Observations of teamwork and social processes in design

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This paper analyses the teamwork experiment of the Delft Protocols Workshop, with particular reference to design activity as a social process. Observations are made on the following aspects: on the roles and relationships within the team, on their planning of the design process and their actions relative to that plan, on their gathering and sharing of information, on their ways of analysing and understanding the design problem, on their ways of developing and adopting design concepts, and on their resolution and avoidance of conflicts. We conclude that the social process of design interacts significantly with the technical and the cognitive processes of design.

Keywords: protocol analysis, teamwork, design process, collaborative design

Most of what is known about design activity and the design process comes from studies of individual designers[1]. Teamwork in design has been studied relatively little. However, teamwork is of considerable importance in normal professional design activity, and is becoming of even greater importance in product design as it becomes a more integrated activity. There has been a growing number of studies of teamwork, particularly in the context of computer supported cooperative work (CSCW)[2]. In this paper, we draw observations from the three-person team design session recorded for the Delft Protocols Workshop.

Working as a member of a team introduces different problems and possibilities for the designer, in comparison with working alone. Some of the areas of difference can be surmised from the practical necessities of

1 **Cross, N** 'Research in design thinking' in **N Cross, K Dorst and N Roozenburg** (eds) *Research in design thinking* Delft University Press, The Netherlands (1992)

2 **Olson, G M, Olson J S *et al.*** 'Small group design meetings: an analysis of collaboration' *Human-Computer Interaction* Vol 7 (1992) 347–374

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the situation – such as the need to communicate with other members of the team – and some others we have noticed from observation of the particular team recorded in this experiment. We have selected the following aspects for observation

- Roles and relationships
- Planning and acting
- Information gathering and sharing
- Problem analysing and understanding
- Concept generating and adopting
- Conflict avoiding and resolving

In a team there will be various roles and relationships to be acted out, which will affect the work of the team in some way. It has been conventional in considering design teamwork to ignore these social or psychological factors of group dynamics. However, the social dimension of teamwork in design has been acknowleged more recently[3,4]. There are some aspects of the *roles and relationships* within this particular team that we feel are important to comment on.

Whether working alone or in a team, it would seem necessary to have to plan one's activities to fit within the available time, but in fact overt planning of activities is not always evident either in individual or teamwork. Furthermore, it seems to be necessary in design work for unplanned or 'opportunistic' activities to be pursued when they are perceived as relevant by the designer[5]. This particular team does overtly plan its activities, but if opportunistic activities are to occur, it should be interesting to investigate how *planning and acting* are handled by the team.

In any design task, information relevant to the task has to be gathered from a variety of sources. Information search strategies for designers are poorly understood[6]. A particular feature of the experiment design of this study is that information on aspects of the problem were kept in a file by the experimenter, to be given to the designers if and when they ask for particular items. This formalizes and makes explicit and observable some aspects of the necessary *gathering and sharing of information* that any team would have to undertake.

In design, it is not normal to have a clear and immediately apparent problem given as the task, in the way that is normal in other problem-solving studies. The ill-defined nature of design problems means that *analysing and understanding the problem* is an influential part of the design process[7]. Individual designers can form their own, possibly idiosyn-

3 **Minneman, S and Leifer, L** 'Group engineering design practice: the social construction of a technical reality' in **N Roozenburg** (ed) *Proc. Int. Conf. Eng. Des. ICED93* Heurista, Zurich, Switzerland (1993)

4 **Branki, N, Edmonds, E and Jones, R** 'A study of socially shared cognition in design' *Environment and Planning B: Planning and Design* Vol 20 No 3 (1993) 295–306

5 **Guindon, R** 'Designing the design process: exploiting opportunistic thoughts' *Human-Computer Interaction* Vol 5 (1990) 305–344

6 **Kuffner, T and Ullman, D** 'The information requests of mechanical design engineers' *Design Studies* Vol 12 No 1 (1991) 42–50

7 **Fricke, G** 'Empirical investigations of successful approaches when dealing with differently précised design problems' in **N Roozenburg** (ed) *Proc. Int. Conf. Eng. Des. ICED93* Heurista, Zurich, Switzerland (1993)

cratic understanding of the problem, but a team has to reach some shared or commonly held understanding of the problem.

Since a design task also means that the goal is to produce a design proposal for some artifact, it is necessary to generate some ideas or concepts for what that artifact might be. An advantage of teamwork over individual work should be that a greater number and variety of concepts are generated[8]. Again, in teamwork it will be necessary to communicate and share such concepts and ideas. It should be interesting to see how the *proposing and developing of design concepts* are handled by the team.

A disadvantage of teamwork is likely to be that conflicts will arise between team members[9]. Different interpretations or understandings of the problem may become evident; different design concepts may be favoured by different members of the team. An inevitable part of design teamwork would therefore seem to be *identifying, avoiding and resolving conflicts*.

The aspects selected and identified above are built around a framework of studying essential or key processes of design – planning, information gathering, problem analysing and concept generating – within a context of teamwork and social processes. There are several other aspects of teamwork which we do not have space to address here: a significant one would be the using and sharing of the available work-media (drawing pad, whiteboard etc.).

