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AN EXPLORATION OF THE HUMAN ELEMENT IN COLLABORATION

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ABSTRACT
In this paper, the authors propose that there is an inconsistency in the understanding of collaboration and of the collaborator because of a contradiction between human attitudinal and behavioural characteristics on the one hand, and that which is required from a collaborator and through collaboration on the other. We will argue that the sources of this contradiction are an overdependence on scientific quantification, and certain factors that affect the sociological and psychological formation of individuals and their relationships. We believe that this misunderstanding can be corrected through proper training and we suggest some avenues in that regard.

Keywords: collaboration, behaviour, human-centred design, psychology, sociology

INTRODUCTION

As part of a research project started in 2005 on North American automotive design, this paper reports some results of the authors' ongoing research on collaboration in design. That research is a four-year project to study collaboration in automotive design. The importance of collaboration in design engineering is a commonly held belief. However, even a cursory examination of the literature reveals that relatively little is known about collaboration as it occurs in engineering settings. How can we advance collaborative capabilities if we cannot even agree on what constitutes collaboration?

Our key research questions in this project include:

- What is "collaboration"?
- How, if at all, can collaborative behaviours be identified in engineering design teams?
- How, if at all, can collaborative behaviours be correlated to design outcomes?
- What contextual influences (e.g. corporate culture, organizational structure, process structure, etc.) impact on collaborative behaviours, and how are those impacts manifested?

Our specific focus is on improving collaboration in automotive design teams, but we hope that at least some of our results will be applicable more broadly.

The authors have not yet answered these questions. We are developing studies intended to discover those answers. That is the work presented in this article.

The answers to these questions would form a set of requirements for methods and tools to promote and facilitate collaboration in design teams. If collaboration really is beneficial, then it should be supported with appropriate methods and tools. However, appropriate methods and tools cannot be identified or developed without a better understanding of how collaboration happens in design teams. In this paper, the authors report the initial findings regarding the (a) the nature of collaboration and (b) some of the characteristics that seem to be indicators and counter-indicators of collaborative behaviours.

There are many approaches to improve collaboration in real-world situations. Our review of the literature is ongoing, but we have yet to find an approach that we can just "plug in" to our particular domain of interest. Our dilemma is that we need to produce usable results while also grounding our

work in the current state of research and practice. We need to understand that current state to apply it to our particular domain, but we also need to understand our particular situation to apply existent research properly. This is a chicken-and-egg situation. We have therefore adopted a two-pronged parallelized approach: on the one hand we are reviewing the literature on research in collaboration, while on the other hand devising ways to understand the way in which team-based automotive design currently occurs in North America. Each aspect informs the other. This work is ongoing, and constitutes the bulk of the matter in this paper.

The rest of the paper is organized as follows. We begin with an overview of the literature on collaboration, followed by a discussion of what we perceive to be a fundamental problem in how collaboration is being studied. We then suggest that collaboration should be regarded more as a *skill* than a process, and then begin to identify human characteristics that appear to facilitate collaboration. Then, we briefly describe the framework we are developing to study collaborative behaviours in light of skill-oriented characteristics of collaboration. Finally, we discuss the implications of our preliminary findings, and what we intend to do in the future.

AN OVERVIEW OF "COLLABORATION"

The concept of collaboration is viewed very differently in different contexts. To get an idea of how collaboration is understood in modern conversation, some recent definitions are presented below.

Collaboration is,

> *"...a recursive process where two or more people or businesses work together toward an intersection of common goals [...] by sharing knowledge, learning and building consensus* [5]*."*
>
> *"...a cultural practice of two or more individuals working together on a task or project and is intrinsically a framework for the production, sharing, and contestation of knowledge* [11]."
>
> *"...involves attempts to find integrative solutions where both parties' concerns are recognized and important concerns are not compromised. It merges the insights of persons with differing perspectives, and consensus is gained among those involved in the problem-solving effort through examination and working through reservations regarding particular aspects of the decision*[25]*."*
>
> *"...is the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own. Collaboration creates a shared meaning about a process, a product, or an event. In this sense, there is nothing routine about it. Something is there that wasn't there before*[20]*."*
>
> *"...is a desirable conflict management strategy because it involves working together to find a mutually acceptable solution to the problem. Collaboration allows for both parties to win, but generally takes more time, isn't always possible, and may not be practical for trivial issues* [3]."

Though such definitions might seem quite different at first glance, closer examination shows some commonalities. Figure 1 is a brief summary of the similarities and differences in the definitions given above.

