

# AIS Transactions on Human-Computer Interaction

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Volume 2 | Issue 4

Article 5

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Winter 12-31-2010

## Theory, Design and Evaluation – (Don't Just) Pick any Two

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### Recommended Citation

Prestopnik, N. R. (2010). Theory, Design and Evaluation – (Don't Just) Pick any Two. *AIS Transactions on Human-Computer Interaction*, 2(4), 167-177. Retrieved from <https://aisel.aisnet.org/thci/vol2/iss4/5>

DOI:

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### Theory, Design and Evaluation – (Don't Just) Pick any Two

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#### INTRODUCTION

There is an adage, well known within engineering and other practice-based communities, known as the project triangle (Gardiner and Stewart, 2000). The triangle speaks to the tradeoffs that factor into almost any project; it is usually presented as a balancing act among three equal components: cost, development time, and product quality. The adage goes something like this: "Good, fast and cheap – pick any two."

A variant on the project triangle comes to mind when reading Benbasat's (2010) and Lyytinen's (2010) interesting takes on future directions for HCI research. The modified saying might go something like this: "Theory, design, and evaluation – pick any two." This modified expression addresses the importance, noted by many authors (Ackerman, 2000, Benbasat, 2010, Dix, 2010, Grudin, 1994, Grudin, 2006, Halverson, 2002, Kohavi et al., 2007, Lyytinen, 2010, Rogers, 2004, Shackel, 2009, Zhang et al., 2007), of at least one (and usually more than one) of the following methodological approaches:

- Application of Theory
- Design
- Evaluation

Importantly, this modified adage also implies a key weakness in much HCI literature - that any given study often gives advantage to two of the three methodological approaches while disadvantaging the third. It is surprising how many studies seem to adhere to the modified project triangle – theory, design, and evaluation – *pick any two*.

Many evaluative papers regularly offer only the briefest of theoretical sections (Dix, 2010). Research that does explore theory often leaves it unevaluated in the context of real-world systems and use settings (Rogers, 2004). Papers that do a good job with both theory and evaluation have a tendency to overlook design, offering theoretical explanations and results based on test instrumentation (i.e. existing websites, software, etc.) which are inadequate to

Dennis Galletta was the accepting Senior Editor. This article was submitted on 8/14/2010 and accepted on 12/20/2010. It was with the author 13 days for 1 revision.

Prestopnik, N.R. (2010) "Theory, Design and Evaluation – (Don't Just) Pick any Two," *AIS Transactions on Human-Computer Interaction* (2) 4, pp. 167-177.

answer the research questions or inapplicable to the world of practice. There are a multitude of reasons for these types of omission, and the following discussion is an attempt to highlight several of them, as well as to present potential solutions. The varying and sometimes limited technical skill-sets and abilities of HCI researchers, emphasis on journal-length publication in the field, grant and funding processes, and the rapid pace of technological development may all contribute to the “pick any two” problem. In addition, the fractured nature of the HCI research community, with various “camps” emphasizing different approaches, methodologies, and emphases, also appears to be a major contributor to this issue and a complex challenge to overcome.

The following discussion takes to heart Benbasat's (2010) and Lyytinen's (2010) suggestion that design science techniques should be more fully embraced by the HCI community. Design science approaches, which – in their ideal form – equally emphasize theory, design, and evaluation through an iterative design/research process (Amiel and Reeves, 2008, Hevner et al., 2004, March and Smith, 1995, Markus et al., 2002, Wang and Hannafin, 2005), offer a comprehensive way to tackle many of the complex and sometimes highly subjective design-oriented research questions that are so familiar within the HCI discipline.

