The Role of Shared Physical Space in Affording the Creation of Shared Conceptual Spaces in Design Project Teams

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1. Introduction

Project-based and team-based learning have become a core component of the undergraduate engineering curriculum in recent years in response to the need to meet accreditation requirements. In design courses, a focus on team-based projects has enabled students to work on topics that are much more complex and model real-world situations. However, this pedagogical shift is predicated on students being able to work effectively together (both at an interpersonal and task level) to be able to co-construct a response to the design challenges posed. Further to this, the focus on inter- and multi-disciplinary design work requires students to be able to communicate and work with students whose understandings of concepts may not necessarily match to their disciplinary knowledge and understanding. Thus, the ability to provide students with scaffolding to negotiate and make meaning of their specific team’s work with one another is critical to being able to work effectively together.

Design-team-based projects are both production environments and learning environments. They encourage each participant to develop a greater understanding of the concepts/processes of design work, and of the subject of their design work. Students in these teams need to be able to engage with each other to debate and discuss their respective understandings of the design project and different design concepts, and be able to co-construct a shared meaning that will create a coherent product. This is different from the collaboration required of routine work. Students in these types of projects cannot simply subdivide the projects into smaller individual, independent tasks that can be reassembled into a coherent whole as that is not the way in which design happens. Design teams need to be able to leverage the individual perspectives and understandings of the team members to develop, as a team, a collective understanding of and relationship between the interdependent components of their work. Thus, the concept of a singularity of understandings of a design problem from the outset is not realistic, rather the concept of a multiplicity of understandings that a team makes meaning from to co-construct a shared understanding of their work is more useful. As per Borrego et al. in their review of the team-effectiveness literature, design teams have intensive interdependence.

A common approach that is used in design teams to construct this shared meaning is the use of shared mental models. Much of the research on shared mental models in teamwork has focused on the impact of these models, or on these models as building blocks that can be used to ensure a common understanding to work from. Teams which have a higher degree of “coherence” among their individual mental models are seen as higher performing teams. In this context, the use of these models has focused on building a consensus of terminology and concepts among team members – the focus has been on harmonizing rather than building understanding. Relevant to student design teams, Van den Bossche et al. found that student teams engaging in co-construction and constructive conflict were able to build shared mental models. Marques Santos et. al. determined that teams that build shared mental models can foster creativity – a necessity

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of design team work. However, in the literature the process of how student design teams build shared mental models and shared understanding from their disparate understandings is lacking.

An implicit assumption that by working together students will learn the content, underpins this team- and project-based learning model. However, the tools and techniques students are provided with only address strategies students may use to complete the project and produce the end product. Working from a sociocultural perspective that privileges social interactions as a site of learning, helps make this assumption visible. The students are not only struggling to solve a design problem, they are simultaneously using the process of solving the design problem to develop fundamental design and engineering concepts. Thus, students are required to both build mental models of the constructs, coordinate them to create shared mental models within their team, as well as apply these models to the challenge they are addressing – they need to create shared meaning together.

Students have the opportunity to use different symbolic and material mediational means to help them understand, coordinate and guide their actions within the team. Material mediational means include classroom space, tables and chairs, and shared common writing areas (flipchart paper or whiteboards). Other mediational means are more symbolic such as different design models or decision-making tools. The use of mediational means, in particular in a team setting affords the coordination of team thinking and development as it provides an external representation of the team’s current conception. A space of joint interaction provides the affordances for the students to suggest, test, challenge and develop the shared understanding that initiates their learning. Through creating an external representation of the current thinking, the team creates an artefact that they can then manipulate to develop shared understanding. A reciprocal process of internalization and externalization ensues – a continuous (in the best of worlds) process of expansion and cognitive transformation. We propose that a space of joint interaction affords the opportunity to develop shared conceptual space.

The shared conceptual space is the cognitive and affective environment in which team members ideate, negotiate, determine, and specify the work that they are engaging in by creating intersubjectivity in their understandings. Consider conceptual space to be a sandbox in which all team members work together to create a shared structure. Each will enter with their individual understandings of structures, the tools at their disposal, and the sand. Each “sees” the structure differently. Through committing to negotiating these disparate understandings in a way that the concepts are comparable (through creating intersubjectivity, which includes disagreement) the teams can create a shared conceptual space in which they can co-construct a shared understanding of what they want to create. Radford and Roth remind us that “learning is always an attempt at grasping and overcoming differences (even if these differences may never disappear”). The differences that students bring to their teams’ sandboxes include very different levels of conceptual understanding as well as very different levels of practical skill and knowledge. We argue that a space of joint interaction can afford the opportunity for this grasping and overcoming of differences to occur in order to develop a shared conceptual space that affords the development of shared understanding and shared mental models.
This paper follows up on a previous study on team ‘togethering’ and its effect on making meaning in teams. This study looks specifically at how the physical space a design team uses affords them the ability to create a shared conceptual space to work in. For this analysis of how teams create a shared conceptual space (a space of joint action), we have scoped our analysis to focus on the team use of specific material mediational means -- a shared common writing space. Using an activity-theory framework of ‘togethering’ this paper analyses and compares the way in which five first-year engineering design teams used a common writing space (for text and visual representation) in their design team meetings to ‘together’ and build a shared conceptual space.

2. Conceptual and Theoretical Framework

This research is grounded in Vygotskyian sociocultural theory and specifically activity theory as this particular theoretical perspective allows us to simultaneously examine the interactions of both individual and social actions. The negotiation of these social interactions includes the relationships of: the topics to the object of the team, the team members to each other, and the team as a whole to their object(s). We use the term object here in its activity theory sense to refer to the problem or purpose towards which an activity is directed. An activity is a set of various actions (such as ideating, negotiating, planning, agreeing, disagreeing) carried out by a group, a social unit such as a team, motivated by a socially constructed goal. For our use, the activities studied in this paper are team meetings in which a team uses a whiteboard to mediate a decision or series of decisions.

Togethering, as described by Radford and Roth, “has the purpose of realizing a collectively motivated object”. The concept of togethering allows us to analyze the actions and interactions of the team members from the different perspectives of the team members as well as from the perspective of the team, almost as if we were in the team. Togethering is described as “an analytical category that accounts for the ethical manner in which individuals engage, respond, and tune to each other, despite their cognitive, emotional, and other differences.” The three key components of togethering, which build upon each other, are engaging, responding, and tuning.