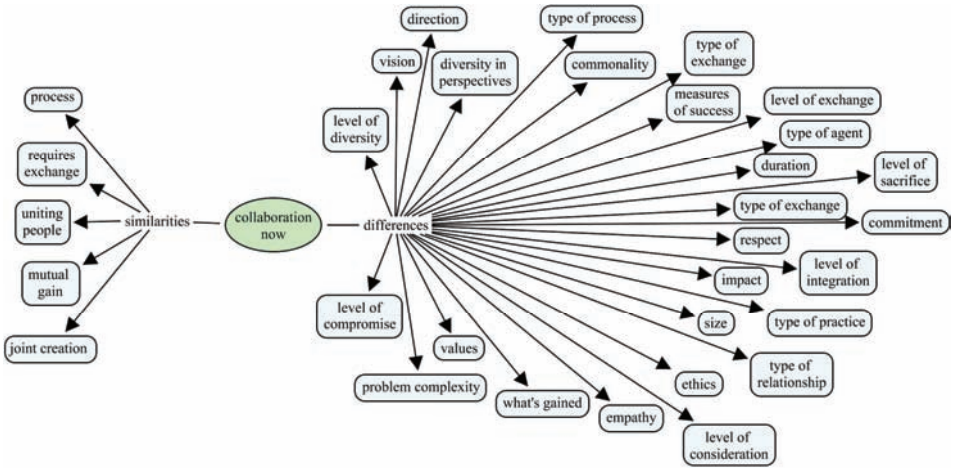

Figure 1. Summary of Similarities and Differences in the Definition of Collaboration amongst Authors.

Figure 1 shows a skewed symmetry between the commonalities and the differences. A closer look at the left side of Figure 1 spells out the general definition of what collaboration is considered to be in today's society. Collaboration has been summarized below to be,

> *'…the coming together of two or more agents with the purpose of doing work to achieve set goal(s) as a result of an exchange.'*

However, a strict interpretation of this definition suggests that the process of nuclear fusion, the generation of a snowflake, and the falling of a leaf are examples of collaborative processes. Since none of these examples agree with any of the above-noted definitions, there is something important missing in our definition of collaboration.

This can be addressed with the right-hand side of Figure 1. The figure clearly shows that collaboration only exists, if it exists at all, because of human participation, and it is the human element and its relationship to collaboration in which we generally do not understand. Thus, understanding human behaviour in collaborative episodes has become a focal point of our work. The authors believe that collaborative behaviours are skills that are not necessarily natural or innate, but rather require reasoning, support (i.e. proper tools), and *practice*. If this is true, then we might be able to shed some light on the nature of collaboration by first considering the nature of humans.

Because of the variability of definition, we must assume that the concept of collaboration is (at the level of the entire engineering community) so vaguely understood as to be problematic at best. On the other hand, there is general – and usually *a-posteriori* – consensus as to what events describe collaboration between humans, and that these collaborative events usually work to the advantage of the participants. So, while we know collaboration when we see it, we have not yet found a way to predict what behaviours will, in some circumstance or context, facilitate collaboration.

Our capacity to capture an understanding of collaboration with consistency and clarity relies in part on the methods of scientific inquiry. These methods provide an understanding that has the required degree of continuity and reproducibility. The inconsistency in our understanding that we have noted above suggests to us some kind of methodological error.

METHODS OF MIS–MEASURE

A definition is a concise description of the concept that individuates it with respect to (ideally) all other concepts. It is our capacity to observe, reason, and synthesize into a language that leads to definitions. These capacities are refined through the methods of scientific inquiry, which empower the individual to think objectively and critically.

There exist several schools of thought about how collaboration and collaborative behaviors can or should be studied, if at all, studied scientifically. Some (e.g. [21, 22]) argue that the variability,

discontinuity, and incoherent behaviour of individuals and the relationships they foster, are evidence that the study of collaboration, fully and with certainty, is essentially impossible.

Others who have attempted to quantify or qualify collaboration typically use one of two general approaches. The first approach (e.g. [11, 15, 16, 26, 27]) consists of the review of the results from an assumed collaborative process at its conclusion. The second approach (e.g. [7, 10]) consists of the examination of collaboration within an extant process during a period of time. Both schools often measure and analyze data using ethnographic methods.

The problem with the first approach is that it assumes that either (a) a collaborative process can be designed or (b) an extant process will lead to collaborative efforts over time and that these efforts will be measurable within the span of observation. We have found no strong evidence that collaborative processes can be designed *a-priori*, and there is no evidence that known measuring methods are reliable in this context.