In this response paper, three typical, high-quality HCI papers are examined in detail to explore the nature of the “pick any two” problem. Suggestions for how missing methodologies might be incorporated into these works through the design science approach are provided. Additionally, a brief review of HCI literature from three publication venues is conducted in order to roughly identify the extent of the “pick any two” problem. Several broad-based reasons for methodology omission are discussed, with suggestions for ways that these institutional challenges might be circumvented or overcome. Most of these challenges can be reduced to a fundamental cause: the division of HCI scholarship into “camps” with varying philosophical and scientific emphases. Because the various HCI camps come from different traditions – HCI in MIS, engineering/computer science, and human factors – their approaches to research (and therefore, their methodological emphases) differ widely. The “pick any two” problem is ultimately used to explore this issue and frame potential solutions to the great challenge of more closely bonding the various “camps” of HCI.

In general, it is hoped that awareness of the “pick any two” problem will help HCI researchers find ways to diversify their approaches to HCI research, emphasizing theory, design, and evaluation more equally both across and within research projects, as well as helping to build bridges between HCI camps that emphasize differing research approaches, traditions, and philosophies.

## NATURE OF THE “PICK ANY TWO” PROBLEM

A literature review of HCI research from varying perspectives and publication outlets was conducted (including conferences and journals with MIS, CHI, and Human Factors emphases), and three exemplar studies were selected for further detailed review. While of high quality, each study exemplifies a variant of the “pick any two” problem. The selected papers are not intended to be taken as empirical evidence of this phenomenon per se, but rather as case studies for the nature of the problem and as indicators that the “pick any two problem” is potentially real and worthy of further discussion.

### Design and Evaluation

Cockburn and McKenzie (2001) presented an evaluation of an interface for organizing documents within a 3D space. Their research emphasizes design and evaluation to the disadvantage of theory, and is typical of many studies published within technically-minded venues (e.g. Denoue et al., 2003, Funkhouser et al., 2003, Li and Hsu, 2004).

In their work, Cockburn and McKenzie (2001) briefly discussed technological advances in computing and graphics technology that have motivated their development and evaluation of a 3D document interface, without entering into a detailed discussion of user-oriented theories that would suggest such a design. They offered the following as justification for their research: “The three-dimensional (3D) graphics of computer games provide compelling evidence that desktop computers are capable of supporting rapidly interactive three-dimensional visualizations, yet 3D interfaces remain largely tied to niche markets such as Computer Aided Design,” (p. 1). While undeniably true, this justification offers no insight into the central research questions as stated by Cockburn and McKenzie (2001): “Firstly, what differences, if any, exist between the efficiency of working with 2D and 3D interfaces for document management? Secondly, what differences, if any, exist between people's preferences for working with these interfaces?” (p. 1).

Arguing from system capability – that modern computers can support 3D, so therefore 3D should be used as a design technique – does not address the broad research questions, which are user (and not technology) oriented. At the conclusion of the study, the most definitive conclusion that can be drawn is that the specifically evaluated Data Mountain 3D interface (Robertson et al., 1998) was not more efficient than its 2D counterpart, but that it was preferred (Cockburn and McKenzie, 2001). Whether that finding is of use to others interested in 3D interfaces in

general is debatable – it is probably useful to those developing an interface similar to Data Mountain, but perhaps less so to those developing other kinds of 3D interfaces. No real insight can be offered regarding 3D interfaces as a class of interface, because no attempt has been made to abstract and generalize findings through the framework of solidly researched and applied theory.

Theory is an important aspect of design science methods; as Hevner, March, Park, and Ram (2004) argue: “In both design science and behavioral science research, rigor is derived from the effective use of the knowledge base - theoretical foundations and research methodologies,” (p. 88). Additionally, as March and Smith (1995) argue, “theories must explain how and why IT systems work within their operating environments,” (p. 255). Ideally, then, Cockburn and McKenzie (2001) would have used theory to argue in general terms why any 3D interface might be “better” than a 2D one. This could have covered affective or cognitive advantages of 3D over 2D, or elaborated on how users (Lamb and Kling, 2003) or context (Dourish, 2004) might play a role in efficiency or preference for 3D interfaces over 2D ones.