1 Roles and relationships

An obvious difference from single-person work is that the team members have roles and relationships within the team, relative to each other. In a normal work situation, some of these roles and relationships may be formally established; for instance, there may be seniorities of position established within the team, there may be a team leader appointed by a higher authority within the organization, there may be particular job roles.

We do not know the normal working background of the team members of this experiment (I – 'Ivan', J – 'John' and K – 'Kerry'). We do know that they all work for the same design consultancy firm, have approximately equal previous design experience, and have very similar job roles within their firm. We assume that they are all approximately equal in the hierarchy of their normal work situation, and that there were no predetermined roles that they brought with them to the experimental session.

8 Visser, W 'Collective design: a cognitive analysis of cooperation in practice' in **N Roozenburg** (ed) *Proc. Int. Conf. Eng. Des. ICED93* Heurista, Zurich Switzerland (1993)

9 Klein, M and Lu, S C-Y 'Conflict resolution in cooperative design' *Artificial Intelligence in Engineering* Vol 4 No 4 (1989) 168–180

However, we observe from the video recording that different roles within the team were adopted. Some of this role-adoption was formalized within the team. Some other potential role-adoption behaviour was not acknowledged and formalized within the team. Informal role-adoption is evident through repeated patterns of behaviour or types of comments by an individual.

Let us illustrate this with just a few examples from the ways we saw roles and relationships being established and played within the team, and influencing what happened.

- Immediately after reading the brief, Kerry suggested that they begin by reviewing the design of the existing prototype

> K what do we need? I guess we should look at their existing prototype, huh?

John suggests a different activity – checking that they all share the same understanding of the problem

> J yeh, em, let me think; we could also just sort of like try to quantify the problem, because – what's your understanding of the problem first of all?

This 'problem clarifying' activity is then adopted as the first shared activity of the team, Kerry's suggestion has been over-ridden.

- During the 'problem-clarifying' activity, Kerry suggests that gathering information from the user evaluation report would be a useful activity

> K they're not pleased with it so far, and the users' tests have some – in in fact it would be nice if we could see those users' tests to em see what the shortcomings were

This suggestion is ignored by the others. Shortly after, during the

scheduling activity, Ivan mentions use of 'information' in the context of refining initial concepts. At this, Kerry again suggests that the user evaluation report might be a source of useful information. Again, this suggestion is not acted upon, and is dismissed as irrelevant to the task in hand

I	information or
K	yeah we wanna look at the em customer feedback or the users' testing
I	oh-yeah, so maybe, yeah, wherever that comes in in this list . . .

A little later still (and after meanwhile requesting from the experimenter the information on the target selling price of the product), Kerry eventually gets to ask for the user evaluation report – but note that now with the addition of Ivan's intervention

I	I think I'd also like to get the information on em
K	the user testing
I	the user testing

- After the 'problem-clarifying' discussion, Ivan suggests that they should prepare a schedule, and John and Ivan proceed to do this. Later, Ivan begins to sort out the various documents on the table top. John takes the opportunity to suggest that Ivan should adopt the role of being in charge of scheduling

I	. . . let's get this stuff sorted out
J	OK you you were talking about schedule stuff before, do you wanna
I	yeah, I think we should uh just figure out
J	just set some time limits for ourselves

Later again, when Ivan is planning the schedule, this role is confirmed for him by John

I	five-thirty we'll move on to the final cost and presentation . . . let's leave ourselves a little bit of time
K	mm mm
J	Ivan's gonna be Mister Schedule
I	yeah [. . .] on time, under budget

Ivan adopts the scheduler/timekeeper role, and plays it throughout the session.

In these examples, we see that Kerry apparently experiences difficulty in getting the team to proceed in a way she would prefer; that Ivan apparently accepts quite happily a facilitator role as timekeeper; and that John apparently has a strong influence on what happens in the team. We believe that these examples demonstrate some of the patterns of roles and relationships within the team that are evident throughout the session. However, these roles and relationships are not simple. For instance, each member at times may take a leadership role, although playing that role in a personal style.

Much more analysis could be made of roles and relationships within the team than we have been able to do here. For instance, it would be relevant to take into account what members of the team are doing whilst others are actively 'centre stage'. Such apparently temporarily nonactive members could be 'doing nothing'; or they could be working independently – whether on the current main activity or some other; or reflecting constructively – perhaps drawing; or pursuing another line of thought; or being attentive and tacitly supportive; or being distractive and unhelpful. Study of body language, for example, would need to be included in this kind of more in-depth analysis. Other forms of action and expression also appear to be very relevant, such as the use of laughter and jokes as ways of covering behaviour and avoiding conflict.

2 *Planning and acting*

Within this team there is a consciousness of planning: members of the team are particularly aware of planning their activities and of keeping their activities to a schedule. This may seem like normal procedure for a team, but in fact not all teams in similar situations construct such an overt procedure as this team does.

