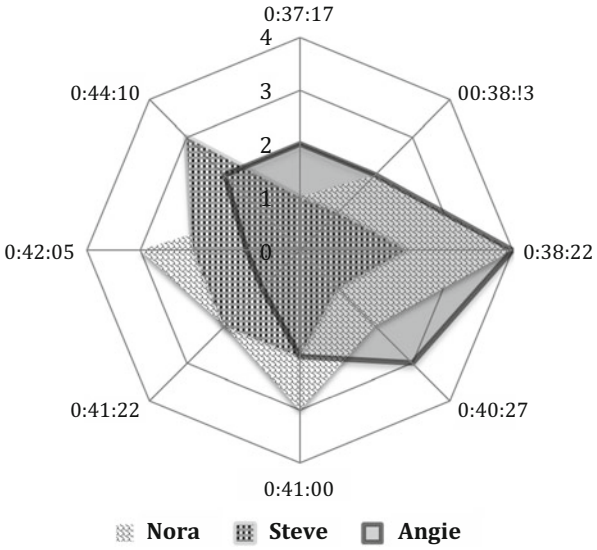


Fig. 12 Tension and alignment in Team Two

individual members resemble each other or are closely *aligned* when members take equal turns to lead, follow, challenge and affirm team progress. In an aligned team, even as members disagree with each other, there is synergy. The flow of the team is dynamic and emergent and is not easily attributed to one member but rather to how they interact and act in concert. In contrast, moments of tension in an erratic team are represented by scattered bidding patterns. Here, members' contributions are misaligned and the shifts from affirming bids (bids that accept and build on) to dissenting bids (bids that ignore or reject) appear abrupt and disjointed. Members appear to be working individualistically.

Figure 11 depicts Team One's struggle to find synergy. The team member's use of affirmation and dissent, passive and active, verbal and spatial are radically different from each other, indicating a struggle to come together. At time 0:00:19, two members are building on (level 2 on radar) while one accepts (level 1 on radar). This is "coming together" but in the next moment, time 0:00:45, one member rejects (level 4 on radar) while the second ignores (level 3 on radar), and the third checks out by wondering offscreen and out of the team space (indicated by 0 on radar).

Below we include the transcript for Team One that corresponds to these eight time segments. Each time segment comprises one bid and two subsequent responses that (1) accept, (2) build-on, (3) ignore or (4) reject the bid in question. Time segments 0:00:45 and 0:03:03 show mixed responses to bids, misalignment and disarray; while time segments 0:01:16 and 0:05:51 show team alignment: somewhat strong and very strong responses to bids.

At 0:00:45 Team is misaligned mixed responses to Megan's bid

Megan	[Consulting the spreadsheet] He's not on this list.
George	[Leans in to see the list. Pauses. Leans closer and points to a line on the spreadsheet repeating the name:] "Jeff" [row] "22."
Ellie	Oh! Here we go! [Talking to herslf. Finds the spot she's looking for on a second whiteboard and strides across the room to place the post-it she's holding on it disappearing offscreen.]

At 0:03:03 Team is misaligned mixed responses to Ellie's bid

Ellie	And also he's not getting exercise!
Megan	[Biting on the cap of the marker] Hmm. But he seemed pretty fit to be honest. He had kind of a beer gut [Chuckles, taps marker with her finger] He didn't seem. . . He seemed. . .Like, he wasn't like this. . . [flicks head to one side]
George	[Ignoring question consults the chart again].

At 0:01:16 Team is aligned somewhat strong responses to George's bid

George	Ok now can we sum [gestures "bringing together"]. . .[continues to speak but cut off by Ellie]
Ellie	[Picking up from George] I think we've hit a couple of different "needs"
Megan	[Picks up a marker from the table and spins around to face the onscreen whiteboard. She uncaps the marker and prepares to write]. Well let's maybe may try to figure out what they need. . .

At 0:05:51 Team is aligned very strong responses to bid

George	He has these interactions they are not. . . [pause as he thinks] . . .they are either too short to be meaningful, or they are like. . .
Ellie	[Perks up and gestures to Megan. Scratches nose while looking at George. Leans forward with elbow on knee. Presses fingers to lips and looks in George's direction]
Megan	Umm hmm