Furthermore, theory could have motivated the rest of Cockburn and McKenzie’s (2001) paper, suggesting a variety of useful research questions (e.g., What does theory say about how this should work? What experimental settings or survey questions will help us to evaluate whether the theory is supported? What are the most appropriate techniques for evaluating this interface and this theory?). Using theory to motivate the evaluation of a particular interface would also allow the researchers to report results in a context broader than just one specific system. In short, theory would make Cockburn and McKenzie’s work more than, as Dix (2010) might argue, a usability study of just one particular 3D interface.

## Theory and Design

Hong, Card and Chen (2006) studied a 3D concept designed to make online books more intuitive by simulating the turning of pages on real, physical books. Their research is an example of the de-emphasis of evaluation in favor of theoretical development and design (e.g. Cubaud et al., 1998, Dumas et al., 1999, Lee and Green, 2006, Marchionini, 2006, Stevens et al., 1994).

Hong, et al. (2006) discussed the ongoing, theory-based debate over 2D versus 3D interfaces and the appropriate use of the book metaphor in an interface context. Though their theoretical development was short, it framed and underpinned their extensive design discussion, which covered topics such as geometric simulation for producing visually accurate page turns, implementation of high- and low-resolution page images, and the ability to “thumb” through pages at will to find content.

This paper’s strength is its emphasis on linking simulation (the 3D book interface) to reality (real-world books that are familiar and comfortable to readers). The connection to physicality was made explicit, when Hong, et al. (2006) said, “As a visually enhanced object (Card et al., 1999), a book metaphor taps into the user’s familiarity with physical books. From the user’s perspective, whether a book is a physical book or a virtual book being shown on a computer screen, ‘turn to the picture in the middle of page 124’ has the same meaning,” (p. 1). Hong, et al. (2006) also argued for a specific page turning implementation using deforming cone geometry rather than cloth simulations. Though this decision was a technical one, it was motivated by theory, in this case, an attempt to make the simulated book as close to physical reality as possible.

Hong, et al. (2006) omitted an evaluative component from their study. Their conclusion stated, “For a virtual 3D book, page turning is a fundamental feature and particularly important to convey the impression of reading or viewing an actual physical book,” (p. 7), but this was left untested. While earlier theoretical discussions suggest that this is so, Hong, et al. (2006) made no attempt to evaluate their finished product against other 3D book systems, 2D reading systems, or, for that matter, real, physical books.

According to Hevner et al. (2004), “Design-science researchers must constantly assess the appropriateness of their metrics, and the construction of effective metrics is an important part of design-science research,” (p. 88). Further, “Design science consists of two basic activities, build and evaluate,” (March and Smith, 1995 p. 254). In that tradition, this research could have concluded with an evaluative section to confirm the theoretical assumptions: that a book-like appearance and behavior will improve the user experience, that readers will enjoy a book-like presentation more than other types of screen-based reading, and that a simulated book will accurately reproduce the impression of reading a real book. By evaluating their prototype, Hong, et al. (2006) could have said something meaningful not only about the prototype itself, but about the theory upon which it was based. Instead, they proposed a design from theory and built it, but ultimately know little about its chances for adoption and success in the contexts for which they envision it.

## Theory and Evaluation

Robins and Holmes (2008) discussed aesthetics and credibility in website design, providing a theoretical section and

evaluative component. Study participants were asked to make credibility judgments about various “high aesthetic appeal” and “low aesthetic appeal” websites. Robins and Holmes omitted the third methodological approach, design, typifying what seems to be potentially the most common variant of the “pick any two” problem (e.g. De Wulf et al., 2006, Hassenzahl, 2004, Kim et al., 2003, Lindgaard et al., 2006, Spink and Saracevic, 1998, Tractinsky et al., 2000, van Schaik and Ling, 2009).

In their evaluation, Robins and Holmes (2008) found that sites with higher aesthetic appeal were seen as more credible by participants, an expected result. However, they also found an unexpectedly high standard deviation in credibility judgments which “indicate[d] that there was not a strong division in judgment between the high and low aesthetic stimuli,” (p. 394).

