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Interaction Research and Interaction Design in a Complex World: A Critical Reflection on Wicked Problems and Methods to Tackle Them

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Abstract

The field of human-computer interaction offers a huge portfolio of methods for interaction research—particularly for understanding the current situation and evaluating designs—and interaction design for envisioning and creating designs. However, there is little literature on the nature of the design situation and particularly its complexity, structure, and dynamics, as well as their influence on the choice of methods. This paper contributes a thorough analysis of methods for interaction research and interaction design as well as a systematic classification of those methods with respect to the complexity of the design situation and design circumstances. This will help researchers and designers get a better understanding of how to apply those methods for current and future research and design activities.

CCS Concepts

• **Human-centered computing** → Human computer interaction (HCI); HCI design and evaluation methods.

Keywords

Wicked Problems, Classification of Methods, Design Situation Classification, Interaction Research, Interaction Design

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1 Introduction

Human-computer interaction (HCI) is an interdisciplinary field that focuses on a deep understanding of users and their needs as well as technological opportunities to fulfil their needs, innovative design of new ways of interaction between users and technology, and their thorough evaluation in order to assess their quality [21].

The analytical understanding and evaluation are often characterised as interaction research, whereas the synthetic design refers to interaction design [17]. Interaction research on the one hand is usually performed by actors in academia and industry with backgrounds in psychology, sociology, and anthropology, as well as computer science, information technology, and engineering. Here, the orientation towards research and science is also visible in the definitions of the field. For instance, HCI has been positioned at the 'intersection between the social and behavioural sciences on the one hand, and computer and information technology on the other. It is concerned with understanding how people use devices and systems that incorporate or embed computation, and how such devices and systems can be more useful and usable.' [6, p. 1]. It has been characterised as 'the study of the interaction between people (user) and computers' [39, p. 45]. Interaction design, on the other hand, in academia and industry recruits actors from visual design, product design, industrial design, and the like. Here, the perspective is often less that of engineering design, and more of creative design—that is, a process which begins openly where the definition of the design problem is part of the solution process and where the problem sometimes cannot easily be grasped and specified [43].

Interaction research offers a plethora of methods and techniques for understanding and evaluating interaction [5; 8; 12; 30; 31; 41]. For instance, interviews and experience sampling [18] contribute to a better understanding of the current and future users and their characteristics, but also their requirements and needs for current and future systems [8]. Diverse forms of feedback from users contribute to a better assessment of their effectiveness, efficiency, and satisfaction with existing and new systems. The methods and techniques here range from informal feedback in situations with a small budget in terms of time and money to full-fledged, systematic, empirical user studies [33].

Interaction design provides multifarious methods and techniques for developing early concepts, prototypes, and systems [1; 7; 13; 14; 20; 26; 27; 36]. For instance, sketching graphical user interfaces of future systems can help the designers and future users better understand the designers' visions for future interaction with the system [4]. Prototyping offers diverse flavours of anticipations of the future system. Early prototypes can be simple mock-ups, whereas late prototypes can provide real functionality and real interaction for users [26].

So, overall, in HCI, one has a vast choice of methods and techniques for interaction research and interaction design. Each individual methods and technique is typically neither good nor bad, but rather more or less adequate for a given research and design scenario.

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Process models can help find proper methods and techniques for each given phase of developing an interactive system [21]. They originated in engineering and later spread to software engineering and HCI. In HCI, the process models crudely distinguish the phases: understanding the current state, designing, and evaluating the design. Out of the existing process models, the process model of the International Organisation for Standardisation (ISO) 'Human-Centred Design for Interactive Systems' [21] is the most widely accepted and applied. Two other elaborate process models are the 'Wheel of UX Processes, Lifecycles, Methods, and Techniques' [19], and the 'Goal-Directed Design Process' [8]. While the first model is based on an international standard, the second one provides an insightful academic and educational perspective, and the third model shares much practical and industrial hands-on experience.

Interestingly, in the process models and beyond there is little discussion on the nature of the design situation and particularly the design situations' complexity as well as the influence of this complexity on the choice of methods. This is even more astonishing since there is a great deal of literature on the nature of design problems and design solutions concerning their complexity. Tame design situations have been distinguished from wicked ones. Tame design situations are typically easy to describe and communicate; wicked design situations are mostly of a complex nature and challenging to describe and formalise [9; 38]. Furthermore, the number and diversity of stakeholders involved in design situations and their perspectives on the design, including aesthetic aspects, have the potential to make the design situation more complex [14].