Figure 12 illustrates a smooth transition from tension and dissent to alignment and affirmation over 5 min of Team Two's meeting. The team disagrees in the first few minutes and finally arrives at a moment of synergy. One member follows the other's lead, navigating the problem solving process in a fluid fashion. For example, at time 0:38:13, two out of the three members are building on (level 2 on radar) an idea, they quickly shift to rejecting bids (level 4 on radar), and then to ignoring (level 3 on radar) some and finally building on again at time 0:41:22. While this team has synergy, it does not move in a straight line, and these moments of tension allow the team to discover interesting ground. That this team accepts a lot of bids without building on them or disagreeing helps them interact smoothly, but they don't take any risks or take up many novel doesn't or creative ideas. Below the graph we include a segment of transcript for Team Two that corresponds to a several of these eight time segments. Like the time segments for Team One, each comprises one bid and two subsequent responses that (1) accept, (2) build-on, (3) ignore or (4) reject the bid in question. Time segments 0:38:22 and 0:40:27 show weak response to bids, misalignment and disarray; while time segments 0:41:22 and 0:42:05 show team alignment: very strong and somewhat strong responses to bids, respectively.

At 0:38:22 *Team is misaligned, weak responses to Steve's bid*

Steve	If the technology works and this does transform that space then we'll take that on. I'll take that on as a primary. . .
Angie	[Interrupting Steve but addressing everyone] Do you think all these are fun? I'm not sure how much fun that part of the

	program. . . I'm not sure if the game should be focused on helping the students or. . .
Nora	I think that any of these games could be framed in a fun way, or framed in a more informative way. I think they can be fun and incredibly important.

At 0:40:27 *Team is misaligned, very weak responses to Steve's bid*

Steve	You were asking [addressing Nora], "What do you mean by: Games with No Rules so that People Can Create Them?" And one game that I was thinking about was–have you ever played [chuckles] Quarters?
Nora	[Ignoring question] Building off of this [leans in and point to "friendly competition" on the board], the "friendly competition", the "one-ups manship" and all of that, umm. . .I think that plays into games like, "Yes, and!" and plays into games like the Incense Story(?) where people say: [starts playing the game]:
Angie	[Walks towards the teacher – who has just poked her head around the team's whiteboard to check their progress – but the teacher has already walked away from the group].

At 0:41:22 *Team is aligned, strong responses to Nora's bid*

Nora	So we have to sort of harness it and direct it [gesturing her meaning] in a positive direction through these games is a good thing.
Angie	Are we. . .[pauses as Steve talks].

Steve	That's a really good thing to capture that thought [Steps in to write on board: "harness competition"]

At 0:42:05 *Team is aligned, mixed responses to Steve's bid*

Steve	I mean. . .[struggles for words] I would personally wave at the Fall, kind of like say a vision but not create it. It's too big to actually poof out.
Angie	. . .right. . .
Nora	[Rubbing her lip as her eyes continue to wander]

5 Summary, Discussion and Implications

The goal of the *Assessing Team Learning Project* was to gain insights into how independent team collaborations were accomplished as students engaged in and learned design thinking. The ethnocentric methods we employed allowed for deep insights into the nature of the process. Through taking an approach to data analysis that privileged our study participants' views of their experiences of their groups, we were pointed to particular events for study in videotapes of team meetings. We started the analyses by looking at what the students reported as problematic or extremely interesting or satisfying. Central to our analysis was the idea of a "bid" for topic introduction, change, or redirection of focus. A bid could be verbal or non-verbal. We also identified responses, from ignoring bids, entering competing bids, building on bids, etc., and traced the trajectories that bids and responses took in the group interactions. Within the larger theme of team interaction, we gained knowledge about how bids and their responses impacted on how teams functioned to accomplish their goals. We explored the diverse interactions that students engaged in, how they negotiated their bids to make contributions, and the effects of their participation moves.

6 Findings

Several findings emerged from the analyses: Team One touched on many stages of the design thinking process [empathy, define, ideate and prototype] in working to find its way. This might have been amplified because the students had trouble

connecting to each other or immediate aspects of the design task (development of the POV). This also might have been their first meeting independent of class. The team established uneven participation patterns and those patterns resulted in them noticing tensions. Ellie's report that she was not being heard was validated by the analysis.

One lens for understanding the data, especially the bids, was the examination of team direction and alignment. One might think that a good collaborative design team navigates a problem solving process smoothly, and that a team where members are not on the same page and/or are abruptly changing directions might fall prey to ineffective problem solving and run of the mill design solutions. Through the analysis we generated an *uptake* count that served as a proxy for how *visible* that member was to their teammates. When we first started, we thought the more uptake one team member had, the more visible they and their use of talk-space were to their teammates. We found this to be a false assumption. In fact, the team that moved in strict linear manner and had shared uptake on bids did not discover any novel ideas or take risks. The group that seemed less focused and experienced the most unevenness ultimately found ways to negotiate their interactions and get on track with each other. Team One had a rougher time than Team Two, but may have had more overall success in designing a creative and innovative solution. The conflicts were not necessarily unproductive in relation to end-results.