When a team engages, each individual team member makes a commitment, manifested in action, to work with others in the joint activity. When team members respond, they make efforts to coordinate individual contributions (their engagements) through agreements and disagreements. When the engagement and response contributions of team members results in the emergence of a common object for common understanding of the activity, the team members have attuned to one another.

The individuals in a team each bring a slightly different set of experiences, conceptual understandings, and mental models to the activity. They have engaged by committing to work together. They respond to one another as they coordinate their individual contributions. To attune to one another requires that they, at least partially, enter into one another’s conceptual spaces – that they refract their team member’s contributions in their mental models of the activity. Refraction, defined by Radford and Roth, is a kind of seeing what another person is saying and simultaneously seeing that contribution in the context of what you are offering. Each individual’s
understanding refracts what others say and do differently but if they are ‘close enough’ in their understanding, they can use these refractions to build and transform the shared object of their activity.

In activity theory, mediational means offer an affordance to individuals or teams to coordinate and facilitate inter-and intramental activity. Symbolic artefacts include languages, discourses, gestures, and visual symbols. Material artefacts include physical tools or technology, anything from a piece of chalk to a smart phone. Mediational means offer an affordance of representing or manipulating an individual's or team's idea such that those present in the discussion can see and interpret it. They also offer an affordance to represent an emerging object.

The concept of 'togethering' creates, with a variety of mediational means, an interactive activity where team members engage with and respond to one another. At a team level, when there is coordination of individual responses the team achieves intersubjectivity. We will label these coordinated contributions as intersubjectivity, following Matsuov in his conceptualization of intersubjectivity. When the group of individuals only responds to one another without tuning a distributed conceptual space results. Each individual maintains his or her own ideas and no shared conceptual space emerges.

When the group of individuals also tune to one another they begin to create a space of joint action. According to Radford and Roth, “The space of joint action is more than a spatial notion where interaction would occur. It is a space of relations and embodied reciprocated tunings occurring in the concrete space of interaction.” It is this emergence of a common object for common understanding that constitutes an activity occurring in a space of joint action. It is in this tuning that the unity of affect and cognition, a central component of joint activity, is most apparent. The cognitive processes and products do not emerge or exist separate from “the motivating sphere of consciousness, a sphere that includes our inclinations and needs, our interests and impulses, and our affect and emotion. The affective and volitional tendency stands behind thought.” Without this aspect, it becomes difficult to fully analyze the qualities of the interactions we observed - how the affective demeanour of the individuals influenced the discussion, the emergent object, and the cognitive and affective demeanour of their team members. With this in mind, we can more clearly differentiate the different qualities of the interactions of the teams studied.

This paper analyzes how student teams in a first-year design course leveraged the physical mediational means at their disposal to attune to one another and create a shared conceptual space in which to do their design work. In particular, we are interested in knowing how students did or did not use the common writing space (for text or visual representation) to create this attunement. Our conceptual framework of how this shared conceptual space is built from student interactions, is described below in, Figure 2-1. This framework is used in subsequent sections to analyse the interactions of the teams in their meetings,
3. Study Design, Methods and Population

This study involved non-participatory observation of five first-year engineering design teams during their team meetings from two different cornerstone design courses. The study took place at a large, publicly-funded, research-intensive university, with a first-year student population of approximately 1300 students. Two of the teams participating in the study took the general engineering client-based consulting engineering cornerstone design course, and the other three teams took the engineering science student-driven entrepreneurial engineering cornerstone design course. Both courses require teams of 3-6 students to work together to define and address a design challenge in their geographic area and interact directly with the client/stakeholders involved. Deliverables consist of written documentation specifying their design as well as a presentation to course instructors and interested stakeholders.

3.1. Study Design

This study follows on a study presented at ASEE 2015\textsuperscript{10} which follows the same study design. Five teams from the course were followed during the winter semester, January to April 2014. Teams volunteered to be a part of the study, and each team member received a gift card to the university bookstore upon completion of the study. Students consented to have three of their team meetings video-recorded. All teams in the study had different tutorial instructional staff, and had their tutorials on different days of the week to minimize any bias one instructor could have over the teams. Video recordings occurred during the week where the team first met, the week immediately after their first major deliverable, and in the last week of the project.

All video-recordings were taken in a private room where only the team was working. Three cameras were positioned around the room to capture each student’s facial expressions as well as any shared work spaces (i.e. whiteboard, flip chart, communal computers). The videos from the
three cameras were then synchronized using video-editing software to create a panoramic video of the team and their workspace. Large common writing/recording spaces such as easels, flip chart paper and whiteboards, were available to all of the teams at every meeting recorded in this study. These tools were also available in their regular tutorial meeting times although they may have been encouraged to use them differently according to the TA in charge of the tutorial.

3.2. Research Methods

The methodology followed in this paper is that of a discourse analysis of social events, grounded in an activity theory perspective – specifically ‘togethering’. Discourse analysis in this paper incorporates both the language (vocabulary, tone, etc.) and the demeanour (gesture, gaze, posture, etc.) of the team members in face-to-face social interaction. Thus, our unit of analysis is the (reciprocated) interaction between the team members rather than their individual behaviours.

We were interested in determining how these students used the physical artifacts at their disposal in these team meetings to develop a shared conceptual space amongst the team members. We scoped our analysis to similar events across the five teams studied – situations in which the teams used a large common writing space (e.g. whiteboard, flipchart paper, etc.) to work on an activity collaboratively. Within each event, we looked for interactions between team members, and between team members and the artifacts at their disposal that allowed the team members to engage with the activity at hand, respond to each other in the context of the activity, and attune their understandings of the activity with those of each other.

Using the definitions from Section 2.1 we analysed these events to determine if and how the teams engaged, responded and tuned to each other and their activity. To determine if team members were engaging with each other or the activity at hand we looked for the orientation of team member gaze and posture, the artifacts they interacted with, and the conversational topics and/or ideas they initiated. To determine if team members were responding to each other we looked at both team member gaze and posture as well as the type and sequencing of discourse moves made by the team members conversation (build, clarify, confirm, agree, disagree, counter, etc). Discourse moves that were coordinated about the activity and allowed the team to move towards greater understanding of the activity were coded as responding; those that were not coordinated about the activity were coded as not responding. To determine if team members were tuning to the activity at hand we looked for building, expanding another’s idea, finishing another’s utterance, supplying the word or gesture needed to clarify or confirm to another.