Beyond the design situations' complexity, the circumstances in which a design is situated potentially have a huge impact on the design situation and, therefore, on selecting methods for interaction research and interaction design. Many projects in HCI have a political dimension [10; 26; 32]. Looking at the big picture, design can be seen as a 'political and ideological activity' since 'every design affects our possibilities for actions and our way of being in the world . . . With designed artefacts, processes, systems, and structures, we decide our relations with each other, society, and nature. Each design is carrying a set of basic assumptions about what it means to be human, to live in a society, to work, and to play' [32, p. 10]. This is even more the case when we include a posthuman-centred design perspective that questions the human-centred and user-centred paradigm. This perspective puts design into perspective and reflects the 'implications of technological and environmental transformations [that] are challenging designers to focus on complex socio-technical systems' [15, pp. 16].

This paper contributes a systematic analysis of methods and techniques for interaction research and interaction design and their positioning in an Integrated Process Model, as well as a Design Situation Classification of those methods and techniques according to the complexity of the design situation and design circumstances. This will help researchers and designers get a better understanding of how to apply methods and techniques for current and future interaction research and interaction design.

2 Related Work

This paper is based on a vast body of knowledge in human-computer interaction with journal and conference papers as well as textbooks on research and design entities, interaction research and interaction design methods and techniques, and process models on how and when to apply them. It also builds on a foundation of works addressing the complexity of these situations.

2.1 Research and Design Entities

HCI focuses—as has been said above—on understanding, designing, and evaluating. This subsection clarifies the entities that need to be understood, designed for, or evaluated. The entities are the users, their tasks, as well as the social and physical environment in which the interaction between the user and the system is taking place [21].

The users, in a narrow sense, are the persons who will use the system—often referred to as the primary users. The users, in a broader sense, can include multiple stakeholders with a legitimate interest in the future system. Depending on the specific project, diverse aspects of users, particularly the primary users, can be relevant. Those aspects include the users' knowledge of the domain and the users' skills and experiences concerning interactive systems. They might also include the users' attitudes and habits, and their personal preferences and capabilities. The latter aspect might also have an influence on the design with respect to accessibility issues [21].

The goals and tasks of the users are also highly relevant. Starting from the overall goals of the users of what they really want to do and achieve with the future system, we can derive concrete tasks that users might want to perform with the system. This includes what the users want to do with the system and how they want to do it with the system. Also, the nature of the task can play an important role. For instance, the complexity of the task, but also the frequency of how often a task is performed, can influence the future design of a system [8].

In cooperative scenarios, the goals and tasks can go beyond the individual and span across a whole team. In order to understand teams and their goals and tasks it is important to look at the nature of the communication among the actors, as well as their coordination, cooperation, and collaboration [37; 40].

The physical environment builds the context in which the user's interaction with the system takes place. Depending on the concrete project, diverse factors can play a role. In a more narrow sense, the physical environment includes the auditory, thermal, and visual environments, as well as factors such as vibration, space, furniture, user posture, etc. In a more general sense, it also includes the technical environment with the hardware, software, network, and so forth, available for the users. Also, the organisational environment can play a role in factors such as work practices, assistance, interruptions management, communication structures, computer use policies, and so forth [34].

2.2 Research and Design Methods and Process Models

There is an excellent body of literature that provides collections of methods and techniques for both interaction research [5; 8; 12; 30; 31; 41] and interaction design [1; 13; 14; 20; 26; 27; 36].

This literature provides insightful details on individual methods and techniques, but also introduces many ways of structuring and categorising methods and techniques. Explorative research methods that address the big picture typically gather and analyse qualitative data that provide a rich picture of the current situation. Here, interviews, surveys, questionnaires, focus groups, or ethnographic studies can be applied. Formative and summative evaluation research methods and techniques aim to precisely measure the effectiveness, efficiency, and satisfaction of the users interacting with the system. They often gather quantitative data and allow for descriptive and inferential statistical analysis. Methods and techniques of collecting those data record the study participants' performance concerning measures such as the time to complete the task, the number of errors, etc., but also include answers to closed questions.

Research methods and techniques can be administered in the laboratory or the field. Proper experiments are often administered in a laboratory, since there all the conditions can be controlled (e.g., the light, the temperature, the interruptions). In contrast, field experiments have the significant advantage that the participants act and react in real environments, and so they often produce results with a higher external validity.