In Team Two, the students contributed fairly evenly or equally in the collaboration. Their "even" style, while conflict-free and less frustrating, misrepresents the potential gains inherent in a more critical or uneven approach. The team had more convergence and less conflict, and the results of the analysis of bids and uptake were not significant. Ultimately, a large part of their work was done individually with teammates later reviewing each other's progress and offering revisions. They had fewer opportunities for teammates to challenge each other, and they may have sacrificed innovation in their class project.

When bids were accepted, built upon, and subject to interpretations, the teams moved smoothly and cohesively. The bid-making patterns of individual members resembled each other or were closely *aligned* when members took equal turns to lead, follow, challenge and affirm team progress. In an aligned team, even as members disagreed with each other, there was synergy. The flow of the team was dynamic and emergent and was not easily attributed to one member, but to how they interacted and acted in concert. The data showed, in contrast, that moments of tension in a team were represented by scattered bidding patterns. Members' contributions were misaligned and the shifts from affirming bids (bids that accept and build on) to dissenting bids (bids that ignore or reject) appeared abrupt and disjointed. Members appeared to be working individualistically in these times of tension.

7 Implications

Much work has gone into designing course pedagogies at the d.school, where this study took place, and our team's observations of five or six courses revealed that courses and pedagogy were in line with the standards called for by design education researchers (Brereton 1996; Dym et al. 1999; Dym et al. 2005; Gerber 2009). These standards included: using problem-based learning and other appropriate pedagogies, making the investment in instructors and group coaches, considering it a crucial investment to educate diverse students with and into design thinking. Attention was paid to developing projects, in class activities, reflective practices (Adams et al. 2003), and assessments. Teams had instructors and groups have coaches. While students were in class, they were guided to engage the design process and mindsets. They were also guided to engage in "idealized" ways, receiving instruction and practice on different aspects of the design process. For example, when they covered how to write a Point of View statement in class, the very task Team One had trouble with, they received instruction and completed activities that included: what the POV is, why it is important, what qualities and standards a POV should meet, and ways to check their POV in order to ensure it is an adequate one. They learned about, and practiced writing POVs in class. Still, our video revealed Team One floundering as it worked independently to develop a POV statement for its user. Even when instructors work extremely hard on course design and cover so many bases, the teaching and learning of design thinking has its *wicked* aspects, such as the team collaboration.

The results raise questions and suggest implications for teaching design thinking and the need to better support independent teamwork.

First, is important to determine how to best help teams manage the design thinking process as they move through the different stages of a project. Finding ways to attend to team interactions in the design thinking process may pay off in terms of groups' overall experiences and success in generalizing solutions.

It is important to pay attention to teams' abilities to recognize ambiguity in the design process. In a prior studies to this one, our research group found that students did not become design thinkers in a developmental sequence. Instead, there were moments of significant insight that shifted one's understanding of the mindsets and processes that underlie design thinking (Goldman et al. 2012).

The development and handling of "teamness" is significant and worthy of extra attention. Teams are comprised of students with different backgrounds, disciplines, and prior design and team experiences. These differences bring both advantages and possibilities for radical collaborations (Booker et al. 2009; Barrick et al. 1998), and students need pointers about how to manage, massage, and capitalize on their differences in support in the instructional process. Students may benefit from the introduction of varied kinds of analytics in the design thinking process such as the creation of team rubrics and specific reflections on team process. Focusing on how teams collaborate in design thinking might benefit from a greater emphasis on evaluating the team process rather than just the end of course design solutions.

John Dewey (1922) wrote, "Conflict is the gadfly of thought. It stirs us to observation and memory. It instigates to invention. It shocks us out of sheeplike passivity, and sets us at noting and contriving." Design thinking relies on the resolution of conflict between a sticky problem and an elegant solution, what is known and unknown, what end-users say and what they really mean, and what does and doesn't work for users. There are times where novice design thinkers are asked to make inferences about people, their needs, the possibility for solutions that will work, and what will pass muster in terms of grading of their work. There is no wonder why student teams seem unanchored in the design thinking process when they work independent of their instructors. The teams we studied found their way, more or less, and presented solutions that met course criteria. Internally, their team processes were not elegant, and they stumbled through and *around* the design process. Some of what they were being taught proved useful in helping them become more attuned and responsive to each other as team members. The process was not conflict free when they worked outside of class, and both groups struggled to achieve a level of "teamness" that enabled them to accomplish their course and project goals.

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