This anomaly underscores methodological challenges in the way that high and low aesthetic appeal websites were selected (not designed) for evaluation. Robins and Holmes (2008) chose twenty-one web home pages to serve as stimuli in their experiment. Each home page as designed was considered to be the “high aesthetic appeal” case. To generate “low aesthetic appeal” versions of the stimuli, each of the twenty-one home pages was opened in an HTML editor and stripped of “visual enhancements”.

The assumption that a web home page as designed must necessarily have high aesthetic appeal seems obviously false. Much research has been published looking at the phenomenon of web aesthetics (Hassenzahl, 2004, Kim et al., 2003, Nielsen, 1996, Norman, 2004, Tractinsky et al., 2000, van Schaik and Ling, 2009), a corpus which belies the simplistic, dichotomous nature of “aesthetic appeal” as used by Robins and Holmes (2008). To assume that because a page was designed it must therefore be well designed is to trust that the myriad developers involved in the twenty-one selected sites were all equally expert at their craft and all equally knowledgeable about what constitutes “high aesthetic appeal” and what does not. This is unlikely at best.

To create “low aesthetic appeal” websites by stripping designed websites of their visual enhancements is equally problematic. Robins and Holmes (2008) reported one site where the “low aesthetic appeal” version was much more highly rated than the high aesthetic appeal version. Robins and Holmes go so far as to suggest that the HTML stripping process may have improved the appearance of this particular home page.

A better test instrumentation for this study would potentially be to strictly control for aesthetic appeal by undertaking the kind of design science approach suggested by Benbasat (2010). Robins and Holmes (2008) might have draw from design and aesthetics literature or sought assistance from expert designers to generate controlled designs that achieve a consistent “high” or “low” aesthetic appeal. Furthermore, in the iterative tradition of design science (Hevner et al., 2004, Markus et al., 2002), it would make sense to repeat the design phase of this research using recurring evaluations to ensure that high and low aesthetic treatments were being produced as desired, and that credibility judgments remained consistent across design iterations.

Though more time-consuming than the method used by Robins and Holmes (2008), a design science approach would afford much greater experimental control, including the ability to focus on specific features of design (such as color, font style, layout, or imagery) as they relate to credibility within both high- and low-aesthetic appeal contexts. In addition, this would be more relevant to practice, since ongoing research could inform the development of aesthetic treatments (a practice-oriented operation), and adjustments to each aesthetic treatment would then be utilized within research.

## EXTENT OF THE “PICK ANY TWO” PROBLEM

From an analysis of individual papers, it is possible to ascertain much about the “pick any two” problem, but not to evaluate its extent within the overall HCI discipline. Accordingly, a brief heuristic review of papers from three HCI publication outlets was conducted. One hundred fourteen individual papers from the following three venues were reviewed and coded: Volume 68 of the International Journal of Human-Computer Studies (IJHCS 2010), the 2007 ACM Symposium on User Interface Software and Technology (UIST 2007), and the 2008 SIGHCI concentration of the Americas Conference on Information Systems (AMCIS 2008). Publication outlets were selected for their diversity of interests, topic areas, and approaches to HCI research, and individual papers from each publication were coded for their inclusion of each of the three methodologies in question: theory, design, and evaluation.

While design and evaluation sections were relatively easy to identify, what constituted a theory section was sometimes more difficult to ascertain. This was due to wide variations in the background material used to justify, support, and conceptualize research. Many papers, especially those in the engineering-oriented camps of HCI, emphasized technological innovation as justification for design or evaluative processes (e.g., computer speeds have improved, so this technology is now viable). These were typically not scored as including theory, unless they also included more meaningful discussions of human interactions with technology – why individuals might desire, adopt, or benefit from the technology under discussion, or how such interactions might be better described or explained by

various concepts, constructs, and models. Since opinions on this matter vary, articles were coded conservatively; papers which included even very superficial theoretical sections were coded as including theory. Data collected during this review should be taken as an indicator of the “pick any two” problem, rather than as a comprehensive and authoritative picture of it. Nonetheless, evidence for the problem was found.