Research methods and techniques in HCI typically involve users and gathering information from users—either about them as a person and their attitudes, or about their behaviour. Nevertheless, some research methods and techniques do not need users. For instance, expert evaluations are performed by usability and domain experts. Other methods and techniques, such as predictive models, calculate and simulate the interaction of the user with the systems and need neither end users nor experts.

Design methods and techniques can be categorised according to the complexity of the design artefact that is generated with the respective method and technique. For instance, low-fidelity prototyping produces representations—mostly graphical or physical—of a system rather than the final system. Mid-fidelity prototyping gives a realistic impression of the design of the graphic user interface. High-fidelity prototyping provides real implementations of parts of the final system.

2.3 Process Models

Process models structure research and design methods and techniques according to the typical temporal sequence of phases that research and design projects go through.

The process model of the ISO is the widely accepted and used process model Human-Centred Design for Interactive Systems [21]. It suggests structuring the overall endeavour of developing an interactive system into four generic activities. According to the model, projects start with a Plan for the Human-Centred Design Process. After the plan has been established, in the first activity, the Context of Use needs to be understood and specified. The next activity is Specify the User Requirements. This includes the specification of the context of use, the specification of the user needs, and the specification of the user requirements. In the next activity—called Produce Design Solutions—design solutions are envisioned and produced with the aim of fulfilling all previously defined requirements. The specification of the user interaction and the user interface document those design solutions. Then, the design solutions are implemented. The implemented solutions later undergo an Evaluation against the previously established requirements. A so-called conformance test documentation records the results of the evaluation.

This process model covers phases of interaction research, mainly when, in early phases, the users, tasks, and environment are analysed and documented, but also when, in later phases, the implemented design solutions are evaluated. It also covers interaction design phases in the middle ground when design solutions are envisioned, prototyped, and implemented.

There are several other process models in HCI. Here we mention two very prominent ones: the Wheel of UX Processes, Lifecycles, Methods, and Techniques with the processes Understand User Work and Needs, Create Design Concepts, Realise Design Alternatives, and Verify and Refine Designs [19]; and the Goal-Directed Design Process with the processes Research, Modelling, and Requirements Definition, as well as Design Framework, Design Refinement, and Design Support [8]. Both models are highly complementary to the ISO process model. The first process model provides vast amounts of information on methods and techniques for all phases of the process model, while the second process model sets the users and their characteristics and goals as the central point of departure for all later phases. As will be seen later, our Integrated Process Model leverages all three models.

2.4 Research and Design Situations

In his seminal paper published more than half a century ago, Horst Rittel addresses challenges in systems analysis and design [38]. The paper distinguishes tame problems and wicked problems and makes the contrasts clear along various dimensions [38, pp. 392f]:

- Tame problems can be exhaustively described, whereas wicked problems 'have no definitive formulation'. Rittel points out that typically, at the beginning of a project, not all questions regarding the research and design endeavour are clear, and so not all answers can be given. Some questions may only arise later in a project, and their answers might depend on the current status of the project and the current status of the solution. So, in other words, the problem can only be properly understood gradually throughout the process of solving the problem.
- Tame problems distinguish the problem from the solution, whereas wicked problems have a strong connection between the problem and the solution. Rittel gives the example of a machine that is to be produced, and that should not exceed a certain weight. This specification of the weight is part of the problem but is also part of the solution.
- Tame problems have a clear end, whereas wicked problems do not have a clear 'stopping rule'. In complex scenarios, there is always room for improvement and optimisation.
- Solutions to tame problems can be tested. Various solutions to big problems cannot be tested. Rittel gives the example of a plan for a city and points out that it can hardly be classified as correct or false.
- Tame problems can be solved with a predefined set of permissible operations, whereas with wicked problems, unprecedented operations might be possible and necessary.

- Tame problems constitute a discrepancy between the state of the art and an intended state with a clear explanation, whereas wicked problems' discrepancies can have multiple and unclear explanations. Yet, depending on the explanation, the solution might change.
- Tame problems can be clearly identified, whereas wicked problems are often nested, and one problem can be the symptom of another problem.
- Tame problems are often recurring, whereas wicked problems are unique. Therefore, learning and transferring from one problem and its solution to the next problem and its solution is hardly possible.

