

# **EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS**

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## **ABSTRACT**

With the increasing use of digital technology, it's important to keep issues of equal access and participation in mind. Interaction with IT-systems is becoming more complex due to the level of networking, diversity, dynamics, etc. While this can provide new functionality to the users, at the same time it can hamper the perceived interaction quality. Against this background, this study presents a tool for identifying and analyzing complex interaction situations and applies it to two development projects for educational infrastructures. Method-wise, structured self-reflection was carried out with the help of a questionnaire completed by 11 resp. 13 members of the development teams. Specific usage scenarios and user groups were identified that are particularly associated with complexity. The analysis was deepened by systematically analyzing the characteristics that generate complexity. The results of both case studies are presented, and conclusions for further project work are drawn. In addition, the presented instrument is evaluated regarding its support in systems development, finally leading to recommendations for future application of this instrument.

## **KEYWORDS**

Human-Machine-Interaction, User-Centered Design, Socio-Technical Systems, Complexity

## **1. COMPLEXITY IN SOCIO-TECHNICAL SYSTEMS**

We are increasingly confronted with a technological environment (Weiser, 2002), in which technology defines how we perceive, evaluate, sense, judge and act. Currently, we are experiencing a process of continuous digitalization in all areas of life. New technologies, like Virtual Reality or Artificial Intelligence, provide not only enhanced functionality, but also new forms of interaction like speech or gesture recognition. In addition, technology is gradually

losing its character as merely a tool and is increasingly appearing as an autonomous actor (e.g., as robots, voice assistants, smart control elements or digital learning companions). This is accompanied by the fact that new technical devices are capable of simulating emotional and intellectual abilities that were previously reserved for humans (White & Katsuno, 2022). This shift is accompanied by various expectations, but also changes and uncertainties (Mason, 2008). Without being able to recognize it from the outside, these technical objects are highly interconnected internally and exchange data and information with other objects in the background (Assadi & Manzeschke, 2020), which somehow obscures the perception and understanding of the system by the users. As a consequence, this may increase the perceived complexity of the system, or rather of the interactions with the system, even though reducing hurdles and increasing comfort was an objective of such developments. If left unresolved, this can lead to a loss of trust which is especially harmful in education (Schlick et al., 2009). In learning and teaching scenarios, the cognitive capacity should be reserved for the learning content and activities, not for operating the systems' interfaces. However, cross-institutional educational spaces or AI-supported educational applications are becoming increasingly relevant, and the loss of trust resulting from perceived complexity might spill over from educational technology to teachers and education institutions. Thus, guidance is needed for users and developers of such complex human-technology interactions (Lucke et al., 2022; Moebert, 2022).

In the context of project management and software development, such dynamic environments are frequently characterized by the VUCA framework—an acronym for Volatility, Uncertainty, Complexity, and Ambiguity. Originally introduced in the context of leadership strategies (Bennis & Nanus, 1985), VUCA has been widely adapted as a vital concept for managing modern, highly dynamic development projects where traditional, linear planning falls short. Existing quality assurance methods and tools are not sufficiently addressing this issue. The focus of user-centered design processes is heavily relying on aspects of a dedicated user interface, but rather not reaching out to interconnections and dynamics of system components in larger infrastructure. As a consequence, the existing toolbox in Human-Computer-Interaction has to be extended with respect to aspects of complexity.

When people perceive complexity, people use different strategies to cope with it. A frequent approach is to reduce complexity by simplifying the structure or conditions in order to regain a sense of control. However, this has a significant disadvantage, because complexity is an inherent part of the system, without which it cannot function as desired (Ulrich & Probst, 1991). An alternative strategy is to ignore or hide the given complexity. However, in addition to the above-mentioned risk of inadequate problem-solving strategies, such an illusion also poses ethical problems if this is imposed on learners without their consent (Mason, 2008). This raises the question of how to deal effectively with the perception of complexity without reducing or ignoring it (Moebert, 2022; Assadi & Manzeschke, 2020).

The term complexity is defined differently in scientific research, depending on the discipline and social context (Grösser, 2017; Schoeneberg, 2014; Luhmann, 2009). Complexity is broadly understood as a multidimensional construct that is considered in different contexts and applied to different systems. However, which dimensions are relevant for consideration and what the corresponding operationalizations look like, depends on the respective research interest (Luhmann, 2009). In order to adequately address the perception of complexity, we use a perspective in which complexity is no longer viewed exclusively as a property of a technical system. Instead, interaction with the system is also attributed a complexity-inducing quality that results from various perception effects. This interaction complexity can be turned visible in the

design process and thus addressed in a targeted manner, as already demonstrated for mobile applications (Moebert, 2022).