Of the 114 papers reviewed, 33.33% emphasized theory and evaluation while excluding design, 26.32% emphasized design and evaluation while excluding theory, and 6.14% emphasized theory and design while excluding evaluation. Of the reviewed papers, 24.56% emphasized all three areas equally, while 9.65% seemed to emphasize just one area.

Papers that emphasized theory and evaluation or design and evaluation were most common. This suggests that the majority of HCI researchers (understandably) place a high value on collecting and analyzing data, while having a more mixed attitude toward whether this analysis should be directed at theoretical constructs or technological artifacts. This split appears to be highly dependent on publication venue; journal articles were more likely to contain all three methodologies, while conference papers tended to include just two of the three.

Publications with an emphasis on theory and design to the exclusion of evaluation were more limited in their extent, comprising just 6.14% of the total. Of these publications, most were found within the more technically-minded *UIST 2007* conference proceedings. This seems to further validate the notion that most HCI researchers prefer to include some form of evaluation in their work. Nonetheless, enough theory-design papers were found in this short review to suggest that, while this aspect of the “pick any two” problem is more limited than its counterparts, it is still an omission in need of redress.

## CAUSES OF THE “PICK ANY TWO” PROBLEM

There are a variety of potential reasons that the “pick any two” problem may exist. Publication type and venue, researcher skill sets, grant and funding processes, and the rapid pace of technological development likely have their roles to play. More fundamentally, the division of HCI research into “camps” with differing approaches and background may be of greatest importance in driving this issue.

### Publication Type

Journal-length articles were most likely to include all three core methodologies, with 38.18% of the *IJHCS 2010* articles containing all three. Nonetheless, 41.81% of the *IJHCS* articles emphasized only theory and evaluation, and 14.55% emphasized only design and evaluation. This suggests that while journal articles, because of their relative length and detail, may be better suited for research that encompasses theory, design, and evaluation, author choice still appears to have the determining role. It is also likely that some projects encompassing all three methodologies may not be suitable for even the relatively lengthy and detailed journal-style publication; some highly involved design research may, in fact, require more space to adequately describe problem spaces, theoretical background, design, technology, and the evaluation thereof.

Addressing the “pick any two” problem may require more than emphasizing the three core methodologies *within* papers. Emphasizing different aspects of research *across* several publications – including different disciplinary outlets – might also be beneficial. This would require more robust research plans so that relevant aspects of research reach the appropriate audiences and venues. Ideally, authors, publishers, editors, and reviewers would see individual publications within such research streams as mutually supporting; a publication emphasizing theory and design in one venue might cross-link or cross-reference a companion piece elsewhere containing an evaluative component. Currently, journals and conferences are not well-g geared toward this model of publication, but such an arrangement would help authors and journals to improve the interrelatedness of varying publications coming out of the same or similar projects. Greater emphasis on other publication types might also make equal emphasis on theory, design, and evaluation more feasible. Currently, there is little emphasis on books and almost none on web-based publications within the HCI community, yet for some kinds of projects, book-length publications might be a useful way to cover a great deal of ground on a variety of project aspects. The World Wide Web, with its potential for multimedia display and interactivity, as well as virtually infinite publication space, could also become a unique way to publish a great deal of detail on theory, design, and evaluation with the added benefit of granting access to the designed artifact itself. This could also help to reach communities of practice more directly.

### Researcher Skill-Sets

Another likely cause of the “pick any two” problem is the varying knowledge and technical skills researchers possess. It is uncommon to find researchers in any tradition, be it HCI in MIS, computer science, or engineering, who are highly proficient at all three of the methodologies under discussion. Those who are theory or evaluation-minded are

unlikely to be adept at technical development, while those who design and build systems as part of research – often on tight schedules and in competition with others – may find detailed theoretical justifications for such development to be unnecessary or even counter-productive. As has been shown, a few are even content to propose and design from theory, but avoid scientific evaluation of what they have implemented. This suggests the need for better collaboration between HCI researchers and with others from outside the HCI community.