Conventionally, much design activity – particularly in the conceptual design stage – is unplanned, intuitive and *ad hoc*. Other protocol studies

of designer behaviour have made clear the 'opportunistic' behaviour of designers, which occurs when they deviate from the current or planned activities in order to pursue ideas as they occur. It has been argued that opportunistic behaviour is appropriate behaviour for designers. However, this must create difficulties in teamwork, where activities need to be co-ordinated, and an opportunistic deviation initiated by one member may be seen as irrelevant by another. Our analysis here attempts to observe how this team deals with these aspects of planning and acting.

2.1 *There is explicit planning of activities and scheduling of time*

Planning is initiated when Ivan suggests that they should prepare a schedule of activities, rather than just doing *ad hoc* activities

I	should we uh prepare a schedule and then just sorta stick to it, or should we uh just start working?
J	no, it's probably a good idea to try to quantify our amount of time; the kinda time we have left (laugh)

Ivan and John proceed to list a design procedure (Figure 1)

- Quantify the problem
- Generate concepts
- Refine concepts
- Select a concept
- Design
- Present
- Test

This procedure seems to be derived from a conventional model of the engineering design process. Ivan and John seem to share a view that this is an appropriate design process to adopt, and this process is in fact broadly followed through the rest of the session.

However, whilst Ivan and John are listing this procedure, Kerry writes on the drawing pad a list which appears to be an alternative procedure (Figure 2)

- Understand
- Observe
- Evaluate

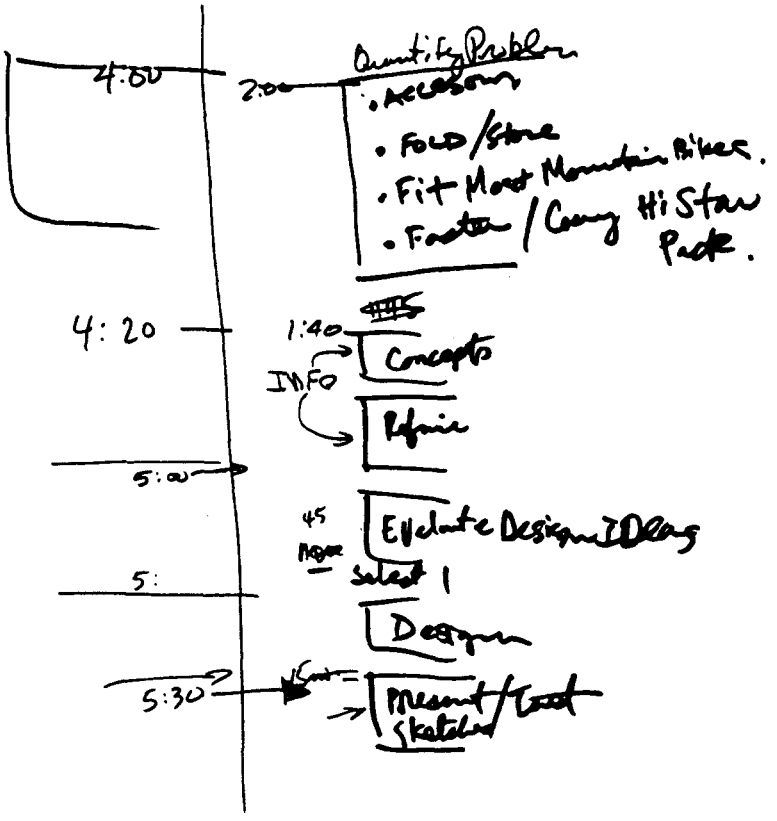

Figure 1 John and Ivan's plan for the design process

Kerry does not draw any attention to this list, it seems to be something personal, like the personal diagram of the problem she has made previously. (This other diagram will be referred to later, under 'Problem analysing and understanding'.) This alternative procedure (if that is what it is), together with Kerry's apparent desire to start with gathering information on the existing prototype design and the user evaluation of this, suggests that she might have preferred to pursue this design task from the starting point of evaluation of an existing design. This is also a conventional approach to a design problem, often adopted by experienced designers.

2.2 *A role of 'scheduler/timekeeper' is assigned to one member*

In making the first suggestion that a schedule of activities should be

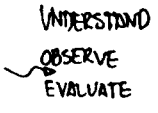

Figure 2 Kerry's plan?

prepared (see earlier transcript), Ivan seems to 'volunteer' as the scheduler, and is confirmed in this role by John. At important points, Ivan draws attention to schedule and time

I	we have to start making decisions, we're already at five-fifteen

At important points, Ivan remembers to draw attention to schedule and time, and towards the end of the session he keeps the time pressure on the others; for example

I	OK um keep moving along, we have er fifteen minutes to finish our design

2.3 *At times someone will draw attention to what to do next or what they should be doing according to the plan*

During the listing of requirements (John using the whiteboard), Ivan and Kerry are involved in discussing some structural design implications arising from considering the existing prototype design. Kerry makes a suggestion about the design of the mounting forks. John suggests that they are 'moving on to ideation', and brings attention back to the scheduled task of listing requirements

K	it'd be nice if you could have the forks coming more like that, so that
I	right
J	mm mm
K	the bouncing
J	it sounds like
K	these'd have to be self-attached
J	it sounds like in a way we're starting to move on to ideation already, but uh have have we kinda fleshed these major things out?