This broader perspective aligns with a recent shift in Human-Computer-Interaction (HCI). The focus of the field has traditionally been the users and how to best serve their needs, initially moving to usability, and then to the more holistic approach of User Experience (UX), thus investing in expensive user tests at various phases of the design process (Soares et al., 2024). However, assessing the complexity below the surface in early stages of a system requires expert knowledge of designers or developers. This is typically addressed using methods like cognitive walkthrough (Lewis et al., 1997), but on the one hand, perceptions of developers and later users may significantly vary, and at the other hand, existing concepts of interaction complexity (Janlert & Stolterman, 2008; Moebert, 2022) have not yet been translated into guidelines for addressing complexity during the design process. At the same time, there is an ongoing shift towards concepts like user eudaimonia, which emphasizes the transformative impact of these interactions on the user's long-term growth and flourishing (Stephanidis et al., 2025). In this sense, capturing the perception of interaction complexity can be viewed as an additional perspective that contributes to moving beyond "just" UX, ultimately encouraging systems that provide deep and meaningful engagement. Until now, there has been no tool available for analyzing complexity that could be used systematically in the design process, helping to improve the prototype even before (costly) user studies can be conducted. Related work, up to now, is limited to user evaluations (Schrepp et al., 2021) at a later design stage.

In this article, we explore how such a structured instrument can be used to identify and analyze complexity when designing educational technology, and what consequences this has for the further development process. To this end, we draw on two case studies that are particularly characterized by complexity. First, we look at a national digital education ecosystem (Hartmann et al., 2025), which generates highly heterogeneous and changeable scenarios through cross-institutional, formal and informal settings. Second, we look at an AI-based study assistance system (von der Heyde et al., 2023), which, due to the high degree of automation of the technology, leads to orientation needs among users. For both case studies, we focus on three research questions, the first two of which relate to the project and the third to the analysis tool:

1. Which usage scenarios are particularly complex and why?
2. For which user groups is interaction particularly complex?
3. To what extent are the results provided by the analysis tool perceived as helpful in the design process?

The main objective is to derive conclusions on how complexity can be meaningfully addressed as early as possible in the design of educational technology. Chapter 2 begins by presenting the instrument that has been developed. Chapters 3 and 4 describe the two case studies that were conducted to test this instrument. Chapter 5 discusses the results. The article concludes with a summary and an outlook in Chapter 6.

## 2. ANALYZING COMPLEXITY

To visualize the complexity of interactions early in the design process, the theoretical model described in Section 2.1 is applied. Its operationalization in a questionnaire and the further procedure for analyzing the collected data are then presented in Section 2.2.

## 2.1 Theoretical Model for Complexity of Interactions

The theoretical model forms the basis for considerations that make it possible to anticipate, already during the design phase, how future users might perceive complexity when interacting with the system. In addition, the perception of complexity during use can also be visualized for existing systems. Fig. 1 shows a schematic representation of the model (Moebert, 2022). It is designed in such a way that specific complexity criteria are derived through the gradual generalization of concrete interaction situations, leading to a categorization of interaction situations following (Ulrich & Probst, 1991). The method consists of three steps:

1. Collection of interaction situations
2. Determination of their complexity
3. Assigning criteria for interaction complexity

The original model is used with qualitative methods (interviews and categorization). In addition, a reflection tool (Lucke et al., 2022) can be used for independent analysis of complexity during the design process. However, both require methodological knowledge or otherwise run the risk of remaining unsystematic or superficial. To enable independent work with the model, a questionnaire set is provided below.

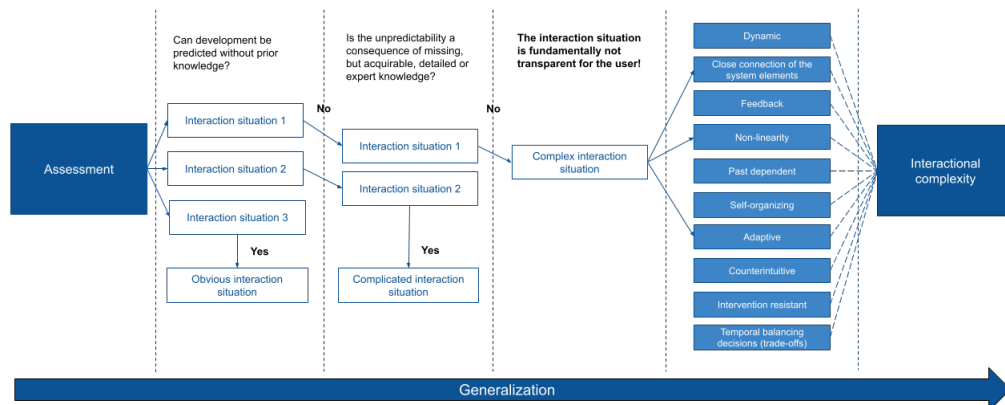


Figure 1. Analysis of interaction complexity with step-by-step generalization and mapping to specific complexity criteria