Large research programs and research partnerships, encompassing researchers with a variety of viewpoints and expertise, would help to strengthen research that might otherwise emphasize just one or two of the “pick any two” methodologies. Such collaborations can be challenging, as noted by Galison (1997). However, such collaborations have worked in the past through “trading zones,” an approach whereby researchers from different domains negotiate for the specific needs of their domain until a satisfactory solution can be reached (Galison, 1997). In the HCI community, this might entail an engineering-minded researcher and a theory-minded researcher coming to an agreement over the relative emphasis for both the theoretical and design-based aspects of a particular research program. This is not compromising, but rather establishing a research plan that will be highly successful for both perspectives.

Complementary to collaboration, better design resources for non-technical researchers are also desirable. The phrase, “we’ll find some Master’s students to do it as part of a class project,” is commonly heard, but serious design-science requires developers who are experts, not students. Furthermore, these developers must thoroughly understand how design for research differs from commercial production. Training individuals for these seemingly disparate sets of skills and providing HCI researchers with better access to them is a challenging problem, with no obvious solution yet in sight.

## Grants and Funding

The nature of funding within the HCI community is another potential point where one of the three “pick any two” methodologies can become deemphasized. Most funding agencies do not require or emphasize a holistic approach to research that might include theory, design and evaluation. This is exacerbated by the nature of the HCI proposal review process, which typically has funding proposals reviewed by engineering-focused or social-science focused reviewers, but usually not both. As an additional challenge, design science is a relatively new approach to the conduct of research, and is not yet widely acknowledged by funding agencies. While this situation is improving, with the NSF and others now occasionally requesting design-based proposals specifically, there is still space for more inclusion of design science approaches in the mainstream of the funding process.

## Rapid Technological Development

The rapid pace of technological development is another potential culprit in the “pick any two” problem. The pace of technological change can be incredibly quick, and as a result, many HCI researchers, especially those with a design emphasis, find themselves working in newly conceptualized spaces. This creates challenges with respect to all three of the “pick any two” methodologies. In newly generated research spaces, theory is often limited or even non-existent, making it difficult to tackle design challenges without deemphasizing theory in favor of simply trying something new. Additionally, new research spaces come with extra challenges for design research, where technical problems to be solved may be non-trivial, requiring relatively more attention than other aspects of research. Finally, during evaluation, new and rapidly changing domains raise questions about what is important, what should be evaluated, and how such evaluations should be conducted. While individual researchers must weigh these various challenges for themselves, collaborative partnerships and a wider perspective on HCI research as a whole may help to produce more holistic approaches to “bleeding edge” research, even within tight deadlines and competitive research spaces.

## HCI “Camps”

Publication type and venue, researcher skill sets, grant and funding processes, and the rapid pace of technological development are all potential causes for the “pick any two” problem, and each comes with a host of practical challenges and potential solutions. These difficulties appear to be traceable to a more fundamental issue, however: the division of HCI research into several uniquely different “camps.” Researchers from these camps typically disagree about the issues above – whether journal or conference publication is more valuable and useful to the discipline, what skill sets are necessary within HCI research, what funding agencies should look for in valid HCI research, and how rapidly evolving areas within the HCI domain should be studied. Camp differences and the reasons for them are likely the root cause for why the “pick any two” problem exists at all.

The HCI camps have been identified by Grudin (2005):

- Human Factors and Ergonomics

- HCI in MIS
- Computer-Human Interaction (CHI) and its Antecedents (such as CSCW)

The differences between HCI camps are historical and complex, but Grudin (2005, Grudin, 2006) emphasized that the historical interest in mandatory computer use vs. discretionary computer use, different theoretical foundations between camps, and differences in research and disciplinary foci are potential reasons why HCI researchers remain divided.