3.3. Demographics of the Studied Course and Population

The teams who volunteered to participate reflected the demographic of the Faculty, a purely serendipitous occurrence. Of the 22 participants there were five students who were not visible minorities in engineering, nine students who appeared to be English dominant and seven who were female. None of the teams investigated in this paper consist of all monolingual English speakers, and only one team, Team 4, consisted of all domestic students. The language diversity of the teams was representative of the University’s (and in particular the Faculty’s) linguistic diversity. Given the demographics of the teams and the student population in this course, the probability of having teams volunteer that did not have similar diversity to the student body was
minimal. The students’ motivations for participating ranged from “I had a terrible experience first term so I want to do everything I can not to repeat it” to “This might be interesting” to “I wanted the $30 gift card”. With this range of demographic and motivational diversity in each of the teams, we do not feel that that there was a unified demographic or motivational volunteer bias.

4. Analysis

The analysis of the teams’ interactions and their ability to engage, respond, and tune to create shared conceptual space follows the conceptual framework presented in Figure 2-1. For each team we will first describe the incident by providing a narrative of the interactions within the team and providing select quotations from the incident that define the type of interactions present. Then we will discuss how the team used the mediational means at their disposal during the incident, with specific reference to the shared writing space as the main physical space used. Next, we will discuss the interactions of the team-members using the engage-respond-tune model of togethering, and conclude with whether the resultant activity was in fact one that occurred in a space of joint action that led to shared conceptual space, or in an uncoordinated activity that led to distributed conceptual space. The names of team members discussed below have been replaced with pseudonyms to maintain participant anonymity. A summary of our findings is presented in Table 4-1.

4.1. Team 1

Team 1 was a team of 5 males from different first-year engineering disciplines taking the client-based consulting design course. The team was comprised of Michael, Farid, Tony, Da, and Karim. Michael was both the designated team leader and the only English-dominant member of the team.

This section analyses Team 1’s interactions in the first half of their second recorded team meeting. The team is filling time during their scheduled tutorial meeting throwing out their frustrations with the way they worked on their first deliverable. The team names this activity their “Lessons Learned” – modeled after an individual assignment each team member must submit in approximately two weeks’ time.

4.1.1. Activity Description

The meeting for Team 1 occurs later in the same day that they had handed in their first deliverable. The five team members are initially seated around the table but re-distribute themselves to get comfortable, Figure 4-1. Michael, the designated team leader, is busy on his laptop searching for a meeting agenda, expecting one to be provided by the course instructors as had been done for the first three meetings.
There are three topics in play at this time, “Lessons Learned”; instructions for the next deliverable, the Conceptual Design Specifications document; and the Status Report, a weekly report due during the tutorial. While Michael is searching for an agenda, Farid and Michael begin discussing the document they just submitted. When Michael realizes there is no prepared agenda, he proposes working on “Lessons Learned”. Everyone quickly agrees with this, and two critiques of their previous work process are quickly introduced but neither followed up or developed before another idea is introduced. Tony reminds the team they talked about this the night before but only Da pays attention to his comment.

Farid describes an issue with their process while Tony and Michael suggest how to record the issue for the Lessons Learned. During this time, Da is looking down and Michael makes no eye contact with anyone even when he provides his extended summary of his perception of their work process. Over the next thirty minutes individuals introduce multiple topics of discussion with interjections of content or evaluative comments. All of the team members talk over each other, competing to be heard. They phrase each point as a negative criticism, sometimes sarcastically, with limited recommendations of what to improve.

The whiteboard comes into use when Farid says that they need to write on the whiteboard as evidence that they are working so that the TA can just glance through the window and see that they are working. Da then gets up and goes to the whiteboard and asks what he should write, Figure 4-2.

He is given one idea before the discussion shifts again. Farid finds the instructions have been posted for the next assignment and as he reads out the section names of the next document. The list of sections names prompt criticisms of the deliverable they have just handed in. Da writes the “Lessons Learned” from memory as others continue introducing other topics. Da then resumes his seat. Other team members only glance at what Da has written.
Table 4-1: Comparison of design work, space usage, and shared conceptual space development across the studied teams.

<table>
<thead>
<tr>
<th>Teams</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Conceptual Space? Y/N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Physical Space &amp; Artifacts present</td>
<td>- physical handouts - engineering notebooks - whiteboard - markers - individual computers</td>
<td>- physical handouts - engineering notebooks - whiteboard - markers - individual computers - smart phones</td>
<td>- 3 computers - common writing space - markers</td>
<td>- printed/written agenda - computer - smart phones - common writing space - print outs of resources - markers</td>
<td>- whiteboard - markers - 3 computers</td>
</tr>
<tr>
<td>Topic</td>
<td>Reasons why they did poorly at delivering their last assignment</td>
<td>Design problem: Real-time tracking of a campus service's usage and purpose</td>
<td>Relative importance of aspects of their design</td>
<td>Criteria for selecting a community</td>
<td>The key features of their design</td>
</tr>
<tr>
<td>Task</td>
<td>Brainstorming &quot;Lessons Learned&quot;</td>
<td>Brainstorming possible design ideas</td>
<td>Determining the poster layout for Showcase</td>
<td>Determine the target community they wanted to work with</td>
<td>Determining the poster layout for Showcase</td>
</tr>
<tr>
<td>How the physical space is used</td>
<td>Ad-hoc and post-hoc single member recording of discussion points on the whiteboard</td>
<td>Single member records ideas on the whiteboard while individual members follow an agreed upon speaking path to voice their ideas</td>
<td>Members took turns drawing their personal representations on the whiteboard</td>
<td>Single member records on a large sheet of paper in the centre of the group that all can access and point at to focus discussion</td>
<td>Members write over each other on the whiteboard to work out and visualise different ideas, while the computer is used to record the agreed upon representation</td>
</tr>
<tr>
<td>Physical Artefacts Leveraged</td>
<td>- whiteboard - markers</td>
<td>- whiteboard - markers - individual recording mechanisms (some engineering notebook and a smart phone)</td>
<td>- whiteboard - markers</td>
<td>- printed/written agenda - computer - smart phones - common writing space - print outs of resources - markers</td>
<td>- whiteboard - markers - 1 computer</td>
</tr>
<tr>
<td>How physical space is used to construct shared conceptual space</td>
<td>Not used</td>
<td>Whiteboard used to record, build, and clarify ideas until agreement was reached</td>
<td>Whiteboard used to find grounds for discussion, but no tuning occurred</td>
<td>Large flip chart paper placed where all had access to it, and used to record the progress and outcomes of the discussion</td>
<td>Whiteboard used as a shared drafting and recording space</td>
</tr>
</tbody>
</table>
Figure 4-2: Da moves to the whiteboard to record the Teams' Lessons Learned.