## 2.2 Instrument for Collecting and Analyzing Interaction Complexity

Based on the above-mentioned construct definition, three indicators were derived and corresponding test items developed, which can be used to classify situations as obvious, complicated, complex, or chaotic (Ulrich & Probst, 1991). In the first part of the questionnaire, these test items enable the identification of interaction situations that are perceived as complex (from the perspective of the users of the technical system). In the second part, these situations are analyzed in more detail according to complexity criteria (Grösser, 2017), for which test items have also been developed: dynamic, close connection of the system elements, feedback, non-linearity, past dependent, self-organizing, adaptive, counterintuitive, intervention resistant and temporal balancing decisions (trade-offs).

## EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS

These characteristics are regarded as sources of complexity perceived by potential users, which help to make the otherwise elusive quality of complexity in the design process more comprehensible. Therefore, the characteristics of these features for the specific interaction situation are reported back graphically to the users of the questionnaire so that further conclusions can be drawn. The questionnaire is designed as a ‘do-it-yourself’ tool for all stakeholders in system development and provided as a spreadsheet (Moebert et al., 2026) as depicted in Figure 2. Its use is accompanied by textual prompts for action. The procedure is as follows:

- In a first step, all potential interaction situations (Fig. 2, left, rows) are anticipated from the perspective of all involved user groups (tabs of the spreadsheet). Their perspectives are classified using three test items on a 4-point Likert scale (applies without restriction – applies mostly – applies with significant restrictions – does not apply). The answers are assigned a numerical value (columns) and classified using a binary tree graph as obvious, complicated, complex or chaotic (right column, color-coded). If interaction situations turn out to be complex, the second part of the questionnaire is continued.
- In the second step, interaction situations classified as complex are analyzed (Figure 2, right, rows) using ten test items on a 5-point Likert scale (always applies – mostly applies – partly applies – mostly does not apply – never applies). Numerical values are also assigned to these answers (columns), and then transferred to a ten-dimensional network diagram. This makes it possible to classify a specific interaction situation in terms of its complexity dimensions and to respond appropriately in system development. This can involve both an adjustment of the interaction dynamics or structure, or additional system-side assistance to successfully manage the complexity on the user side.

A		B		C		D		E		F		G	
for user group: Administrative Staff				Imagine a typical person from this group! For all applicable scenarios, answer the three questions by selecting one of the four options. Non-applicable rows may be omitted.									
Interaction Scenarios				Assessment Questions:				From the perspective of the targeted user group ...				Categorization	
Use Cases		User Stories / Epics		Can users predict the behaviour of the system and the effects of their own actions?		Is specific detailed or expert knowledge required for such a prediction?		To what extent can the behaviour of the system be reconstructed retrospectively?				03	
8	Designing Study Regulations	Model study regulation in SemLogic	(1) fully predictable	(2) moderate knowledge	(1) fully reconstructable							complicated	
10		various criteria of studyability	(1) fully predictable	(1) extensive knowledge	(1) fully reconstructable							complicated	
11	Quality Control	Criteria (from higher order regulations)	(1) fully predictable	(1) extensive knowledge	(1) fully reconstructable							complicated	
12		progress plan (SDPP)	(1) fully predictable	(2) moderate knowledge	(1) fully reconstructable							complicated	
13		study regulation	(1) fully predictable	(2) moderate knowledge	(1) fully reconstructable							complicated	
14	Study Planner	structural factors	(1) fully predictable	(3) limited knowledge	(1) fully reconstructable							obvious	
15		preferences on favored elective modules	(2) mostly predictable	(2) moderate knowledge	(1) fully reconstructable							complicated	
16		Course recommendation	(1) fully predictable	(3) limited knowledge	(1) fully reconstructable							obvious	
17		achievements with requirements of the	(1) fully predictable	(2) moderate knowledge	(1) fully reconstructable							complicated	
18	Curriculum Planning	previous semesters with study regulation on the basis of study regulation	(2) mostly predictable	(3) limited knowledge	(1) fully reconstructable							obvious	
19			(2) mostly predictable	(3) limited knowledge	(1) fully reconstructable							obvious	
20	Student Counseling	degree in time which can be generated from given situation or problem of a student	(2) mostly predictable	(3) limited knowledge	(1) fully reconstructable							obvious	
21		study plans of a student to match best	(2) mostly predictable	(2) moderate knowledge	(2) mostly reconstructable							complicated	
22			(3) partly predictable	(2) moderate knowledge	(2) mostly reconstructable							complex	
		Student   Professor   Academic Staff   Administrative Staff		(dropdown values)									