After listing design requirements, Ivan suggests it is time to move on to

generating ideas. (John agrees, but decides to check through the information again)

I	OK shall we move into uh idea-ideation?
J	yeah; I think we've, have we covered the uh all the stuff that (inaudible)? I'll just read some of this out loud 'cos I (reads from marketing report)

2.4 *There are unplanned discontinuities of activities*

Despite the conscious planning that the team undertakes, not all activities proceed strictly according to the plan, and there are some curious discontinuities of activities.

These discontinuities are usually initiated by one member of the team, who draws one or both of the others into this unplanned activity.

During the period of information gathering and listing of requirements (John listing requirements on the board), Kerry suddenly shifts attention to the design of the existing prototype

K	(referring to drawing) now this looks like a snap-in feature

This observation is then taken up by Ivan, and Ivan and Kerry spend a little time discussing structural design implications of the jolting and vibrating motion of the backpack on the rack. This leads to Kerry making a suggestion about the design of the mounting forks (this is an example of an opportunistic deviation leading to a suggestion for a design feature)

K	it'd be nice if you could have the forks coming more like that

During discussion about alternative materials, John asks for a tape measure and begins to take measurements of the backpack frame. This activity displaces the previous listing activity, and Ivan and Kerry get drawn into it (e.g. John asks for the measurements he is reading off to be recorded)

J	do you have a ruler or a measuring tape anywhere?
Ex	Yes there is a ruler
J	just wondering how big this rack is; oooh . . . this looks like
I	eighteen
J	em eyeballing it looks like seventeen
I	OK
J	seventeen there, and em shall we record some of this stuff?

Later, John acknowledges that his measuring activity had interrupted the previous activity, and gives a justification for it – his train of thought had been triggered by earlier comments about strength and stability

J	I kinda disrupted our materials discussion but I was
I	that's OK
J	when Kerry started talking about sorta the strength issue I was thinking well how big are we looking at?

Kerry then immediately returns the discussion to strength and stability.

A little later, discussion falters, during generation of ideas for the kind of rack that might be designed. After a pause, Kerry resumes discussion with something that concerns her – how to make a 'nice connection' between the rack and the bike frame. Johns turns away to ask the experimenter for information on dimensions of the backpack; the experimenter provides a drawing. Kerry and Ivan continue to discuss the issue of a bracket design. John inspects the drawing but then abandons it when he realizes it has Dutch writing on it, and interrupts the others

J	OK who reads Flemish or Dutch or whatever this is?
I	where is it?
J	there's not too much on there (laugh)

John rejoins the discussion about the connector design. The drawing is abandoned; no information about dimensions of the backpack is gained.

2.5 *Activities may be initiated tacitly, rather than there being a formal decision to undertake the activity*

When Ivan suggests it is time to move on to the ideation phase, John agrees, but begins reading aloud from the brief in order to check that the listing of requirements is complete. Whilst he is reading, the other two become restless: Ivan gets up and goes to look at the bike; Kerry finishes her coffee, gets up to put the cup in the bin, then picks up the backpack and goes to the bike with it; Ivan lifts the bike down from its stand; Kerry positions the backpack behind the saddle. Nothing prior is said: there appears to be a tacit agreement between Ivan and Kerry that they will work directly with the bike and the backpack at this point. They are ignoring John, who concludes reading and then goes to join the others at the bike, and immediately enters into the activity, suggesting that they fill the backpack

> J So I think we've covered that . . .
> is there anything we could put like some weight into this? to kinda give us the right

Although they had earlier agreed that it was time to move to ideation, there was no overt decision about how to do this.

John now straddles the bike and begins to talk about placing the backpack within the central diamond of the bike frame. Kerry points out the impracticability of this; she holds the backpack in the position behind the saddle that the prototype design has adopted. John suggests positioning it in front of the handlebars. Ivan records suggestions on the board. The team has now entered upon an activity of considering alternative mounting positions for the backpack, but there was no overt decision made to adopt that activity.

2.6 *There is opportunistic drifting from the agreed plan*

One form of opportunistic deviation from a plan is 'drifting'. For example, during discussion of weights (of the backpack; of the product that is to be designed), Kerry asks for information on existing bike racks (presumably to check the weight of comparable products). When this information is made available, it becomes more interesting as a source of design ideas

K this looks a lot like the little backpack frame doesn't it?
I yeah . . . you see we've been, it seems like mentally trying to just, because of a similarity in size and shape between the two, thinking of ways to er use the same product for the same thing but I dunno that we necessarily – I mean we're on a target for $55, I mean if they're able to make that for 42.95 . . . and if we just add a plastic part

This discussion further develops into talk based on Ivan's experience with a child seat on his own bike. After a while, John brings the discussion back to the consideration of the weight of the product

J can I interject here?
I yeah
J on our weight spec, if you just wanna sorta look at these they have weights; yeah they're between 430 grams to er 630 grams

These tacit and unplanned, drifting and discontinuous changes of activity mean that it is not always easy to track what is actually happening in teamwork. This has implications for the construction of design 'rationales' and for the design of support systems which must tolerate such implicitly understood shifts of activity.