Later, when the topic has shifted back to the “Lessons Learned” discussion Karim stands and goes to the whiteboard to add to the list with more critiques previously put forward by the team. Farid make a coherent critique of their writing process, including a proposal of a new process that could help them, but no one listens. It is not recorded on the white board. The team continues their three separate conversations and after a while Karim returns to the board and records a question of his own, “Do you have any particular complaints about team members?” Karim leaves the board to eat but returns a second time and draws stars around the question he had written previously, Figure 4-3. He states it aloud as he goes back to his seat. The team members glance at the board or Karim briefly, and then continue their three separate conversations.

4.1.2. Use of Common Writing Space
The team used the common writing space only as a display of evidence that the team was working on a course activity. This was done so that it could be easily seen by the teaching assistant if he passed by the room they were working in. Separate from the conversations at the table, “Lessons Learned” were recorded from memory. The use of the whiteboard did not focus or guide the discussion, it simply recorded (after the fact) for display.
4.1.3. Engagement
The team could not engage as there was no commitment to any shared goal. The team was constantly distracted during the discussion, sometimes getting sidetracked by other courses. The team bounced back and forth between different topics within and across the separate conversations that were happening almost simultaneously. In short, there was no continuous discussion or focus on a topic shared by the team.
4.1.4. Response or Attunement
During the haphazard discussion of the lessons learned, the team is not focused on the topic nor do they use the tools at their disposal to develop their discussion. These contributions were not intended by all parties to be coordinated. The team members speak over each other and at the same time compete to have their point be the one heard. They continually introduce new topics or re-introduce their own previous topic. They are not responding to each other. The irony of competing perspectives on “what went wrong” within the team is not noticed, as they are perpetuating the same patterns they are describing as being troublesome. As a result, their contributions were not coordinated and the team could not attune.

4.1.5. Uncoordinated Activity
This team is a strong example of distributed conceptual space as can be seen in the conversation pattern of the team members, where the team’s utterances do not overlap, or build on each other, but instead pass by each other without ever intersecting. Shared conceptual space does not emerge for this team through the use of their shared physical space as the team does not treat the space as a tool to leverage in developing their work. The team sees and uses the whiteboard as a display mechanism to signal their compliance with a perceived course requirement – to work during the tutorial. As a result of using it post-hoc of their discussion, it cannot be used to guide, refine, or clarify the discussion points being raised.

4.2. Team 2
Team 2 was a team of 4 females and 2 males from different first-year engineering disciplines taking the client-based consulting design course. The team was comprised of Barb, Tala, David, Shen, Lily and Sanova. Barb was the designated team leader, and she and Tala were the only English-dominant members of the team.

This section analyses Team 2’s interactions in the second half of their second recorded team meeting. At this time, the team is attempting to brainstorm ideas for their design challenge as a group. They follow an unstructured brainstorming process where all team members are asked to contribute ideas to the team’s repository.

4.2.1. Incident Description
The incident begins when Barb asks who wants to write down their ideas for brainstorming and David moves to the whiteboard to record, Figure 4-5. Barb and Tala begin throwing out ideas and Barb asks the team what other ideas they have. David reinforces the activity by reminding everyone that it is a judgment free space. As two vocal team members begin to throw out ideas, David recommends and the team accepts that they go around the table clockwise to ensure everyone gets to voice their idea. He also asks if the team should be taking individual notes as well as him writing on the board as some team members are already taking notes. The team agrees that they want to take notes but that they should also have a ‘collected focus.’ They then move clockwise around the table to have each team member share an idea, or pass on their turn, Figure 4-6.
Figure 4-5: David moves to the whiteboard to start the team's brainstorming session.

Figure 4-6: The team decides to go around the able in a clockwise manner. They determine this through moving their hands in a circular motion demonstrating the direction of flow.

David records the ideas on the board, but always turns around to face the group when ideas are being pitched. He often asks questions of clarification, as do other team members, or provides critique to ensure sufficient understanding of the idea being presented before completing the recording. Barb and Tala summarise out loud what the team members say while David records it on the board. As David records the idea, so do the other team members in their personal notes. As new ideas are introduced, team members re-clarify or modify designs they had previously
proposed based on new understandings of the problem. David steps out for a moment and Barb takes over on the whiteboard. As she watches students from other teams stare at their team, she comments that other teams must be jealous because of their ‘awesome whiteboard’, Figure 4-7.

As they are drawing near the end of their meeting time, a few team members share ideas out of the agreed on rotation. Tala comments that they have come up with 47 ideas from this brainstorming session. Barb suggests they do some individual brainstorming at home before their next meeting, which Tala requests the team do on their collective GoogleDoc. Barb takes a picture of the whiteboard, and Tala tells the team she will send everyone the notes she took on her phone.

Figure 4-7: Barb goes to the whiteboard to summarize the team's progress and comments on how 'awesome' their whiteboard is.

4.2.2. Use of Common Writing Space
The whiteboard is used as a negotiating and recording space to ensure everyone on the team had the same understanding of the ideas being proposed, Figure 4-8. The recording on the whiteboard guides the discussion as it facilitates an understanding of when an idea has been understood and accepted by the group. Once an idea has been accepted in this way, the whiteboard signals to the next team member in the rotation that it is their turn. It is used as a means of developing a greater understanding of the design problem as team members re-clarify and modify previous ideas as new ideas are added to the set. Visually, the whiteboard allowed for each person to speak and be present in the collective set of ideas and provided a source of pride and evidence of progress to the team.
4.2.3. Engagement
The whiteboard focuses the team’s attention to the activity and the ideas being proposed. The re-orientation of team members to face the whiteboard during recording and the change in the focus of their gaze to individual speakers during idea sharing demonstrates the team’s commitment to the activity. At no time during the activity was another topic of activity introduced, nor was a team member not visually or verbally acknowledging the ideas being presented by the other team members. No one stepped on the speaking space of others. All team members were fully engaged in the brainstorming activity which they committed to continuing beyond this meeting time.

4.2.4. Response
The whiteboard provides a grounding for the team members to respond to each other’s ideas and coordinates the sharing of ideas. It mediates the transition between ideas and speakers and allows for other team members to build on, clarify, or confirm the ideas being proposed. During the activity, no idea is recorded as initially proposed, but instead a development of the idea as generated through the response of other team members is what is finally accepted and recorded.