The CHI and human factors camps trace their lineage to engineering-oriented disciplines such as computer science, ergonomics, and aeronautical engineering. It is therefore unsurprising to see research from these camps emphasizing the design and evaluation of technical systems; such methodologies are the lifeblood of engineers and engineering-minded scholars. The HCI in MIS camp has a background oriented around mandatory-use, organizational applications (2005, Grudin, 2006) and is further steeped in a social science, rather than an engineering, tradition. Rather than emphasizing specific technical solutions geared toward the individual, therefore, HCI in MIS researchers seem to gravitate toward broad, socially or organizationally-oriented theories with wide applicability in a variety of use contexts. This is supported by the previously described review of publications, which showed that publishing outlets favored by HCI in MIS researchers (SIGHCI-AMCIS 2009 and IJHCS 2010) heavily emphasized theory and evaluation, while the outlet favored by engineering and computer science-minded researchers (UIST 2007) heavily emphasized design and evaluation.

The HCI camps may further be described in terms of “prescriptive” and “descriptive” science (March and Smith, 1995). Prescriptive science is aimed at “improving IT performance,” (March and Smith, 1995) and appears to be the basis of the design and evaluate model found within CHI and the other technically-minded camps. Descriptive research, on the other hand, “aims at understanding the nature of IT. It is a knowledge-producing activity corresponding to natural science,” (March and Smith, 1995 p. 252). The HCI in MIS camp seems most comfortable with seeking understanding through theory and evaluation, rather than through a process that emphasizes building and testing. Though most HCI in MIS researchers have a social science rather than a natural science mindset, their desire to explain human phenomena in the context of computational systems is more akin to the natural science researcher, who desires to explain natural phenomena in the world, than the computer scientist or engineer, who desires to design and build new technological artifacts. Therefore, it seems likely that the “pick any two” problem, which sees different researches emphasizing different methodological approaches, may ultimately stem from methodological and philosophical distinctions between HCI camps.

**Table 1: HCI camps, their scientific philosophy/orientations, domain emphases, and resulting methodological approaches**

HCI Camp	Scientific Philosophy	Domain Emphasis	Resulting Methods
HCI in MIS	Descriptive: Social Science	Business & Organizational Computing	Theory & Evaluation
Computer-Human Interaction	Prescriptive: Computer Science	Discretionary Computing; Personal Computing	Design & Evaluation or Theory & Design
Human Factors & Ergonomics	Prescriptive: Engineering	Physical Interface; Human Factors	Design & Evaluation or Theory & Design

Many have suggested that the various camps of HCI should work together, arguing that mutual conferences, joint publication venues, and other “mandated” methods of unification are the answer to bridging the gap. While such collaboration may seem ideal, it has not worked well in the past (Grudin, 2005, Grudin, 2006). Too many small but important differences exist; for example emphasis on journal vs. conference publication, different uses of terminology, and different methodological groundings have all resulted in a lack of cohesiveness in HCI.

These are sharp divisions which are not easily overcome, and it may be that “top-down,” mandated approaches to unifying the camps are not the solution, if indeed a solution is even needed. There is much to be said for a research community that encompasses a variety of theoretical and methodological traditions, at least when those traditions are complementary. Forcing the camps of HCI into a unified whole without due consideration for their individual uniqueness may not turn out to be an overall improvement of the discipline.

On the other hand, the desire for a more cohesive HCI research community, as expressed by many (Dix, 2010, Grudin, 1994, Grudin, 2005, Grudin, 2006, Halverson, 2002), is non-trivial, stemming from a desire to see each camp’s work more strongly influence and improve the others. In a sense, the desire for camp unification may at its root be a desire for methodological completeness – an interest in seeing the “pick any two” problem conquered through better coordination amongst the camps of HCI.



## PICKING ALL THREE

It was suggested earlier that design science, with its equal emphasis on theory, iterative design, and evaluation (Hevner et al., 2004, March and Smith, 1995, Markus et al., 2002), is a candidate for solving the “pick any two” problem. If that problem is symptomatic of something larger – the camp divisions in HCI – perhaps the design science solution is equally applicable to this larger issue.