3 *Information gathering and sharing*

The difficulties experienced by Kerry in persuading the others to collect items of information early in the session have already been referred to. The experiment design, with its controlled access to the available information, means that gathering information is a more overt activity than it might be otherwise. Relevant information not only has to be gathered, as in any design task, but also extracted from its source and somehow shared among the team.

3.1 *Gathering and sharing of information is not formalized*

Kerry is the team member who first identifies that it might be useful to gather some of the specific information that is available, and which is mentioned in the brief. In doing this she is effectively 'volunteering' to be the information-gatherer for the team, in the way that Ivan 'volunteered' to be the scheduler/timekeeper. A formal role for an information

gatherer/sharer might have been instituted by the team, in the same way that a scheduler/timekeeper role was instituted.

Despite the difficulties in 'persuading' the others to agree to gather information, within the first 15 minutes of the session, Kerry asks for, and receives information on the target selling price, the user evaluation report, and the prior prototype design. She interrupts the listing of the 'functional specification' on the board by Ivan and John to ask for information on the target selling price when this is mentioned as an item for the specification

J . . . cost target, we don't really know what that is (laugh)
K low
J low but
K maybe they have a – do we have that information, let's see do we ask for em – do we have any specification on what the uh reasonable price range is?

Having gathered several items of information in the form of reports the team tries to assimilate all this new information by simultaneous reading of the reports over each other's shoulders. Some parts (which apparently interest them or seem relevant to them) are read aloud by individuals. No formalized method for gathering and sharing information is instituted by the team, apart from the 'public' listing of requirements and concepts on the board.

At one point in discussing the removability of the rack, 'theft' is raised as an issue. Kerry refers to the marketing research report.

I was theft er an issue?
J er let's see – user marketing research?

Kerry then reads through the marketing research report, while the others continue to list design requirements, and 'theft-proof' is added to the list. In fact, there is no mention of theft as an issue in the marketing research report, but Kerry does not report this.

3.2 *Errors in understanding the design requirements, misinterpretation of the information and forgetfulness of requirements are evident*

There is no suggestion in the design brief that anything other than the specific, 'HiStar' external-frame backpack is the backpack for which the carrying/fastening device has to be designed, and the experimenter also makes this clear. But both Ivan and John are confused about this, and Kerry has to correct their misinterpretation

J	OK I missed that
I	which part did you miss?
J	oh the fact that – I I thought I picked up that they were going to, that they were conceiving of making an internal frame pack but em I guess that's not what they're saying; you're saying that they make external frame packs currently?
K	mm hmm they make external
J	does it say that they want to stick with that?
J	well it doesn't say anything about going uh external or internal so that I think that you raised a good point
K	they just, yeah
I	yeah that we have that freedom right now
J	OK maybe we could get something that we're gonna propose to them that if it has any advantage in this application, right?
I	sure
J	OK
K	but they wanna use it with this external frame backpack it looks like
I	right with this, well let's see
K	because the HiStar, this this is a best-selling backpack, the mid-range HiStar
I	right and they have their best-selling bike, right
K	they've decided to develop an accessory for the HiStar

Late on in the session, as details of the concept design are being resolved over a drawing, Kerry and Ivan have forgotten that a requirement mentioned in the brief is that the device 'should fold down, or at any rate be stacked away easily'

K	what, the rack has to fold?
J	yes the rack has to fold
K	where does it say that?
J	is says that in our spec
I	where?
K	our spec?
J	says right here
K	(reads from brief) should fold down or – stacked away easily

3.3 *Misunderstanding of apparently shared concepts is evident*

Ivan and John make several references to the 'rooster tail problem'. Kerry does not query this until quite late in the session, when it becomes evident that she has not shared the same concept as the other two. She asks if they are referring to a particular strap on the backpack, whereas they are actually referring to the splashing of water/mud from the rear wheel of the bike onto the rider

K	we're calling this the rooster tail, this little tail?
J	no, the rooster tail – when you, when you ride in the rain and it goes whoosh all over your

3.4 *They use personal knowledge, and are prepared to rely on this individual experience or knowledge*

Kerry's experience with bike riding is referred to early on by John, as the backpack is being prepared by having things stuffed into it

J	you ride with a pack on occasionally don't you Kerry?
K	I used to use my em bike courier bags 'cos those don't pull on my shoulder

Later, Kerry refers again to her own experience and offers an opinion on off-centre loading

K well I've done a lot of lake touring and I've done front panniers and I've done rear panniers
[. . .]
K yeah front panniers, you could, you could set it up so you could have one of these on each side – there's no guarantee you'd always have two but it's actually not as bad as you'd think to have just one that's off

Further on, discussing whether braze-on mounting positions are standard on mountain bikes, Kerry claims that they are, and John defers to her 'expert knowledge'