4.2.5. Attunement
The whiteboard is the artefact of the attunement, because David both scribes and changes what gets written based on the interactions of the team members (their responses). This coordination and tuning of responses facilitates the team to create a space of joint action about their design problem. The tuned interpretations of the ideas (the ones consistent with their intention and shared understanding of the design challenge) are the ones that are recorded on the whiteboard. The process of negotiation and development of ideas, and the subsequent development of the
design problem preceding the recording, allowed the team to tune their respective understandings creating a shared conceptual space of the team’s emerging, shared, understanding.

4.3. Team 3

Team 3 was a team of 3 males and 1 female from the same first-year engineering discipline taking the student-driven entrepreneurial design course. The team was comprised of Benjamin, Gregor, Makin, and Ashima. Makin was the acknowledged, but not designated, team leader, and Gregor and Benjamin were the only English-dominant members of the team.

This section analyses Team 3’s interactions in their third recorded team meeting. At this time, the team is attempting to select a poster layout from the poster layouts proposed by different team members.

4.3.1. Incident Description

Team 3 is in the midst of designing their poster for the final public presentation of their design that was to occur a few days from the time of this meeting. Three team members are present at this meeting, Gregor, Benjamin and Makin. The incident begins with the team reviewing two different poster layouts, one proposed by Ashima, and one proposed by Makin, Figure 4-9.

Figure 4-9: Makin shows Benjamin and Gregor the poster layout he had determined on his laptop.

A discussion between the team members ensues comparing the two posters. They agree that they prefer the colour scheme of Ashima’s poster, but Benjamin is uncertain of the layout Makin has proposed – Benjamin is having trouble understanding the difference in representation of the internal and external components of their design. Gregor interprets the layout as trying to describe the two functions of the buckling mechanism (automatic buckling and manual buckling) as compared to the whole design, however Makin is trying to show their design in his poster as a three-phase system comprising three key physical components: casing, handle, and fire sensor. Gregor challenges Makin’s idea that he can just “zoom-in” to show the interior of the design as it is a 1:1 scale and thus not a zoom. He proposes that they show that the visuals are branching into the two subsystems of the main system (manual and automatic) rather than zooming in.
Makin does not like Gregor’s suggestion, as he feels it does not market his idea the way he wants it presented. He then proposes that they show the design as three components (casing, manual function, and automatic function) as in his original poster. However, these are three different components than he had initially presented as being the content of the poster.

Gregor proposes a third poster layout based on his branching idea, and he and Makin move over to the whiteboard where Gregor sketches out his and Makin’s posters’ layouts side-by-side with Gregor’s showing the branching with the two functionalities, and Makin’s showing the three stage progression of components, Figure 4-10.

Makin argues that Gregor’s branching idea has a better visual layout but leaves a lot of white space and requires redundant information to be displayed in multiple places – he says that he likes it, and then verbally and with gesture but not with marker on the whiteboard, converts it into a design almost identical to his original idea. Benjamin argues that the two posters explain the same thing just one is analytic in description and the other holistic, Figure 4-11. Gregor and Makin point at the two posters layouts to critique how each poster could incorporate the team’s design considerations. Neither hear Benjamin’s comment.

Gregor describes how the poster layout facilitates their presentation of the functionality of their design. Makin responds by discussing how the poster shows the physical components of the design. Makin is uncomfortable with focusing on the functionality of the buckle in terms of manual and automatic release, as it does not highlight the functionality of the casing to hold the buckle together. Gregor argues that a figure of the whole buckle covers the casing, but Makin insists that it needs to be presented separate from the whole. He is worried that demonstrating a branching pattern in the poster representation will “segregate” the casing such that it will not look as important as the other components. This conversation pattern between Gregor and Makin is repeated as Gregor paces about the room while Benjamin goes to get a snack from his bag, Figure 4-12.
The conversation moves to a new topic of how to communicate the design decisions the team made. Makin does not believe they made any intentionally so they don’t want to talk about them in specific, but Gregor argues that the modifications he made while he was doing the solid model count as they were intentional. Gregor proposes a way of outlining only a few design considerations pointing to his poster layout. Makin concludes that if they present a few key design considerations, pointing to his poster layout on his computer, they are done, barring some small additions, Figure 4-13. Gregor comments that they need to get it done quickly so that he can focus on the prototype. No visible or verbal selection of a particular layout occurs.
4.3.2. Use of Common Writing Space
In this incident, the team uses the whiteboard as a way to ground their discussion – it is used to compare poster layouts of similar fidelity, Figure 4-14. The whiteboard is used to sketch out alternate poster designs, and once to modify one of the proposed poster designs. They use the sketches on the board to point out where they can place their design decisions on the poster and discuss how they will use the white space around the images of their design. It is used to show which components of the design fall under the manual and automatic functions of the buckling mechanism.

Figure 4-13: Gregor re-looks at Makin's poster design on his computer.

Figure 4-14: The whiteboard of the team showing the two poster designs one on top of the other.
4.3.3. Engagement
All three team members are engaged in the discussion. They are focused on and invested in the conversation, are able to provide their thoughts and input as needed and are comfortable sharing their ideas. The whiteboard provides a space for the team to focus on the ideas under consideration and allows them to critique specific aspects of the designs.

4.3.4. Response
All three team members respond to each other in the discussion. The whiteboard is used mediationally to capture these responses as they describe, annotate, explore, and explain the poster representations. Their contributions are coordinated, and they are on the same topic. Gregor and Makin use the whiteboard to create representations of similar fidelity which allows them to coordinate their input. Sketching in the physical components of the two functions of the buckle by Gregor provides a better way for Makin to respond to Gregor’s comments as it allows him to see the physical components of the design in their functions.

4.3.5. Attunement
The team members are not tuned to each other. We see this as a product of the students engaging in different conversations. Gregor is engaging in a discussion on how best to represent and present their design at the showcase, whereas Makin is engaging in a discussion of how the poster layout demonstrates the importance of the physical components of their design. As a result the discussion can contain the same content and topics, but because of the different objects (goals of the discussion) they cannot tune as they do not realize the different activities taking place. Benjamin is the only one who realises that there are two separate conversations, however his voicing of this is not taken up by the group as Gregor and Makin continue their separate discussions. We see these as different conversations rather than different perspectives refracted in the activity as neither Gregor nor Makin acknowledge the two differing aspects of the poster layout under discussion.

4.3.6. Uncoordinated Activity
This team is an example of distributed conceptual space. The whiteboard is able to focus the discussion and ensure the team members are discussing the same layout of the poster, but is not able to afford them a shared conceptual space. It does not help them determine they are having two different conversations about different objectives for their poster. Their activity is uncoordinated as they are engaging in two different activities with two different objects. Without coming to an agreement on what the objective of their poster is, they are not able to form the conceptual space required to debate the poster layout in an effective manner that allows for them to build on and develop each other’s ideas.