Many authors have followed up on this notion of tame versus wicked problems. Some authors in the design literature even claim that 'design tasks are commonly regarded as wicked or ill-structured' [9, p. 5]. For other authors, it is essential that in wicked design situations, multi-disciplinary approaches combine design with multiple sciences such as 'natural, social, or humanistic' sciences in a new design thinking approach [3, p. 20]. Another consequence of wicked design situations is that designers must alternate between thinking and doing in multiple iterations—since problems and solutions co-evolve over time [11].
A central lesson from the literature on wicked problems and their consequences for the design approach [3; 9; 11; 38] is that many design problems are wicked. At the same time, there are tame design problems. The nature of the design problem—as we will see below—strongly influences the research and design approach to address it adequately.

3 Towards an Integrated Process Model

Our process model integrates principles and phases from the three process models Human-Centred Design for Interactive Systems; Wheel of UX Processes, Lifecycles, Methods, and Techniques; and Goal-Directed Design Process.

3.1 Principles of the Integrated Process Model

Process models in HCI should leverage principles from predecessors. Process models originated in engineering and spread to software engineering. Process models in software engineering can be seen as direct predecessors to process models in HCI. They provide valuable principles that are relevant beyond the scope of software engineering. In software engineering, process models have already included principles and phases with an early analysis that eventually converges into later phases of design [42; 44]. Also, the concept of iterations—that is, going through all phases of a project and then starting from the beginning to go through all phases of the project again—has been a central principle to many prominent process models and software engineering [2]. The advent of the Unified Modelling Language (UML) not only helps to better structure software components and their interfaces, but also better document the results of different stages of a software engineering project [22; 44]—and was a great manifestation of standardised documentation across individual projects and even organisations.

The process model Human-Centred Design for Interactive Systems of the ISO is widely accepted and used [21]. It follows several highly relevant principles. It combines interaction research in analysis activities with interaction design in synthesis activities. It is iterative and suggests going through the four phases until the designed solution meets user requirements. It also recommends documenting the results of the individual phases. Furthermore, the process model foresees cooperation in multidisciplinary teams. It follows a participatory paradigm—that is, it suggests involving users from the beginning in all phases until the end of the project. Although this model is somewhat agnostic towards specific methods—it allows for choosing from various methods in each phase [23].

The two other process models introduced above—the Wheel of UX Processes, Lifecycles, Methods, and Techniques [19], and the Goal-Directed Design Process [8]—are highly complementary to the ISO process model. In particular, they provide principles on the use of methods and techniques throughout all phases. With the first model come insightful definitions of central terms that serve as guiding principles for the rest of this paper [19]: the authors refer to their process model as a UX Design Lifecycle with the 'activities': Understand User Work and Needs (analogue to Understand and Specify the Context of Use in the ISO model), Create Design Concepts (analogue to Specify the User Requirements), Realise Design Alternatives (analogue to Produce Design Solutions), and Verify and Refine Designs (analogue to Evaluate Designs). A method is defined as 'a way one can carry out the whole or part of a given life cycle activity' (e.g., Usage Research within the first phase). And a technique is 'a specific, detailed practice you can use to perform a step within an activity, subjectivity, or method' (e.g., a user interview to collect data in the context of Usage Research) [19].

The Goal-Directed Design Process recommends the 'six phases': Research (analogue to Understand and Specify the Context of Use in the ISO model); Modelling, and Requirements Definition (both together summarised in Specify the User Requirements); Design Framework, Design Refinement, and Design Support (together analogue to Produce Design Solutions, but also including Evaluate Designs in the Design Refinement activity). Those phases are broken down into hands-on recommendations for interaction design practice in the sense of 'best practices' [8].

3.2 Phases of the Integrated Process Model and Their Methods and Principles

The combination of the three process models leads us to the following Integrated Process Model and details for the individual phases. Notably, we will also look at the requirements for each phase. This is an important prerequisite in order to identify adequate methods for each phase later, based on each individual method's potential to fulfil the respective requirements. Table 1 provides a summary of the three process models and their phases. As can be seen from the table, the phases of the three models are not entirely in sync—that is, the phases sometimes have the same or similar beginning or end (e.g., design activities), but sometimes are not aligned with each other (e.g., the first phase Understand user Work and Needs in the middle model does include the specification of requirements whereas in the first and third model the specification comes only in later phases).

Table 1: Summarising the three process models that were integrated: Human-Centred Design for Interactive Systems [21]; Wheel of UX Processes, Lifecycles, Methods, and Techniques [19]; Goal-Directed Design Process [8].