K but these are pretty standard though
J the lower ones I would agree, but the uppers?
K that's pretty standard too
J the uppers are?
K it's getting to be, yeah; I mean it's not on this, but – actually some mountain bikes are pretty scoopy and weird, but
J we can assume Kerry has expert knowledge (laugh)

The errors and misunderstandings suggest that the team did not have a very effective strategy for gathering and sharing information. The fact that this was a short, experimental design session, and that there was relevant personal knowledge available within the team probably significantly affected the team's strategy. However, the reliance on personal knowledge, rather than public and more formalized knowledge sources, could again create difficulties for support systems and rationales. Even when information is apparently shared, misinterpretations and misunderstandings are evident, which means that common, shared understanding cannot be assumed in collaborative work.

4 Problem analysing and understanding

The first shared activity of the team is to seek a common understanding of the problem. An attempt is made to externalize this understanding of the problem, through listing design requirements and specifications in a public form. Attempts are also made to create a more internalized understanding, through 'framing' the problem in some more intuitive or conceptualized form.

4.1 Listing and framing are used as means of understanding the problem

During the initial discussion and clarification of the problem, John starts to list on the drawing pad a set of design requirements. Listing requirements becomes the principal activity by which the problem is summarized and shared through use of the large, public whiteboard. However, immediately after the initial problem-clarification discussion, whilst John re-reads aloud sections of the brief, Kerry makes a small, personal drawing on the drawing pad which is a diagram of the problem, showing in a graphic form the basic concept of what has to be designed, an accessory that links the backpack to the bike (Figure 3). This may be an example of 'framing' the problem in a way that helps the designer to internalize, as well as externalize her understanding of the problem.

Problem framing may also develop through verbal exchanges. For example, during the listing of the specification of design requirements, Ivan and Kerry become involved in a discussion of the problem, based on understanding how people are expected to want to use the bike and backpack together

I	do they talk about how the people wanna use it? They uh do these, do the vacations – they take long bicycle trips and then take short feet off uh short trips off by foot
K	mm mm
I	em so they use the bike to get where they're going and then do a little hiking; sounds like the bike becomes the
J	so you
I	it sounds like they wanta really ride the bicycle and just temporarily go to work or something but you wanna be able to ride the bicycle
K	right mm mm
J	does it sound like
K	ride it through the country and then you get to the base of the hill and you wanna take your backpack and summit the mountain or something
I	mm hmm
J	so
I	so you want like a real
K	and it's an off-road bike so you'd need a real rugged rugged attachment or a rigid attachment
I	mm mm

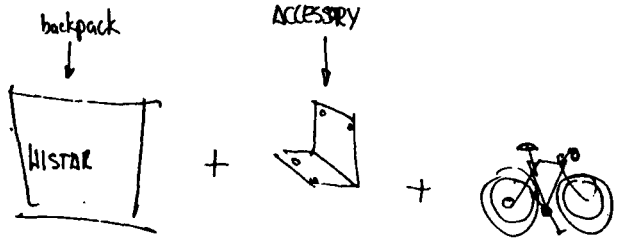

Figure 3 Kerry's diagrammatic 'framing' of the problem

This conversation is probably instrumental in provoking a later design concept proposal by Kerry for the rack to double as a lock when the bike is left unattended. John interrupts this problem-framing discussion to bring attention back to the listing of a specification of the design requirements, introducing an attempt to quantify a particular requirement

> J so what's a reasonable time to like allow somebody to take this off their bike – should it take like under five seconds or under 30 seconds?

There is a contrast, and perhaps a conflict between attempts at problem-understanding through 'listing' and through 'framing'. Listing establishes an externalized specification, but it does not necessarily lead to an internalized conceptualizing or grasping of the problem in the way that attempts to 'frame' the problem do.

5 *Concept generating and adopting*

Clearly it is necessary for the team to generate design concepts, and jointly to build those concepts into a specific design proposal. The team therefore has to develop initial concepts into more detailed and robust versions, and it has to decide to adopt certain concepts from among the many that may be proposed. Two kinds of concepts are proposed by team members: general principles that should underlie or figure in the design solution, and specific ideas for the solution concept or a feature of the solution concept. An example of a general principle would be to make use of the existing frame of the backpack

K	you've already got that nice frame on the pack – it'd be nice if we can take advantage of that, it seems redundant like this . . . it seems redundant to have that and the frame

An example of a specific idea would be to propose the concept of a tray

J	maybe it's like a little vacuum-formed tray kinda for it to sit in

There are many concepts proposed by the team members; the above are just two examples. We do not propose here to analyse further the proposing of concepts, but to focus on the ways concepts are developed together by the team and how team members persuade the others to adopt concepts.

5.1 *Concepts are built co-operatively*

A design proposal may begin life as a very sketchy concept that has to have a lot of development work put into it. Concepts need to be built up, with additions and variations being developed to turn the initial idea into something more robust. There are many examples of this concept building by the team members, co-operatively adding to and refining an initial concept.