4.4. Team 4
Team 4 was a team of 3 males and 1 female from the same first-year engineering discipline, taking the student-driven entrepreneurial design course. The team was comprised of Adam, Bart, Isaac, and Sahar. All were English-dominant speakers.
This section analyses Team 4’s interactions in their first recorded team meeting. At this time, the team is determining which community they should decide to work with from the candidates proposed by different team members.

4.4.1. Incident Description
Team 4 is engaged in their second official team meeting, and the first recorded meeting, in the third week of the course. The team has a clear intention that determining a community to work with is the focus of the meeting, as per the agreed upon agenda that Adam drafted. As they begin their meeting, they rename the communities they had discussed in their meeting the day before, and Bart records them on the agenda that Adam has made for the team while all team members share their impressions and feelings about the communities, Figure 4-15. Bart confirms that no team members have concerns about any communities.

As the discussion ensues, Bart goes to the easel in the room to remove a sheet of flip chart paper which he places at the centre of the team’s table. As he goes up to the easel, Adam confirms that they are going to use a Pugh Chart as their selection method and Sahar and Bart agree with this. Bart goes and gets a marker and starts to write the team’s communities from the agenda onto the sheet of flipchart paper. Sahar asks what the team will use as criteria for selection while Isaac confirms the parameters of a Pugh Chart. Once Bart has recorded these communities, the team starts to work through what their criteria are. Bart offers as suggestions what he thinks the ‘[team] values’ in a community, Figure 4-16. The team responds by critiquing, offering alternate suggestions, and rephrasing these ‘values’ into criteria.
The team then moves through the chart cell-by-cell from the upper left corner moving through their communities. Isaac begins the discussion by phrasing the first community as a question. Bart and Isaac guide the conversation by Bart placing his marker in the cell to be discussed, or by either mentioning the criteria at hand, Figure 4-17. All team members debate what value (+ / 0 / -) should go in the cell and then Bart records it. Sometimes as Bart is recording, a team member will voice that they are unsure and two values will be recorded by Bart. As they move through the criteria the team explores their understandings of each criteria. As they debate them some criteria are renamed, some are removed, and some are clarified until the team is comfortable to proceed with using them to assess their communities. One criteria, ‘available problems’ is eliminated by Isaac as he believes it is unassessable. Bart, similarly, comments that their last criteria ‘structure’ is not properly phrased, as it is trying to get at a concept they already have defined as ‘accessibility’. The team ignores both these columns in their future assessments.
As they go through the Pugh Chart, Adam tries to find a way to combine all the communities in a way that they could address all the criteria. This becomes a recurring joke throughout their meeting, and surfaces whenever the discussion gets intense. At this point it becomes evident that their leading community according to the Pugh Chart does not meet their criteria of ‘fun’ – something Isaac was very intent on. As they discuss this community in more depth, Adam brings in a new criteria ‘researchability’ which their leading community would be good for, and their ‘fun’ communities would not be. Bart crosses out ‘available problems’ and replaces it with ‘researchability’. He quickly fills out that column without seeking input from the team, and without the team challenging any of his value assignments. At this point Isaac agrees that ‘researchability’ trumps “fun” and the team agrees to move forward with that community. Isaac begins researching it, and Adam gets some notes he had about the community from his folder to share with the team, Figure 4-18.

Figure 4-18: The team moves on to their next activity to research new information about their selected community.

4.4.2. Use of Common Writing Space
The team uses the flip chart paper as the place to create a Pugh Chart, Figure 4-19, which serves as the focus of their discussion. By locating the paper in the centre of the table, Bart provides the entire team with access to point at different criteria and communities. Team members take this up, and point at criteria, communities, and cells in the Pugh Chart as a way to direct their questions and critique. Additionally, it is used as a way to represent the team’s thinking about the selection process. It demonstrates the evolution of their criteria in selection, and visually compares their candidate communities. When the leading candidate community does not match the team’s implicit criteria, they use the Pugh Chart to determine the criteria they were missing in their analysis.
4.4.3. Engagement
The team is engaged with one another, the flipchart paper and the task they are completing. Bart demonstrates this commitment to the team by opening the activity with the language ‘we value’, and all other team members demonstrate that commitment by taking up that language in the rest of their discussions. Team members direct their gaze at the flip chart paper or a specific team member while they are speaking.

4.4.4. Response
The team members’ responses are coordinated through the flip chart paper and by the verbal or visual motions to the particular cell they are discussing and completing. No discussion topic was ignored and the continual build of the team to create humourous communities that met all the criteria demonstrates their ability to build ideas in response to their situation and their team members’ contributions. Crossing out, and adding criteria visually on the Pugh Chart displays their responses so they can keep track of where the discussion has evolved.

4.4.5. Attunement
The team is attuned to one another and to the activity. This can be seen through the manifestation of the team’s thinking on the flipchart paper and the clarifying discussions that occur to ensure everyone has a similar conception of the topic at hand. This is seen most evidently in the team’s rephrasing and elimination of criteria as they develop, together, a better understanding of the characteristics they as a team want in the community they work with. As a result of the team’s attunement to the similarities and differences in the understandings each team member voices, the team as a whole is able to build a shared conceptual space in which the different perspectives are acknowledged, and discussed until a collective understanding emerges.
Team 5 is comprised of 2 males and 1 female from the same first-year engineering discipline, taking the student-driven entrepreneurial design course. The team is comprised of Case, Grant, and Amy. None of the team members were English-dominant speakers, and were operating in their second or third language during all of their team meetings.

This section analyses Team 5’s interactions in their third recorded team meeting. Team 5 is in the midst of designing their poster for the final public presentation of their design that will occur one week from the day of this meeting. This incident occurs over an hour, during which the team discusses their title, their design focus, their design itself, and how they want to represent it on the poster they are laying out during the meeting.

4.5.1. Incident Description

At the beginning of the meeting, Grant wrote a series of consonants across the top of the white board, Figure 4-20, representing the words in the draft title of their poster. Grant and Case both move back and forth between the whiteboard and the table as they speak and eat their lunches. Amy is seated at the table with her laptop open. She is working on the design of the poster and so records wording and placement of information as it is discussed and tried out on the whiteboard. She is also eating her lunch at the same time.