Human-Centred Design for Interactive Systems [21]	Wheel of UX Processes, Lifecycles, Methods, and Techniques [19]	Goal-Directed Design Process [8]
Plan the Human-Centred Design Process	Understand User Work and Needs	Research
Understand and Specify the Context of Use		
Specify the User Requirements		
		Modelling
Produce Design Solutions		Requirements Definition
Evaluate the Designs	Create Design Concepts	
	Realise Design Alternatives	Design Framework
	Verify and Refine Designs	Design Refinement
		Design Support

The phases Plan the Human-Centred Design Process and Understand and Specify the Context of Use starts with a project plan. Overall it is analytic and involves interaction research. It includes getting a better understanding of the big picture of the project with details on the project's objectives, timelines, financial matters, etc. It also involves identifying the future users and their goals and needs and requirements for the future system to be designed. In order to get a better understanding of the future users, their tasks, as well as their requirements and wishes for the future system, adequate methods and techniques are needed. The methods and techniques in this phase are used to elicit data, and to analyse data. Techniques for eliciting data include user interviews and user observations, but also document analysis [19]. Explorative qualitative methods include techniques such as ethnographic studies and contextual inquiries, which can produce further insights on the users in their natural habitats [8]. Cultural probes are a special technique where means for capturing user experiences are prototyped and given to the users of the future system. Those users can then record their user experiences in a playful manner (e.g., by taking instant photographs) [16].

The phase Specify the User Requirements is based on the findings of the previous phase. The methods and techniques here extend those findings with further details, and are used to model data and to extract and define requirements. The techniques are applied here to generate models and documentations. Still, the primary perspective is interaction research rather than interaction design. The most adequate and prominent technique for modelling users is personas that cluster future users into groups with the same or similar characteristics on relevant criteria (e.g., domain knowledge, technology affinity). Besides basic characteristics of the users, personas can also include goals and behaviour, and activities towards reaching those goals. Requirement specifications techniques extract essential aspects and include information on the functionality and other aspects of future systems. Future usage scenarios can complement the requirement specifications and illustrate how the future functionality will actually be used [8]. Depending on the complexity of the tasks that users need to perform, task models can be invaluable for modelling tasks, especially in cases where they get complex [19].

The phase Produce Design Solutions to Meet User Requirements is where interaction research gradually converges into interaction design. This phase starts with top-down methods and first envisions the future user experience and user interaction with the system. This is then put into a design framework. Further details can be added to the design framework by using techniques such as interaction design patterns. During this activity, the designs are refined stepwise: the designs are tested, feedback on the designs is collected, and the designs are revised and optimised, and further details are added [8]. Several techniques are adequate for those activities. Design sketches can illustrate early design ideas. Low-fidelity prototypes mimic the future system in a very simple way. Storyboards can be used for the conceptual design of the future interaction of the user with the system. Mid-fidelity prototypes can be produced with techniques such as wireframing and give an impression of the look and feel of the future system while still leaving out several details of the final system [19]. Participatory design is a special approach where future users are involved not only in the initial understanding but also in producing design solutions [28]. Speculative design is still a niche technique, but one that, depending on the circumstances, can be highly adequate. Speculative design can best be performed in situations where the design team has a lot of freedom and is interested in exploring diverse ideas and their consequences. Here designs are often produced as vehicles that should trigger discussions on the design per se but also on the big picture and implications of the design on the bigger environment and society as a whole [14].

The phase Evaluate Design against Requirements can be either organised as a pure interaction research activity where the existing results are tested. It can also be organised in a broader sense where the interaction research is complemented with interaction design—that is, the evaluations are immediately followed by cycles of optimisations, small re-designs, and re-evaluations [8]. Analogue to the interaction research in the first phase, the interaction research here also requires a clear top-down evaluation strategy that specifies evaluation goals and metrics. Here various flavours of the usability testing method are applied. The methods and techniques can basically involve users or experts. During the usability testing, data are gathered, analysed, documented, and interpreted in order to serve as input for optimisations and redesigns [19]. Usability testing with users can sometimes be organised in a complex process, answering many questions. In other circumstances, it can be extremely simple, like the A/B-test technique comparing two alternatives. Eye tracking can be used in the A/B-test technique and beyond to precisely measure the users' fixations and saccades on the screen. Think-aloud can be used as a technique for formative evaluations where users use the current version of a future system and comment on their thoughts and impressions during use. Diaries can be used where users over an extended period record their experiences with a system [30]. Living laboratories are a method best suited for deep dives—that is, here, the system is deployed to the users, and the users typically use the system for an extended period in their natural habitat. This allows users to get an accurate impression of the actual use of the system that can then later be recorded and analysed [25]. Cognitive walkthroughs and heuristic evaluations are techniques that are typically employed by experts, who go through the application and mimic a user, but at the same time build on their previous knowledge and expertise in the field [6].