Bike lock/bike stand

K	maybe if you could flip it out and it becomes a bike lock, 'cos you know – lock up your bike while you go on a hike, that'd be kind of a neat feature so you could justify some extra cost maybe
I	right, right
J	kick-stand alternative (laugh)
I	pull it around your tyre and now you can stand the bike up

Shoulders/child/manikin

K what's what's kinda neat about their thing – it's not really a bag that this rack goes up inside those um webbing details in the back
I right, that are already there
K that kinda envelopes it – it doesn't sit cinch down on this, which we could add, but it's kind of a nice nesting feature
J maybe the rack wears the backpack straps just like we wear the backpack straps
K sure
J (laugh)
K why not, see, like you mount shoulders back here
J yeah, yeah, just maybe maybe you just mount a child seat back there and you give them a child (laugh) and make him wear the backpack
I or a manikin
K a manikin
I with the top towards the
K Harry the backpacker holder

Net/retractable net

I uh uh what if your bag were big er what if your your on er if this tray were not plastic but like a big net you just sorta like pulled it around and zipped there, I dunno
J maybe it could be part maybe it could be a tray with a with a net and a drawstring on the top of it, I like that
I yeah I mean em
J that's a cool idea
I a tray with sort of just hanging down net you can pull it around and and zip it closed
J (inaudible)
K it could be like a a a window shade so you can kinda, it sinks back in so it just
J oh yeah
I it retracts yeah
K you pull down it retracts in

5.2 *Persuasive tactics are used to get favoured concepts adopted*

As well as co-operating in the building and refining of concepts, team members may find it necessary to persuade the others of the value of a concept they particularly favour (usually a concept they generated themselves). It is common for designers to become committed to particular concepts, even to the extent of becoming emotionally attached to a concept. There are two clear examples within this team of the need to persuade others to accept a preferred concept. In the first, John persuades the others that his 'tray' concept is the best to adopt; in the second, Ivan and Kerry persuade John to accept the use of the fixed, brazed-on mounting points on the bike frame.

The tray concept initially just pops up as an idea

> J so it's either a bag or maybe it's like a little vacuum-formed tray kinda for it to sit in

The concept is quickly adopted and discussed, with ideas being added to it, but John takes care to ensure that it is added to the public list of solution concepts

> J I think tray is sorta a new one on the list it's not a subset of bag

John also confirms that he is emotionally attached to the concept

> J yeah, I, I really like that tray idea (laugh)

This emotional commitment is reinforced by a claim that selecting a preferred concept is a 'popularity contest', which is passed off as a joke by Kerry

J	I think all design eventually comes down to a popularity contest
I	(writes on board) tray
K	I hate that idea
J	(laugh)

When it becomes time to proceed with one preferred concept, John is quick to nominate the tray idea

J	well OK well we know we we like this tray idea, right?

The second example of persuasion is based around using the brazed-on mounting points. This is strongly supported by Ivan and Kerry; John has some reservations, but acknowledges Kerry's 'expert knowledge'

J	so I I guess my point is I think if you designed it specifically around mounting points – known mounting points on this bike – you might get yourself into trouble by limiting your market a lot
K	but these are pretty standard though
J	the lower ones I would agree, but the uppers?
K	that's pretty standard too
J	the uppers are?
K	it's getting to be yeah, I mean it's not on this, but actually some mountain bikes are pretty scoopy and weird, but
J	we can assume Kerry has expert knowledge (laugh)

When it comes to making a decision, Kerry conveys her commitment and attachment to the braze-ons with an enthusiastic response

I	we're gonna go with the rack, let's go with er talk about braze-ons – these braze-ons?
K	yeahhh!

John still has doubts, and wonders why the designers of the existing prototype design did not use the braze-on mounting points, but Ivan closes the argument by denigrating the other designers

J	see here's something that just surprises me is – why if the braze-ons are available, why wouldn't they have used them?
I	'cos they're not hot designers!

6 *Avoiding and resolving conflicts*

It is probably inevitable that disagreement will arise between members of a design team. We have already seen that disagreement arose within this team over whether to use the braze-on mounting points. More serious disagreement might have arisen if there had been competing design concepts to which different members of the team were committed. However, provided that a team collectively desires to reach an acceptable conclusion to their design task, it will have to find ways of resolving, or perhaps avoiding conflicts.

In this team, we observe instances where the team members acquiesce in a kind of noncommittal 'agreement' until one of them finds an argument that closes the disagreement, and where they postpone agreement and seem to 'agree to disagree'.

6.1 *Noncommital 'agreements' are reached*

A disagreement becomes evident over designing for adjustability in the rack. John proposes that the support legs of the rack should be adjustable, but Kerry feels sure that this is not necessary

J you know one of the things that seems problematic, and it would be great from a manufacturing standpoint if you could get around it, is this distance is going to vary with frame size all over the map

I right

I but so, y'know, we were talking about maybe those legs could extend before so that you could get some adjusability on your rack, maybe you need that anyway just so that you can adjust to different rack styles – like a telescoping tube here

J mm mm

[. . .]