Rather than attempting to mandate or otherwise force mutual HCI conferences, publication outlets, or interest areas, a less disruptive solution to the fracturing of the HCI discipline may be to encourage the use of design science methods wherever they may be useful. It is suggested here that, instead of picking “any two” of three key methodologies (in practice, the approaches that one’s own camp is most comfortable with), why not try to include all three? This has the challenge – but also the potential advantage – of forcing HCI researchers out of their comfort zones and into new, mutually informative areas. For those in a technical, engineering-oriented camp, a new emphasis on theory will render their design-oriented studies more approachable to researchers with a “descriptive science” mindset. For those in HCI in MIS, a fresh emphasis on design may create inroads to those who already exist comfortably in those domains – computer science and CHI scholars, as well as HCI practitioners. This would also motivate HCI researchers across all camps to find and be informed by studies conducted in areas in which their own camp is not traditionally strong.

Many challenges, tradeoffs, and caveats accompany this suggestion. Too much emphasis on design research could have the unintended consequence of shifting the focus of HCI scholarship away from human problems and toward artifacts for their own sake. Well-planned design science studies should have the opposite effect, encouraging researchers to understand both human and technological problems simultaneously, but in any design project, there is a risk that the difficulties of implementation may come to overshadow other research considerations. It is also wise to remember that not all research questions will be well served by a dogmatic design-based approach. While it is suggested that greater emphasis on design science research will benefit HCI scholarship, it is also acknowledged that different problems require different solutions; HCI research should remain flexible in its approach to problems that involve human-computer interactions. Finally, design science can also be time-consuming, requiring more effort for the same scholarly impact of more traditional research approaches. Nonetheless, by focusing attention on theory, design, and evaluation, researchers may find that they produce more holistic research and, in so doing, create a more unified HCI discipline.

## CONCLUSION

Three methodological elements – theory, design, and evaluation – found within “typical” HCI evaluation studies were discussed in light of the project triangle, an adage which suggests that (as in the case of cost, time, and quality) only two of the three will be optimized at any one time. A detailed examination of three exemplar papers was conducted, followed by a brief review of 114 papers from three different HCI publication outlets. In both reviews, evidence was found for the “pick any two” problem, and its nature and extent were described.

Several potential reasons for the “pick any two” problem were discussed, including publication type, researcher skill sets, funding procedures, and the rapid pace of technological development within the HCI domain. Several practical suggestions for avoiding or overcoming these challenges were given, but each was also reduced to the more fundamental level of HCI “camp” divisions. It was noted that the theoretical and methodological traditions of each camp tend to influence which methodological approaches are used and which are avoided by various researchers.

Design-based approaches to research, which equally emphasize all three methodological components, were proposed as one way to overcome methodological omission. Both Lyytinen (2010) and Benbasat (2010) have suggested that HCI researchers should more fully embrace design science approaches in their research, with Lyytinen (2010) suggesting that this will, “improve ecological validity of [ HCI scholar’s ] studies and also to develop ways to integrate HCI knowledge and theory to effective design interventions,” (p. 24). Benbasat (2010) further argues that, “ to be interesting and relevant (to practice), research in HCI should have a design component coupled with an evaluation of this design,” (p. 16).

Design science is, in many ways, the bridge between pure theory, the value of which is not always apparent to the technically-minded, pure technical development, the value of which is not always apparent to those with a theoretical mindset, and evaluation, the value of which, while acknowledged by most researchers, is highly dependent on *both* theory and design. Design science approaches would have the dual benefit of improving the methodological quality of some types of HCI research, while also forging closer ties between the various HCI camps.

Ultimately, the adage, “Theory, design, and evaluation – pick any two,” should not be a guiding force for HCI research in the future; often, each of these methodological components has an important role to play. Greater effort to capitalize on each of them via a design science approach to research, if thoughtfully and appropriately done, will have

the result of improving scholarly research and bridging gaps within the HCI discipline.

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