Table 2 summarises interaction research and interaction design methods and techniques and their properties.

4 The Design Situation Classification

As has been pointed out above, the situation in which a project takes place can be very diverse. Tame situations are low in complexity and high in structure; wicked situations are high in complexity and low in structure [9; 24]. The choice of methods and techniques in the respective phase needs to reflect this complexity and structure at hand. Therefore, we start by revisiting tame versus wicked situations concerning their complexity and structure. We use that as input and as a requirement for a possible approach and, consequently, the choice of methods and techniques.

4.1 The Open-Closed Spectrum

Tame situations and problems with a high structure are those where all aspects of the problem at hand are well known and can be easily described. Here, the initial state is well known, the goal state is also clear, and the steps from the initial state to the goal state are also known. Established rules and principles can be applied when solving the problem. Wicked situations and problems with a low structure are often dynamic and emergent, where not all problem elements are known at the beginning. Therefore, it is not easy to describe the problem. Not only is the initial state unclear, but also the goal state. Indeed, a given problem might lead to different solutions depending on the path to the solution. Here, it is much less evident which rules and principles can and should be applied. The same holds for the criteria for the evaluation of the solution. During the process of solving wicked problems, often personal judgment, opinions, and beliefs can play a role, particularly since there is no objective right or wrong.

Tame situations and problems can be characterised by a low complexity, and wicked ones by high complexity. The complexity emerges from the number of issues, functions and variables that are part of the situation and the problem. It is also related to the degree of connectivity among them, the number of changes that occur to them and their connections over time. Low complexity has a low number of entities, with only a few connections and very little dynamics. High complexity, on the other hand, can be characterised by a large number of entities that are highly interconnected and that change frequently over time.

Design problems often face low structure and high complexity, as well as uncertainties on the side of the designers. So, in projects that aim to develop interactive systems, the interaction research and interaction design—and particularly the methods and techniques used—need to address this fact. Beyond the challenges entailed by a low structure and high complexity, the typically high number of stakeholders can also cause additional challenges. During interaction research and interaction design, one needs to deal with users but also clients. Also, legislators might play a role, and designers might have their personal position [24; 29].

4.2 The Classification

The new classification of methods and techniques according to their fit into process model phases and closed versus open situations and problems is shown below (cf. Figure 1). The x-axis has four entries corresponding to the process model's four phases described in the previous subsection. The y-axis represents a spectrum from closed to open situations and problems. Close situations and problems refer to tame situations with high structure and low complexity, but also with low dynamics and a manageable number of stakeholders. Open situations and problems refer to wicked situations with low structure and high complexity as well as high dynamics and a considerable number of stakeholders. This axis represents a continuum.

The methods and techniques included in the classification come from the previous section. They serve as examples and as placeholders. Certainly, other methods and techniques with similar properties can also be used. Variations of the methods and techniques can also be used. For instance, instead of user interviews where single persons are interviewed, one could also perform focus groups where multiple persons are interviewed at the same time in the same location, which allows for a group discussion.

The positioning of the individual methods and techniques in the classification follows a clear logic.

- Document analysis and user interviews can be used to understand relatively closed situations. Contextual inquiries, where one goes to the users' location for a limited amount of time, and particularly ethnographic studies, where one typically goes to the users' locations for an extended period, are very well suited to analyse open situations. Ethnographic studies also have the advantage of allowing one to encounter multiple user groups, so one gets an insight into various perspectives of numerous stakeholders within the user population.
- Requirement specifications and task models can only be successful if the situation has properties of a tame situation. For instance, this is the case if all entities are known in advance at the beginning of the project. Personas to represent users in a lightweight fashion and scenarios to describe the future interaction of the users with the system allow for some