Certainly, if there were such knowledge in today's corporate culture, it would have been embraced quickly. This has not happened, which suggests either that a solution exists that industry is not aware of, or that no solution has been found yet. We believe the former alternative is the best explanation, based on the amount of effort expended by modern businesses and industries to attempt to improve innovation, healthy working environments, lean operations, etc.

The problem with the second approach is that it assumes that collaboration exists in some process, and that it can be identified and evaluated with the predefined metrics, which are assumed to be appropriate. We have found no way to guarantee that a given set of predefined metrics is sufficient to identify and measure the extent of collaboration.

The literature reviewed so far has shown that collaboration is understood under an umbrella of assumptions that suggest collaboration can be recognized and evaluated, but the authors have not found any evidence to date, which would support a correlation between those results and the human element of collaboration. That is, collaboration is most quantitatively measured only in terms of outcomes and artifacts, and not the actual activities carried out by human agents. In addition, no evidence has been found to date that would suggest reasonable boundaries of what actually constitutes human collaborative activities or behaviours.

There is a "feedback loop" here. In engineering research as it is practiced in Canada, the assumptions in extant research are generally assumed to be either very reasonable or valid for a particular context. This is because most engineering research is firmly rooted in the natural and engineering sciences. However, as design engineering researchers recognize more fully the importance other research approaches, they are finding that assumptions are not always as robust as those to which they are accustomed. That is, when engineers research a subject like collaboration, they will often carry forward assumptions from the literature without question. However, those assumptions may be inappropriate in other contexts for a variety of reasons. Thus, errors in existent research can be carried forward to new research. This can strengthen the legitimacy those potentially incorrect assumptions.

This underscores a methodological weakness in engineering research on subjects like collaboration. Without routinely and scrupulously re-examining assumptions drawn from extant work, we (design engineering researchers) risk perpetuating errors that we ostensibly seek to eliminate. Most importantly, the results of new research of this kind can perpetuate errors into business and industry, where the damage can be quite severe.

In the end, no matter how important we believe collaboration to be in design processes, we will not be able to develop and teach new collaborative methods because of shortcomings in how collaboration is researched, especially within the North American design engineering community.

OUTLINING THE HUMAN IN HUMANITY

We present ourselves from birth as more or less blank canvases waiting to be filled in. Many experienced parents say that *children are so impressionable*, and science supports this perception [9]. As children pass into adulthood, they develop based on what they are taught and what they experience. If we cannot as adults clearly convey the concept of collaborating to others, then this would suggest that we either are not aware that we are collaborating when we collaborate, or we do not know how to collaborate. How exactly are we transferring this human experience to students and, if our lessons are filled with obscurity, then what are we teaching them exactly?

A child's world begins first with its family. Families these days have become more fractured [29], with the adults spending less time with their children and the children searching outward for sources of socialization, [28], guidance, and affection. This sense of the need to be active continues through adolescence and into University education as well.

When it comes to developing a sense of community, children witness "the ingredients that traditionally linked people together in a common moral ethos (physical place, shared history, similar social characteristics, and so forth) have been displaced by the growth of a bureaucratic, corporate culture" [23]. This culture promotes a concept of progress whereby "devaluing human relationships and exaggerating economic gain creates a public consciousness in which individuals are licensed, even encouraged, to get as much as they can for themselves, making the sense of a cooperative, global community illusive" [23].

When it comes to the education of our students the "content driven teaching methods sort children according to their skills as well as the specializations of teachers, an opposing expectation for conformity of performance matches those individuals against one another in a competition for placement within a narrowly-defined ranking system" [23]. This places our children a world in which competition is the norm and the roles that they are to accept are those whereby "dominance and subordination as inevitable, and to associate both with distinct ways of being" [23]. The end result is one in which the children struggle into adulthood, and although the struggle is not necessarily the problem, it is the fact that they face the challenge with a moral deficit.

In short, the shadow of humanity outlines a competitive – not a collaborative – figure. Even for those who do not accept the role, ignoring it completely is not an option.

GAINING CLARITY

In a competition, a participant exhibits specific behaviors when engaging the opposing side. When a competition is allowed to last long enough, it results in particular ways of being and thinking because of positive behavioural reinforcement. A short list of these behaviors, attitudes, and respective consequences associated with competing are summarized in Figure 2.