The team begins their discussion by critiquing the title Grant has laid out on the board in letters. No one asked for clarification as to the meaning of these letters, they simply begin discussing whether the title has all the information in it that they want to convey. They can’t decide whether it has all of the information in the title, so Grant proposes that they move to the rest of the layout and then return to their title. He proposes to look at the poster their TA’s way – by organizing the poster according to the objectives of their design.

Grant initially holds a marker to write on the white board as they make suggestions about the organization of the information to be included on the poster. He passes the marker to Case when Case moves in to explain his ideas, Figure 4-21. Case returns the marker to Grant when Grant begins to add to, amend or move on with another idea.

As they attempt to decide on how they want to approach the organization of information in their poster, Grant begins to describe how he would approach a poster as someone who was unfamiliar with their project would approach the poster. Amy proposes a one-line summary of their design to introduce it to a reader. As they determine how to state this design problem, the team debates the meaning of multiple words that they used to describe their design’s purpose. Grant uses the white board as a composing area asking the others to be quiet as he figures out the phrasing of his intended meaning. They both silently watch Grant compose. When he finishes, the team reads his sentence, and then tries out different words to describe their users and their use cases. The description of the team’s design becomes more precise and clear through this discussion, which they agree will be clearer to a poster reader now.
Figure 4-20: Grant records the initials of their poster's title on the board while Amy and Case eat their lunches.

Figure 4-21: Grant and Case exchange the marker to give Case control over the whiteboard.

As they move on to discussing how they will represent the important features of their design, Case expresses concern that one of their key features is not fully represented. He goes up to the board, and points to one of the consonants recorded at the top of the board referring to their idea of energy efficient as an element of their design that needs to be represented in their poster, Figure 4-22. Grant agrees is not currently represented in their summary sentence. Amy argues that they cannot have everything represented in the title, and clarifies the meaning of certain words in their sentence that imply the meaning that Grant is missing. Grant is insistent that it is not clear enough, however Amy convinces the team that the meaning is in the words they have already chosen.
As the team explores the difference between the meaning conveyed in the sentence and their intended meaning, the team begins debating the energy efficiency of their design. Grant then uses the whiteboard as a computational space to determine whether they can argue that their wind turbine is actually an energy efficient means of powering their design. Ultimately, Case argues that the design needs to be more cost-efficient than energy-efficient, and the team accepts that they do not need to explore the energy-efficiency of their design any further in that moment.

Figure 4-22: Case uses the marker to direct the team's focus on the area he thought was important while the others look on.

Although Case and Grant began by passing one marker back and forth between them, Case acquires a marker of his own when he doesn’t wait for Grant to finish, but moves in to add to the poster layout. Amy remains at the table but watches the whiteboard carefully, building their poster on her laptop as Grant and Case continue to develop the poster design and freely interjecting her ideas and comments, Figure 4-23. Case insists that there needs to be a picture in the middle of their poster, which he adds to the layout without challenge.

When Amy speaks, both Case and Grant turn to face her. Either Case or Grant will record some of her comments and suggestions on the whiteboard. They speak in phrases, picking up and often finishing each other’s phrase or providing a word that the other is searching for. Even though Amy never leaves her seat, she reads what has been written on the whiteboard and gestures towards either words or sketches to emphasize or confirm everyone’s attention.
Figure 4-23: Amy records the developing poster in a virtual version while Grant records on the whiteboard the information he and Case are debating.

4.5.2. Use of Common Writing Space
The whiteboard, Figure 4-24, creates a physical, visual artefact that facilitates discussion and the creation of different representations and understandings of the purpose and content of their poster. It is a space for test running their ideas, a space where they can visualize the team’s thinking and can contribute to it verbally as well as physically. The whiteboard is also a holding area for ideas.

Figure 4-24: The whiteboard used by Team 5 which shows its use as a record of thinking.
4.5.3. Engagement
All team members were engaged in the discussion. They were committed to developing their poster and their understanding of their design. During these discussions gaze is always directed at the speaker or at the whiteboard, showing their commitment to working with each other. The team also shows their commitment to their work in their unwillingness to drop a topic until it has been resolved.

4.5.4. Response
The team members readily respond to one another, their contributions are focused and coordinated on the topic under consideration. They are attentive to one another’s ideas and contributions, willing to share, express agreement or disagreement or ask questions. The marker as ‘talking stick’ coordinates their response patterns and focuses attention on the speaker, even though others may interrupt to add or build the ideas. The whiteboard records their responses and then focuses their attention on that aspect of their discussion. In effect, the whiteboard represents the coordination of their thinking in demonstrating the evolution of multiple different concepts over time.

4.5.5. Attunement
Amy, Case and Grant are attuned to one another throughout this discussion. This can be seen in the way they follow on each other’s utterances, clarifying an idea, and building on what has been said, often before the speaker fully completes the utterance. This is also demonstrated in the way that they can work from a general idea to find the specific word that best fits their meaning. They do this by each sharing their ideas, and then debating them as a team until suddenly all agreeing once the right word emerged. The whiteboard focuses their attention, allowing them to visually work through their personal refractions of the concept they were debating by “staying on the same page” even when they change topics. The repository of ideas it contains for them, and the workspace it provides, allows the physical space to model the conceptual space in which they are adding, revising and modifying their understandings. Thus it facilitated their attention to the emergence of their shared understanding of their poster design, their design concept and their rationale for design decisions.

5. Discussion
This discussion aims to contrast the teams which succeeded and did not succeed at developing shared conceptual space through their engagement, response, and attunement within the team. The key difference between the teams was how they interacted with the affordance of the shared writing space.

Each of the teams had a different interaction pattern and the use of their shared writing space mirrored their interaction patterns. It also afforded team members a way to ‘see’ other team member’s contributions from a different perspective. For teams that used it effectively, the space represented a collective perspective or understanding that emerged from the use of the shared writing space. For teams that were less effective, it afforded them a way to see what each other was saying but not necessarily to build a shared understanding – they didn’t necessarily take
advantage of the space to engage with multiple perspectives. For these teams, no collective understanding emerged from their interactions with their shared writing space.

From our data, we have identified three different ways in which teams took up the affordance according to our togetherness framework. Other than Team 1, the shared writing space allowed the teams to operate one level higher in the togetherness framework than was seen through their interactions without using it – from engage to respond, or from respond to tune.

Teams 1 did not engage with the whiteboard because they did not interact with it as part of their discussion. It was for “the other” as a display of their work after the fact. They did not take up the affordance that the whiteboard could have provided to coordinate their conversations. Although the five individuals were in the same room at the same time for the same activity, they each remained in their own individual conceptual spaces pursuing their own individual goals, Figure 5-1. Thus, they could not respond to one another. Team 1 did not create a space of joint action, and thus a distributed conceptual space emerged. Because they chose to use the shared writing space for display only, they did not leverage the its affordances to create any shared conceptual space.