K I don't think you really need it

I (laughter) OK

K because this is a 26 inch wheel or whatever, it's pretty standard and so if this distance – you're right it just does vary a lot, but what's gonna change is maybe your angle on your on your rack is gonna change er er what really is gonna happen is is this is gonna be a fixed distance because if we go onto the braze-on or something down here and and you want to make sure that there's clearance here and then as the bike grows it might pivot up a little bit more

Later, John returns again to the adjustability issue, appealing to the authority of 'good human factors'. Both Kerry and Ivan make rather noncommittal 'agreement' responses; Kerry just shrugs her shoulders, Ivan says 'OK'. Their doubt is evident to John, who admits that what he is suggesting is 'opinion not fact'. Ivan resolves the issue for the time being by suggesting that they can 'look at ways of making it adjustable' when they are finalizing their design

J I think good human factors says it should be adjustable so that people can find the position they like

(K shrugs)

I OK

J em that's my opinion

I whatever idea we come up with I think we can

J opinion not fact (laugh)

I we can look at ways of making it adjustable

6.2 *An argument is found that closes a disagreement*

The noncommittal 'agreement' over adjustability is not permanent. At a later point John proposes a way of incorporating adjustability into the design, but Kerry comes up with an argument that resolves the disagreement in her favour – if adjustability was necessary then it would feature in the commercially-available rack designs of the Blackburn company

J	one way to get that adjustability for the seat post height and all that stuff is if this, say this was a single bar and it went like this
K	mm mm
J	and it could slide along here, that way if you need to come up more, y'know pivots around the braze-ons if it needs to come up more for a taller person or for better wheel clearance or whatever, you just kinda slide it forward and put little lock-downs on it
K	yeah yeah, I don't think you need to change this length 'cos the wheel is fixed enough that you can rotate about the braze-on, and I mean if if you really need adjustment I think all these Blackburn racks would have adjustments

Interestingly, the work of other designers can be used either to support an argument (as here in Kerry's reference to the Blackburn designers) or to refute an argument (as in Ivan's earlier reference to the 'not hot' designers of the prototype device).

6.3 *Disagreement may remain unresolved for the sake of expediency*

John disagrees with Ivan and Kerry over their proposal to include with the rack an Allan key for fastening/unfastening the rack to the mounting points. Because time is running out, Ivan suggests that they keep going without resolving this issue for the time being

J I think 'no tools' – they should come off with no tools, except for
I maybe it should be an option
J well except for the thing that you wanna lock
I well see, OK, OK
J (laugh)
I well let's keep going – we can we can add features later

When the question of attaching the rack to the bike in a theft-proof manner is raised a little later, Kerry returns to the proposal to bolt the rack to the mounting points, using an Allan key. The disagreement on this issue is not resolved, but is defused by everyone becoming jokey about it, and Ivan and Kerry poking fun at John's alternative (time is running out and they want to reach a conclusion)

I I'm talking lock in terms of theft
K yeah
J right um and I don't know how we address
K that doesn't address that
J yeah this doesn't address that yet
K that's why a nice Allan wrench and bolt is nice
I we'll just throw it in, have this and the other thing, yeah
K mm mm for the Johns of the world
I mm mm
K they can use these expensive
I ugly
J (inaudible)
K aerodynamic-drag, heavy
J I'll just evaluate my idea now!
K (laugh)
I no, I think that's a good idea
J oh yeah!? (laugh) uh uh
I OK
J they're ganging up on me! (laugh)
K help I want out of this design exercise!

7 *Conclusions*

It is perhaps important to point out that this particular group of designers worked productively as a team and reached a relatively successful conclusion to the set task, within the prescribed time. In the debriefing after the working session, they reported that they were reasonably happy with what they had achieved in the available time, and that 'it was fun'. Despite some of the observations we have made about the roles, relationships and social interactions within the team, there were no overt signs of frustration or dissatisfaction within individual members of the team.

However, it is clear that team work is a social process, and therefore social interactions, roles and relationships cannot be ignored in the analysis of design activity performed by teams. From our analysis, many aspects of team design activity can be seen to be influenced by social process factors. For example, we saw it immediately in the very first planning activity of the team, when Kerry's alternative approach was ignored or over-ridden. We saw it in the ways the team shifted among planned and unplanned activities. We saw it in the way personal commitments to particular concepts lead to social process actions such as expressing commitment and persuading others. We saw it in the socially skilful ways in which conflicts were resolved or avoided.

We suggest that these observations are relevant to the analysis of design activity, and important to the design methodology of teamwork. Design methodology, particularly in the engineering domain, has tended to treat the design process as a technical process – as a sequence of activities based on a rationalized approach to a purely technical problem. More recently, and more particularly in the architecture, product design and software design domains, attention has also been directed to designing as a cognitive process – to the cognitive skills and limitations of the individual designer. Just a few studies have begun to suggest that designing is also a social process, to point out how designers interact with others such as their clients or their professional colleagues, and to observe the social interactions that influence the activities of teamwork in design. Design methodology now has to address the design process as an integration of all three of these: as a technical process, as a cognitive process and as a social process.