Table 2: Phases and interaction research and interaction design methods, techniques, and their properties. Interaction Research vs. Interaction Design [IR/ID]: Interaction Research [1] vs. Interaction Design [2]; Quantitative vs. Qualitative [Q/Q]: Quantitative [1] vs. Qualitative [2]; Attitude vs. Behaviour [A/B]: Attitude [1] vs. Behaviour [2]; Laboratory vs. Field [L/F]: Laboratory [1] vs. Field [2]; Users vs. Experts vs. Neither [U/E/N]: Users [1] vs. Experts [2] vs. Neither [3]; Material [M]: Analogue [1]; Digital Different from Final System [2]; Digital Same as Final System [3]; Sophistication of System [S]: Low [1] vs. Medium [2] vs. High [3]; Alternatives [A]: One [1]; Few [2]; Many [3]; Effort [E]; Low [1]; Medium [2]; High [3]

Phases / *Methods* / Techniques	IR/ ID	Q/Q	A/B	L/F	U/E/N	M	S	A	E
Plan the Human-Centred Design Process									
Understand and Specify the Context of Use									
Elicit Data									
User Interviews	1	2	1	1	1	-	2	-	2
User Observations	1	2	2	2	1	-	2	-	2
Document Analysis	1	2	2	2	1	-	2	-	2
Ethnographic Studies	1	2	1	2	1	-	3	-	3
Contextual Inquiries	1	2	2	2	1	-	2	-	3
Cultural Probes	1	2	1	2	1	-	3	-	3
Specify the User Requirements									
Model Data									
Personas	1	-	-	-	-	-	2	-	2
Extract Requirements									
Requirement Spec.	1	-	-	-	-	-	2	-	2
Scenarios	1	-	-	-	-	-	1	-	1
Task Models	1	-	-	-	-	-	2	-	2
Produce Design Solutions									
Envision the Future User Exp.									
Design Framework	2	-	-	-	-	-	3	1	2
Interact. Design Patterns	2	-	-	-	-	-	2	1	2
Design Sketches	2	-	-	-	-	1	1	3	1
Low-Fidelity Prototyping	2	-	-	-	-	2	1	2	1
Storyboards	2	-	-	-	-	2	1	2	1
Wireframing	2	-	-	-	-	2	2	2	2
Participatory Design	2	-	-	-	-	2	3	2	3
Speculative Design	2	-	-	-	-	3	3	2	2
Evaluate Design									
Usability Testing with Users									
A/B-Test	1	-	-	1	1	-	2	-	2
Think Aloud	1	-	-	1	1	-	2	-	2
Diaries	1	-	-	2	1	-	2	-	2
Living Laboratory	1	-	-	2	1	-	3	-	3
Usability Testing with Experts									
Cognitive Walkthrough	1	-	-	1	2	-	2	-	2
Heuristic Evaluation	1	-	-	1	2	-	2	-	2

vagueness, which is good when the situation has characteristics towards the open end of the spectrum. Personas provide a means by which different user groups can be represented.

- Design frameworks and interaction design patterns require a lot of knowledge of the detailed interaction of the user with the future system. They can, therefore, only be applied in closed situations. Interaction design patterns require some structure to be applied successfully. Wireframing is a bit more relaxed, but still needs considerable precision. Low-fidelity prototypes, design sketches, and storyboards allow for some vagueness and can be applied in slightly more open situations. Participatory design allows for the continual involvement of users throughout the whole analysis and design process. Therefore, it is well suited for an iterative exploration of the problem space and the solution space. This is even more the case for speculative design, where it is a central feature of the method that the persons involved in

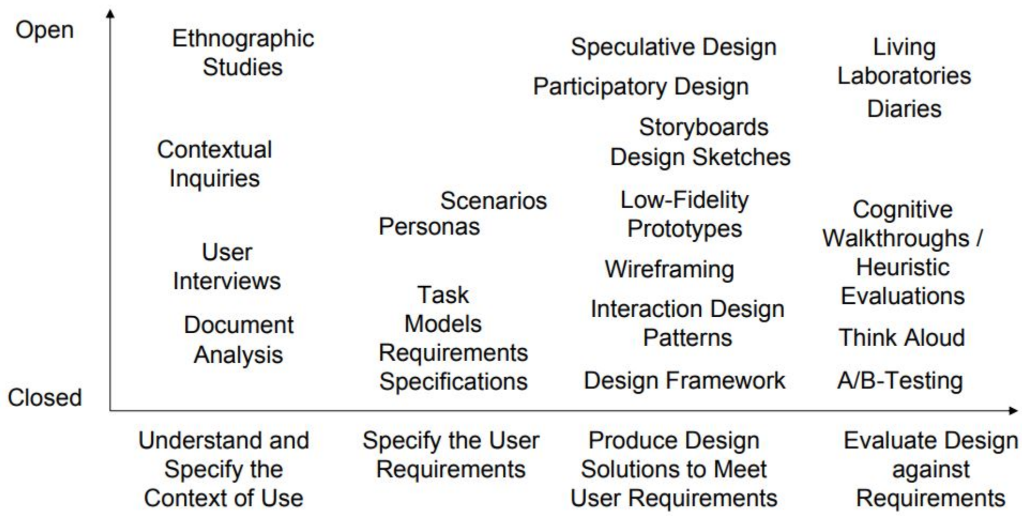

Figure 1: Design Situation Classification of methods and techniques according to their fit into process model phases and tame versus wicked situations and problems.