![Figure 5-1: Diagram of engagement-only conversation, nodes represent individuals and arrows represent the direction of conversation they are attempting to pursue.](image)

5.1. Engagement \(\rightarrow\) Response

The whiteboard serves as a mediational tool that allowed Team 3 to operate one level higher in togetherness than where they started their discussion – it afforded them the ability to respond to one another. Before Makin proposed drawing the posters on the whiteboard, the team members were engaging by providing their opinions, but were not able to compare them. By having the sketches of similar fidelity on the whiteboard, the team members were able to coordinate their discussion by “seeing” the others arguments in their perspective using the sketches of the posters on the whiteboard. Makin was able to see the relationship between the physical components and the functions of the design, Gregor was able to determine that Makin saw the figures of the casing and the whole as showing two different, but equally important, parts of the design, and Benjamin was able to see where Gregor and Makin were seeing the design differently. While they were able to use the whiteboard to see these different perspectives in a way that they couldn’t before sketching on it, they were not able to build a shared understanding as they continued to see their design from their perspectives only, Figure 5-2. They did take the
opportunity to see each other’s perspectives in the design, but did not take up the affordance of the whiteboard to see and represent each other’s arguments through the lenses of their own perspectives. Thus, the team was not able to negotiate and build a unified perspective with which to see (and work on) their design. Thus it allowed the team to be more effective than they would have been without the whiteboard as they were able to coordinate and respond. However, they did not leverage its ability to build shared understanding together.

![Figure 5-2: Diagram of engagement-response conversation, nodes represent individuals and arrows represent the direction of conversation they are attempting to pursue.](image)

5.2. Response → Tuning

With the teams that we saw attuned to each other, the shared writing space was used to either collaboratively co-construct an idea or to create a singular representation of a verbal co-construction of an idea. The common writing space was used to record only that which was mutually agreed upon or co-developed.

In Team 2, the whiteboard displayed the content of their discussion that provided an artefact that mediated their idea generation process. David stood at the whiteboard and constantly watched the other team members when someone proposed an idea. He coordinated the development of their conceptual space as he watched for comments, questions, clarifications or additions to the ideas before he would turn to begin to write. Sometimes he would initiate a clarification question himself to ensure his understanding and the recording of the idea matched that which the team intended. There appeared to be an understanding that he would not begin to record until there was a sense of shared understanding, guaranteeing that what was recorded was an accurate representation of what had been co-developed.

In Team 4 the paper mediated and focused the team on the concept that they were building of an acceptable community. As in Team 2, there was only one writer, Bart, and the two teams were similar in the way there appeared to be an understanding that nothing would be written without agreement and that what was written could be changed, e.g. crossed out, amended or ignored. However, Team 4 was physically much closer to the shared space allowing for the additional affordance of directly pointing to the word or area the speaker wished to focus on. All four team members made use of such gestures to ensure their idea as presented was the idea taken up by the team. Because of this the team was able to discuss all ideas until the team built their own understanding from the contributions of others into a shared perspective. In addition to constructing their shared understanding, the space also afforded them the opportunity to
recognize when their agreed upon community did not fit with the concept that had emerged from their discussion. By the team being able to identify this, it shows us how Team 4 was working from a space of joint action that gave them the ability to recognize and comfortably challenge the outcome of the design tools they were using.

Team 5 collaboratively used the space as an idea holder, composing space and negotiation space where they co-constructed their poster layout, their design and the process they were engaged in. They had two writers, Grant and Case. Both had shared access to the whiteboard although they respected each other’s turns, initially passing one marker back and forth, almost like a ‘talking stick’, allowing the speaker to use the marker and the whiteboard to develop his idea. Team 5, unlike Teams 2 and 4, used the shared writing space as both an individual and collaborative space. The whiteboard afforded both individual and collective development of candidate understandings. These candidate understandings were countered, challenged, modified, and built into a shared understanding that they were all willing to accept as their shared concept. In the end both Grant and Case had markers and moved fluidly in and out of the writing space, much in the same way their verbal utterances overlapped, completed and built on one another. Amy participated equally through her use of gesture, and interjection, and in her transcription on the computer of the ideas worked out on the whiteboard.

All three of these teams used the whiteboard to collaboratively develop a shared understanding of the task they were pursuing. They each used it as a way to understand the contributions of their team members, accept/counter/develop the idea into one that worked with their individual understandings, and build with each other through this process a shared understanding of the idea that represented all of their perspectives and contributions. We see this attunement, or togetherness, as the development of a space of joint action at the intersection of the team members individual conceptual spaces, where an agreed upon direction of idea development emerges, Figure 5-3.

![Figure 5-3: Diagram of attuned conversation, circles represent the conceptual space of individuals the arrow represents the unified direction of conversation they created.](image-url)
6. Conclusion and Implications for Supporting Student Design Teams

We have shown that teams who take advantage of a shared writing space are able to tune and collaboratively co-construct a shared conceptual space through the representation of their shared understandings. Shared writing space is an affordance that must be taken up by the students to be used effectively as a tool to mediate this process. The teams we observed took up this affordance in a variety of ways. However, we see that when student teams take up the shared writing space as a means of coordinating and consolidating their individual contributions and perspectives, they allow the teams to operate one level higher towards togethering — to move from engagement to response, or from response to tuning.

Three ways in which we have seen teams take up shared writing space effectively to build shared conceptual space are:

1) focus and coordinate a discussion and record a shared understanding that is visible to all team members
2) to make an explicit representation of implicit individual understandings to compare and adapt until those understandings are aligned
3) to represent the construction process of an idea for all to participate in.

Thus, simply providing a shared writing space for students to use is insufficient, something we saw with Team 1 who only used it as a display to authority. Students need to see shared writing spaces as a site for the development of ideas. This use needs to be modelled and introduced as a learning/design concept distinct from the ideation and selection tools in which students are asked to use it. Instructors, tutors and teaching assistants are in the best position to provide both the explanations and the modelling of the effective use of shared writing space in their interactive discussions with students. We propose that if instructors want to support the use of shared writing spaces then they need to introduce the idea and the rationale for its use to their students. They need to talk about how a shared writing space can provide a place in which students can build models of their thinking and of their ideas that others can see and respond to. They also need to demonstrate this practice through samples of their or other’s work (images of shared writing spaces, models and paper prototypes) as well as in their direct interactions with students and student teams.

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