A		B		C		D		E		F		G		H		I		J		K		L	
for all user groups				Imagine the interaction between users and the CAVAS+ system in the two use cases listed below in our previous analysis. They have been identified to be particularly complex. Which properties contribute to which extent to this complexity, in your perception?																			
Scenarios				Assessments:		Dynamics		Interconnection of Feedback or system elements		Non-linearity in system behaviour		Dependence on past events		Self-organisation		Adaptability		Counter-intuitiveness		Resistance to intervention		Weighting up decisions	
7	D1) Designing Study Regulations. Model study regulation in SemLogic			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
8	C) Student Counseling. Show possible adaptations of the individual study plans of a student to match best practices			4 - "rarely applies" 1 - "always applies" 2 - "mostly applies" 2 - "mostly applies" 4 - "rarely applies" 4 - "rarely applies" 3 - "partly applies" 4 - "rarely applies" 4 - "rarely applies" 3 - "partly applies" 1 - "always applies"																			
9				3 - "partly applies" 1 - "always applies" 1 - "always applies" 1 - "always applies" 2 - "mostly applies" 4 - "rarely applies" 1 - "always applies" 4 - "rarely applies" 3 - "partly applies" 2 - "mostly applies"																			
10																							

Figure 2. Analytical instrument for assessing the perceived complexity of interaction (above) and the parameters generating this complexity (below) filled with sample data from the second case below

Initial pilot tests of the instrument showed very positive effects. Participants [N=5] reported perceiving at least one interaction situation with a changed understanding. The instrument was therefore subsequently tested in real educational technology projects, as described below.

### **3. FIRST CASE: A NATIONAL DIGITAL EDUCATION ECOSYSTEM**

This case study was selected because we expected to find particular complexity from the large, heterogeneous and dynamic structure of the technical solution. Moreover, we consider the very large and diverse project team (with a total of around 100 people from across the country and with different disciplinary backgrounds) to be an additional contributor to complexity.

#### **3.1 Background and Structure of the Case Study**

When transitioning between different sectors of education, for example from school to university, users are often confronted with different platforms and usage scenarios. It is necessary to repeatedly compile personal data and collected materials along one's educational path. An interconnectivity infrastructure (Hartmann et al., 2025) supports such transitions. Against this background, the project pursued specific goals in three main areas:

- In the application context, specific needs in educational settings were identified, in order to demonstrate the usability of a federated education infrastructure and to prove the practical benefits for stakeholders.
- In the development context, a reference architecture was designed and implemented. The prototype demonstrated the suitability of the approach, including integration of existing institutions and services, and openness to future technological changes.
- In the transfer context, the applicability of the approach to other educational and social contexts was investigated, while at the same time expertise for potential operators and policymakers was provided.

The prototype was designed based on personas and usage scenarios. The personas were empirically identified and characterized using target group analysis and market research. Ten primary personas were developed in particular detail and serve as representative user profiles or main actors in the scenarios. Over 100 usage scenarios were defined, providing a comprehensive picture of potential use cases (Erdmann et al., 2023). The technical implementation of the prototype is based on these scenarios and makes maximum use of existing services in the digital education ecosystem that are interlinked via interfaces. Fig. 3 shows two exemplary components of the prototype. The workspace (left) allows users to assemble collaboration tools (like shared editors and communication tools) along with shared files as widgets in a drag-and-drop mode; fellow users can be invited from the list of contacts (Endries et al., 2026). The learning path finder (right) evaluates previous achievements of the user from his/her personal wallet (not depicted) along with given learning goals and provides recommendations on possible learning pathways (Ziemann et al., 2023) consisting of references to various educational resources from the data space component (not depicted) behind this ecosystem.

## EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS

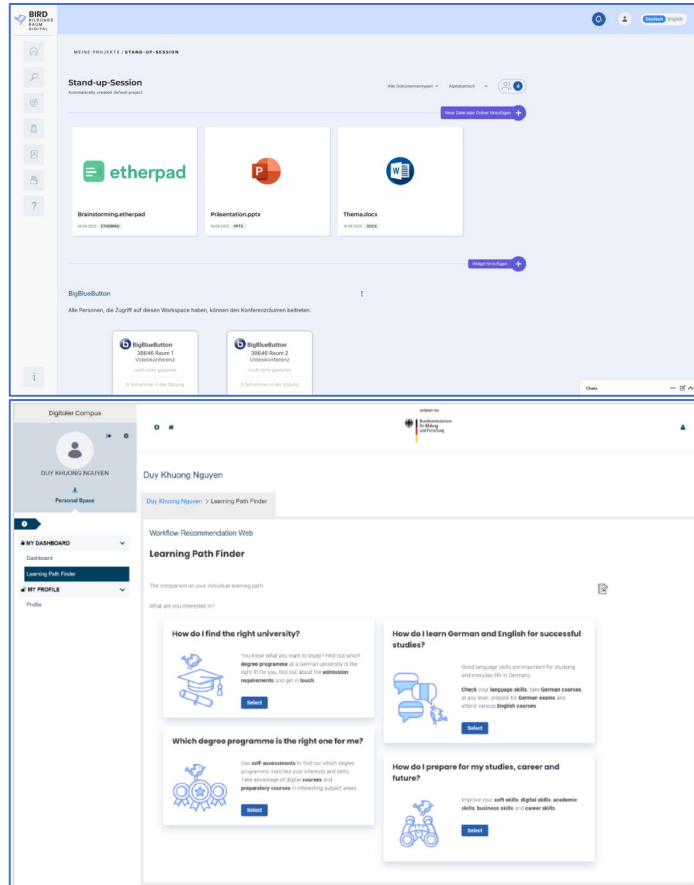


Figure 3. Prototypes of the shared workspace (above) and the learning path finder (below)

Other components were provided, like single sign-on, metadata management, buddy recommendations etc., but are not depicted here. The application of the developed analysis tool for complexity was tested on this basis in a face-to-face workshop. 11 members of the design team first evaluated 13 key scenarios from the perspective of all personas conceivable in that scenario regarding their assumed complexity. Tab. 1 shows the professional backgrounds of these individuals; care was taken to ensure a balanced distribution in the selection process. For the scenarios classified as complex, 8 of them (numbers marked in *italics*) then asynchronously evaluated the contribution of possible complexity-generating properties of the system using the feature questionnaire.

Table 1. Disciplinary backgrounds of surveyed persons from the project team in the first case study

Expertise	01	02	03	04	05	06	07	08	09	10	11
Pedagogy	x	x	x			x		x		x	
Technology			x		x		x	x	x		x
Design				x					x		
Management										x	x

### 3.2 Identifying Complex Interaction Situations

In all scenarios considered, complex interaction situations were found to occur to a relatively small extent across all personas (see Fig. 4). Furthermore, with the exception of three scenarios, chaotic interaction situations were rarely identified. Two participants (No. 06 and No. 11 in Tab. 1) showed a comparatively high perception of complexity. For further consideration, only the complex classifications are relevant at this stage; the chaotic ones will be discussed in Section 3.4.

Thus, the first research question for this case study can be answered positively as follows. The application scenario ‘Student wants to study music education’ was classified as potentially (and by far particularly) complex. In contrast, the scenario ‘Registration via BUND-ID’ is potentially associated with only a low degree of complexity. For this evaluation, the complex classifications were counted across all evaluators and separately for each scenario. The data was also evaluated per persona across all evaluators and scenarios. In response to research question 2, it was thus possible to identify a persona for whom a particularly complex perception is to be expected, namely the group of parents represented by the persona ‘Alvin’ (see Fig. 5).

This led to two key findings for interaction design within the project: there is an application scenario that is particularly strongly associated with complex perception, as well as a user group that requires further attention. The following section analyses the causes of the suspected complexity in further detail.

## EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS

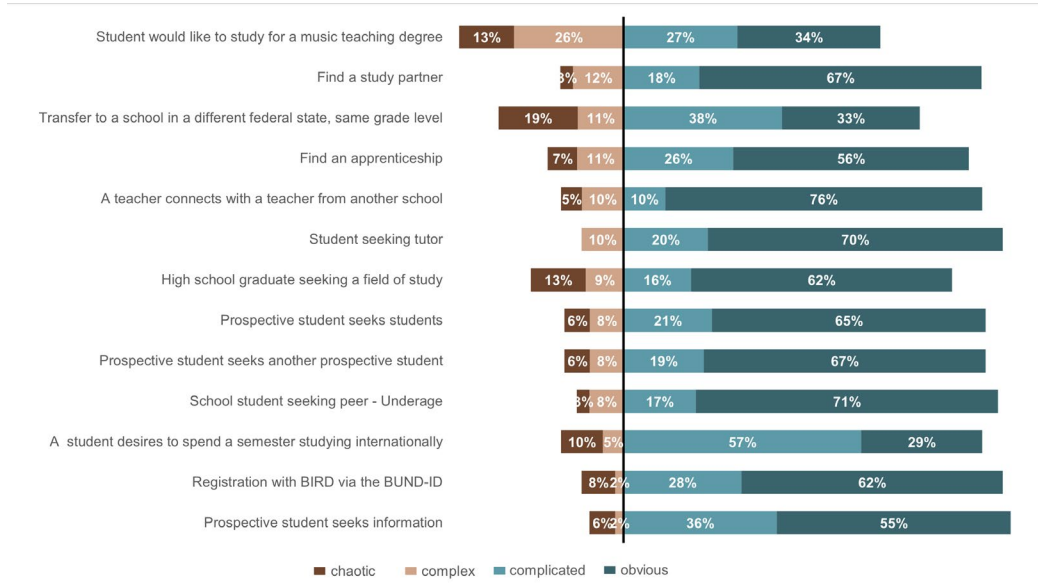


Figure 4. Proportions of chaotic, complex, complicated and obvious classifications per scenario and across personas. Scenarios are sorted according to their shares of complex classifications

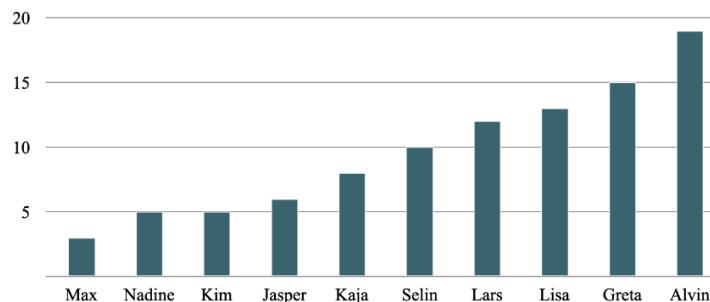


Figure 5. Cross-scenario and cross-evaluator cumulative frequency of persona-related complex classifications.

### 3.3 Analyzing Complexity-Generating Properties

All scenarios with a complex classification were examined in more detail using the second part of the analysis tool. For clarity, the comparative results are presented for three selected scenarios (see Fig. 6). Continuing the answer to research question 1, the complexity found is generated by all feature dimensions when viewed as a whole. Furthermore, a plausible, albeit unsurprising, finding is that the higher the proportion of complex classifications, the broader the complexity-generating features come into play.

In principle, the analysis now allows each scenario associated with complexity to be re-examined by using the complexity characteristics, and returned to the design process with suggestions for addressing this complexity. For example, in the scenario ‘Student wants to study music education’, several evaluators recognize a high degree of complexity in terms of adaptability. Here, in the further design process, an improvement for users can be achieved, for example, by visualizing the adaptability parameters and techniques used in the respective interaction situation (e.g., through tooltips that open when hovering over them with the mouse), in order to make it easier to cope with the inherent complexity and to support orientation.

### 3.4 Deducing Consequences

It became apparent that the perspective of the persona ‘Alvin’ particularly often led to complex classifications. The conclusion is that the underlying user group of parents can be expected to have a particularly frequent complex perception in several scenarios; i.e., particular attention must be paid to providing guidance on possible goals and paths during the usage process. Therefore, the interaction and application scenarios have been revised with this user group in mind. In general, the specifics of such groups should be considered to design improved interaction scenarios and to handle complexity, for instance by introducing dedicated support in the onboarding process.

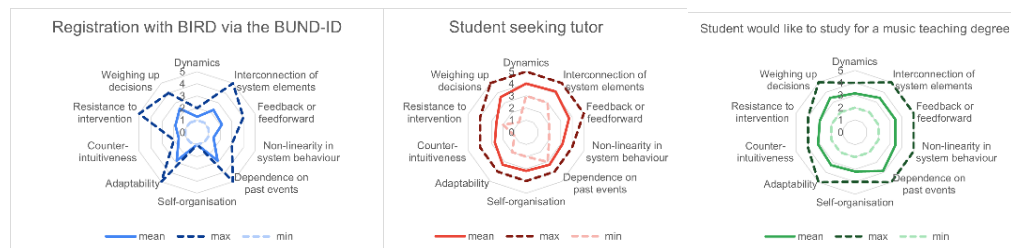


Figure 6. Expression of complexity-generating characteristics (mean values) for three selected scenarios

Fig. 4 has already shown that chaotic interaction situations can occur in small proportions. These were particularly problematic, as no regulated influence would be possible on the user or system side. The approach to tackle this is to examine each interaction situation separately and break it down into smaller levels of analysis until at least complex classifications are possible. If this is not feasible, the chaotic interaction situation must be fundamentally rethought and revised with the help of further empirical data, e.g., through user tests. Both ideas were pursued in the project.

With regard to the third research question, all participants were asked to what extent the analysis tool used was helpful. Almost all stated that the method was partially to very helpful (5-point Likert scale) in viewing at least one of the interaction situations under consideration with a changed understanding. Only one participant with a background in user-experience design did not see any added value in using the tool. Even if – especially in larger and heterogeneous development teams – only partial assistance is achieved, problem areas can be uncovered that might otherwise have remained hidden.