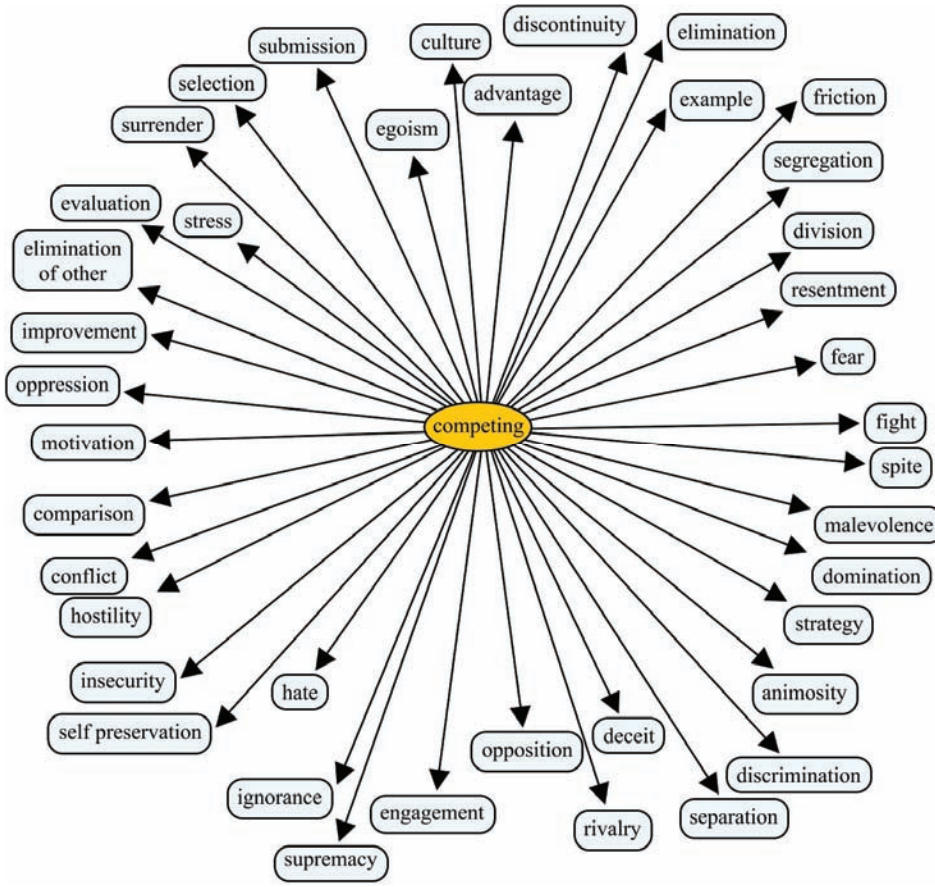

Figure 2. A Short List of the Behaviors, Attitudes, and Consequences Associated with Competing.

Humans' innate tendencies are to compete (due to the survival instinct), but a better understanding of collaboration and the collaborator is desired – assuming that collaboration actually yields better results in general. Therefore, in order to understand what it is that should be studied, evaluated, transcribed, and taught of collaboration, we must first understand what is being asked of us.

Competition is antithetical to collaboration, because competition does not bring about united individuals. Given a consensus among agents, they must share similar, complimentary behaviors and attitudes when engaged in a creative process; as creation itself requires an extent of complimentary exchange which is itself an act of giving and receiving. One might then reasonably ask, what characteristics of collaborative exchanges have been identified in the literature? Figure 3 summarizes a short list of observed behaviors, attitudes, and respective consequences indicated by researchers, [1, 11-14, 17-19, 23-26], to be characteristics of this type of exchange.