the analysis and design process speculate about potential outcomes. Participatory design and speculative design allow for interaction with multiple stakeholders.

- A/B-Testing, think aloud, and other usability testing methods with users require a precise understanding of the situation and a prototype or system that has already been developed and can be tested. They are, therefore, more suited for closed situations. Cognitive walkthroughs and heuristic evaluations are done by experts, and some vagueness in the design of the system is possible. Living laboratories are an excellent method for intensively studying the prolonged use of a system as well as continual improvements and redesigns. Diaries are a flexible way to help users document their experiences in relatively open situations in situ. Living laboratories can address multiple stakeholders: future users can live in the living laboratory, and other stakeholders, such as designers or clients, can visit the users.

In order to illustrate the use of the classification two use cases are presented. In use case UC1, imagine the use of the process model and its methods and techniques in a relatively closed situation, such as an office application for a small company with only a handful of employees. Here you could start your Understanding phase by interviewing the future users and other stakeholders. You might also ask for documents and analyse those documents. Specifying the user requirement should be a straightforward process. As the tasks are pretty clear, it is straightforward to develop task models. During the Design phase, a design system can be established and feature interaction design patterns. Early prototypes can be developed. In the Evaluation phase they can easily tested and compared if you have multiple alternative prototypes, for instance, with the think-aloud technique, with the actual future uses.

In use case UC2 imagine you want to develop a mobile app for the public transport of a whole country. Here you might have millions of future users, various types of users, and diverse groups of stakeholders. The stakeholders might have partly complementary but sometimes also partly orthogonal goals. Here you might also want to start out the Understanding phase with user interviews, but at the same time it could be essential to understand users in the real situation. So, you might want to do contextual inquiries and ethnographic studies and ask users in the situation where they are actually using the app, for instance, at the bus stop, at the railway station or on the train. In the Specification phase, you might need to come up with a considerable number of personas and scenarios for them. In the Design phase you will probably need to involve many users to either get feedback on your own designs or to integrate them in participatory scenarios where they contribute their design ideas. Finally, in the Evaluation phase, you could start with some simple laboratory tests and think-aloud techniques, but it might be helpful to study the use of the application in real life, in a kind of living laboratory scenario. There you would go into the field again to see if and how the application is being used in-situ.

5 Conclusions

This paper presented our Integrated Process Model and our Design Situation Classification. The Integrated Process Model is based on an extension and combination of the ISO process model Human-Centred Design for Interactive Systems with the Wheel of UX Processes, Lifecycles, Methods, and Techniques as well as the Goal-Directed Design Process. It combines the widely accepted and used international standard with detailed principles, methods and techniques of the latter two models. A thorough analysis of existing interaction research and interaction design methods and techniques led to a detailed classification of numerous methods and techniques. The paper also contributed a discussion of the design situation. The aggregation of parameters of tame versus wicked situations and problems, such as their complexity and structure, with other parameters, such as the number of stakeholders, was used as a foundation for the open-closed spectrum in the Design Situation Classification.

A limiting factor for the critical reader of this paper might be that the paper, on the one hand, argues for the wickedness of design situations and problems, where planning is hardly possible or even impossible, while at the same time it tries to make predictions of when to use which method and technique. Indeed, some authors have pointed out that—from the perspective of creative design—design phases are unique, and design phases are influenced by the values and ideals of the stakeholders. Furthermore, design activities typically have a political and ideological dimension. After all, the systems we are designing, in one way or another, influence our environment and, with that, our society and nature [32].

For this latter reason, the current and future inclusion of Generative AI tools into interaction research and interaction design has great potential but also significant risks. Generative AI tools—and AI tools in general—must follow core ethical principles such as fairness, transparency, accountability, and privacy [35]. However, in open design situations with little structure, high complexity, high dynamics, and many stakeholders, it might become difficult to trace the evolution of designs and systems.

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