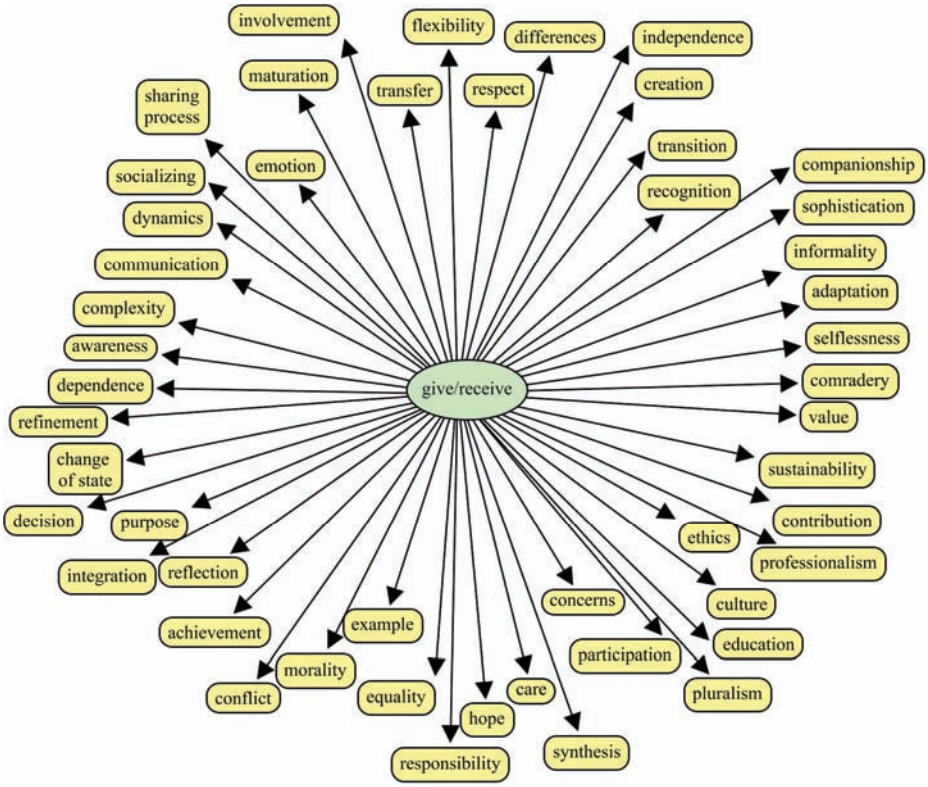

Figure 3. A Short List of the Suggested Behaviors, Attitudes, and Consequences Associated with Creating.

Figure 4 summarizes the consequences and implications of competing, per Figure 2, and indicates the respective synonyms or antonyms from Figure 3.

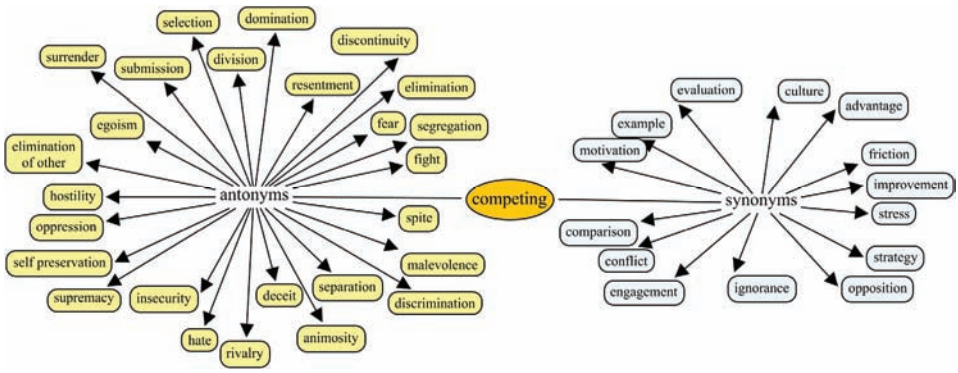

Figure 4. Comparison of the Synonyms and Antonyms of Competing to that of Collaborating.

This comparison is not exhaustive, but through referencing the language we use to describe both states of being and by identifying the synonyms and antonyms between these two states, we have an

approximation of the pertinent human characteristics and a place to start to gain some consistency in our understanding of collaboration.

The synonyms and antonyms presented above represent a lexicon of terms that can be used as labels for collaborative behaviours or their opposites. This lexicon is important for our work because it will be used to analyze observed team behaviours. This is described below.

COMPARING EXISTENT COLLABORATIVE TOOLS

The lexicon described above will be used to categorize existent collaborative tools. The categorization will be done in the form of visualizations related to *rugplots* (per [24, 8]). We will collect our lexical terms into disjoint sets of approximately five items each. Each set will be considered an axis "orthogonal" to the others. The members of each set/axis will be arranged in an order; each axis will have its own ordering that will depend on the individual items in that set/axis. One can then form 2D (or 3D) "spaces" by combining and two (or three) sets/axes.

We will then evaluate a number of collaborative tools (including, for example, wikis, email, web-based collaboration platforms like BaseCamp and dotProject, commercial systems like Unigraphics TeamCenter, and other platforms like CmapTools and a.nnotate.com). Each tool will be assigned a region within the spaces described above. The result will indicate "conventional" characteristics (i.e. those with significant overlap by many tools) as well as those not (yet) addressed by tools (i.e. those where few or no tools include). Such a series of plots will inform us regarding where typical collaborative software is able (and unable) to provide support. It will also allow user groups to select the tools that are likely to best help them collaborate, by selecting from the plots those tools that cover the characteristics in which the user groups are most interested.

PLANNED COLLABORATION STUDIES

Armed with a lexicon intended to describe collaborative behaviours, we can now design activities meant to observe collaboration. The observations will be modeled by associating with them terms from the lexicon. Subsequent analysis of the models will look for correlations between observed behaviours and outcomes of the design activities.

In the next step of this project, we will study these characteristics and develop ways to identify them in design teams. Because of the organizational and IP issues that typically surround the observation of practicing design engineers, we will begin by observing senior undergraduate engineering student teams. Our goal will be to correlate at least some of the characteristics with observable behaviours in the teams. If our hypothesis (i.e. that these characteristics are exhibited in collaborative work) is true, then we should be able to identify outcomes that are distinct due to the degree of collaboration by the participants. This work is scheduled to begin by September 2009 and last approximately three years.

To devise appropriate design activities for this work, we will follow the Design Research Methodology (DRM) [2] which is, to the best of our knowledge, the only design research methodology for design engineering research that includes key aspects of social science research.

The DRM consists of three main stages. In the first stage, a descriptive study is executed to determine key variables that would define a successful intervention in a particular context, with respect to established criteria. The second stage is a prescriptive study that results in the development of a new method or tool based on the key variables discovered in stage #1. The third stage is another descriptive study that evaluates the new method or tool in a "live" setting, with respect to the variables determined in stage #1. If the prescriptive model (stage #2) is correct, the new tool will have been successful; otherwise, feedback on the nature of a failed intervention stimulates subsequent prescriptive study.

We will apply the DRM in this project as follows.

The initial "stage 0" is to develop a set of criteria that will establish how we will measure success in the project. We will also develop a specific rubric to correlate decision-making behaviours to quality of the final design, and standardized formats to report data and findings.

The first descriptive study (stage #1) will identify kinds of collaborative behaviours that can be causally related to decision quality in instances of PTS design projects. This study will be carried out as semester- and year-long design projects in University settings. Because of IP considerations, it is unlikely at this time that we will be able to conduct these activities in industry. While it may have been beneficial to run initial projects without any computer support for collaboration, this is simply not possible due to other curriculum requirements. Instead, we will run the projects as required by the curricula, but careful notes will be kept regarding the kinds of collaboration tools used and the extent to which they are used by specific UG teams. Courseware on collaboration will be provided to the teams, along with specifications on reporting such that we collect as much data as possible without interfering with their design work.

The prescriptive study (stage #2) will identify requirements and functionality one should expect of computer tools to support the specific collaborative behaviours identified in the first descriptive study. During this time, the data gathered from the first descriptive study will be analyzed to identify collaborative behaviours that correlate to "successful" designs. We will then survey existent collaborative tools (described above) and recommend those most likely to facilitate the identified behaviours. We will also propose requirements for new computer tools to facilitate collaborative decision-making.

To validate our recommendations, we will introduce tools to the stage #3 study (see below) that satisfy the stage #2 requirements. This will require adjusting the project design briefs, and ensuring that the software is available, tested, and properly documented. However, it is unlikely that we will find tools that ideally satisfy all the requirements. We will therefore seek the best possible tools of those available, carefully assessing the degree of fit between the tools we eventually select and our recommendations.

Therafter, a second descriptive study (stage #3) will introduce to the collaborative project environment computer tools that will satisfy the requirements developed in the prescriptive study. The tools will be introduced to new teams working the same projects as stage #1. Again, we will monitor collaborative decision-making in the teams and evaluate the success of those tools with respect to the criteria established at the outset of the project.

We expect to use the results of these activities to propose (a) guidelines for identifying collaborative behaviours in "real world" settings, (b) guidelines for selecting collaboration tools based on the needs of given teams in particular contexts, and (c) a requirements set for a new generation of collaboration tools that address the shortcomings we expect to identify in the course of this work.

CONCLUSIONS

It was found that through this brief exploration into the human element of collaboration there is an inconsistency in the understanding of collaboration and within our understanding and expectations of a collaborator. It was found that the human element is primarily of a competitive makeup and a brief review into the type of education and example we provide ourselves and our children supports this notion. It was found that our expectations and desires to become collaborators rely heavily upon our abilities and willingness to think and behave as a collaborator or when collaborating. This commitment will enable us to come to a better understanding collaboration, and therefore, we will then be able to study, transcribe, experience, and teach the circumstances of this choice by living through its struggles, with clarity and consistency.

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