## 4. SECOND CASE: AN AI-BASED STUDY ASSISTANCE SYSTEM

As a contrasting case study, we have chosen an internal innovation project involving roughly a dozen people. We expected the results of this project to be particularly complex due to the novel technology combining stochastic and symbolic AI on the one hand, and the close integration of research and practice on the other.

### 4.1 Background and Structure of the Case Study

In the project, an AI-based assistance system for curriculum management is developed (von der Heyde et al., 2023). Based on formal representations of study regulations, support for all user groups involved in the lifecycle of study programs is provided. The project team combines research groups from educational technology and AI with administrative units responsible for the mentioned fields.

Based on the capabilities defined in the Higher Education Reference Model for the curriculum lifecycle, a total of 14 use cases was identified and re-designed based on the potential that AI can deliver. This includes:

- the design of study regulations
- subsequent processes for quality assurance
- planning of curricular offerings
- students generating their individual study paths
- student counselling

Based on the existing process definitions for these use cases at the local university, the respective enhancements for AI-based support have been verbally described. The analysis of targeted users was also taken from these process descriptions. Since the application field was higher education, which all members of the project are well familiar with, the team refrained from an extensive persona or scenario design. Fig. 7 provides two examples from the list of developed components. Designers of study programs are supported in formal modeling of study regulations by a dedicated editor (left), seamlessly translating between natural, graphical and formal language while executing consistency checks (von der Heyde et al., 2024). Students may use the study planer (right) which assists in semester-wise timetabling as well as semester-overarching study planning based on given regulations as well as individual parameters (Ardt et al., 2023). Both tools rely on the same set of microservices in the background, for example to handle variants of study regulations, to calculate possible study paths, or to access current course offerings.

### Beispiel Formalsprache

- Beispiel einer formalsprachliche Definition einer einfachen Struktur eines Studiums als Verkettung von "Und-" und "Oder"-Regel.
- 
- Die Beschreibung vom Sinn und Zweck des Studiums kann beliebig als Fließtext erfolgen. Das Studium besteht aus der Abschlussarbeit, den Pflichtkursen und den Wahlmodulen. Zu den Pflichtkursen gibt es sicherlich weitere Angaben, die in diesem Beispiel entfallen. Aus den Wahlmodulen können 2 bis 3 Alternativen aus den Modulen Geschichte des 19tes Jahrhunderts, Neuere Geschichte, Römische Geschichte oder Griechische Geschichte gewählt werden. In dieser Weise kann die Struktur des Studiums beschrieben werden, so dass aus den einfachen Sätzen sowohl dem Algorithmus als auch dem Mensch klar wird, wie der Aufbau aussieht.
- 
- Die Neuere Geschichte umfasst Praxissemester 1 bis Praxissemester 3 als Elemente.
- // Fehlerkonstellationen, wenn Praxissemester nicht definiert sind:
- Praxissemester 2 ECTS -> 6;
-

#### Semalogic.View

Picture (SVG) Copy to Clipboard 100

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### Master of Science Cognitive Systems (version 2014/15)

#### Course of study

Taking into account:

- 10 completed courses
- 3 favored and 2 unfavored modules
- 3 influence factors

Identify possible courses of study

#### Study Plans

Summer 2023 (completed)	Winter 2023/24 (completed)	Summer 2024	Winter 2024/25
Vorlesung oder Seminar: Diskursparsing (AM12)	Seminar: Individuelles interdisziplinäres Projekt 2 (PM2)	Video-Vorlesung (FM1)	Übung (FM1)
Seminar: Models That Explain Themselves (PM2)	Vorlesung oder Seminar: Current Highlights in NLP (AM11)	Linear Modeling (BM2)	Praktisches Arbeiten (BM3)
Vorlesung oder Seminar: Multi-agent path finding (AM31)	Übung: Advanced Natural Language Processing (BM1)	Intelligent Data Analysis (BM2)	Projekt (BM3)
Vorlesung oder Seminar: Atelier in Experimental and Computational Phonology (AM11)	Forschungsprojekt: Individual Module (IM1)	Intelligent Data Analysis (BM2)	Vorlesung (BM3)
Seminar: Individuelles interdisziplinäres Projekt 1 (PM2)	Seminar: Railway Scheduling (PM3)		Übung (BM3)

Figure 7. Prototype of the editor for study regulations (above) and the course planning assistant (below)

The analysis of the anticipated complexity using the presented instrument was done by the project team in a face-to-face workshop; participants were asked to finalize and send the questionnaire afterwards. 13 of the 18 members of the team participated in the study; the full range of team members (from PIs to academic and administrative staff as well as students) was involved in the study. Tab. 2 provides an overview of their backgrounds. After identification of complex use cases, 5 of these participants also provided an assessment of complexity-generating parameters using the feature questionnaire; they are marked in italics.

EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT  
FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS

Table 2. Disciplinary backgrounds of surveyed persons from the project team in the second case study

Expertise	01	02	03	04	05	06	07	08	09	10	11	12	13
Pedagogy							X			X		X	
Technology	X	X	X	X	X	X		X	X		X		
Administration							X			X		X	X
Management		X	X					X					X

## 4.2 Identifying Complex Interaction Situations

Regarding research question 1, the analysis showed that perceptions of complexity may be expected in three use cases, particularly. Unsurprisingly, this includes the formal modelling of study regulations by curriculum innovators. Moreover, student counselling was also considered to bear above-average complexity. In contrast, daily business regarding quality assurance, curriculum planning and study planning was not assigned additional complexity from AI-support. Fig. 8 provides an overview of these evaluations.

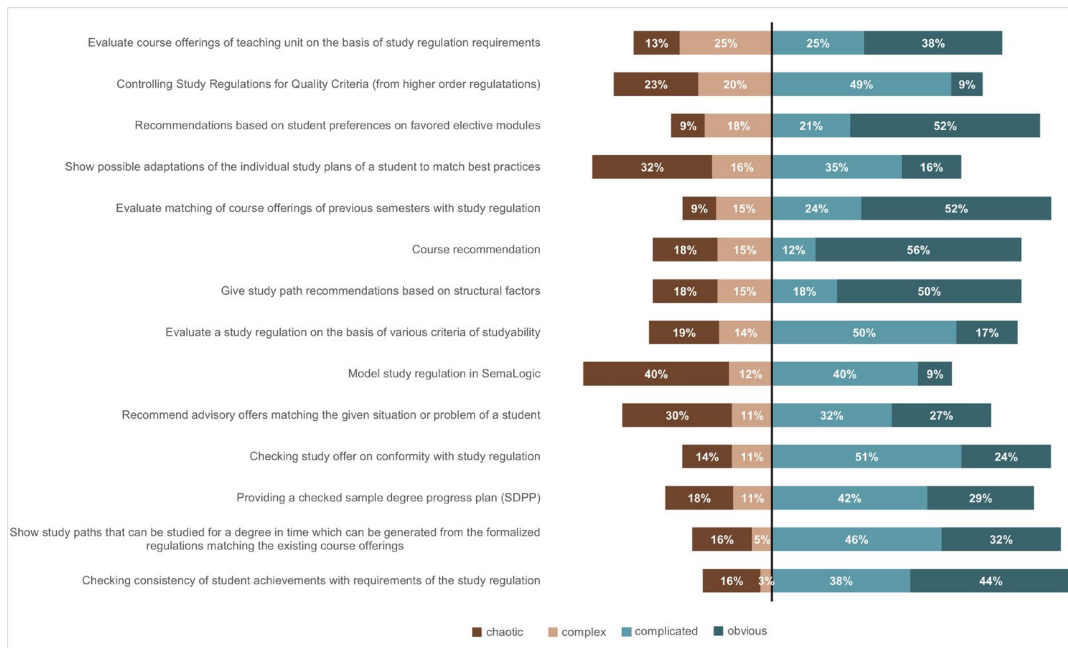


Figure 8. Proportions of chaotic, complex, complicated and obvious classifications per scenario and across user groups. Scenarios are sorted according to their shares of complex classifications

Note that not all participants rated the anticipated complexity for all use cases and all user groups. Some could not imagine a use case for a certain user group. Others refrained from assessing certain user groups at all; for instance, one of the involved professors only rated for the user group of professors.

Some participants showed a high tendency towards obvious or chaotic scenarios (i.e., the extremes). Their rating for predictability seemed to directly determine subsequent ratings of required knowledge and reconstructability. A reason could be that they intuitively rated a use case as “hard” or “easy” and did not deconstruct their assessment into single interaction characteristics. This was more likely for participants from administration and for student participants, which might indicate that the instrument is rather suitable for experienced IT designers. Another reason could have been that this project did not work with personas, but only with abstract user groups, which is why the analysis of the needs of the target group was possibly less in-depth – the team saw themselves as potential users.

Regarding user groups (research question 2), participants rated professors as being confronted with both, most obvious but also most complex and even chaotic scenarios. This was more likely for participants from administration and for students, while professors and postdocs did provide rather moderate ratings here. Figure 9 depicts the expected complexity per user group across all scenarios and participants.

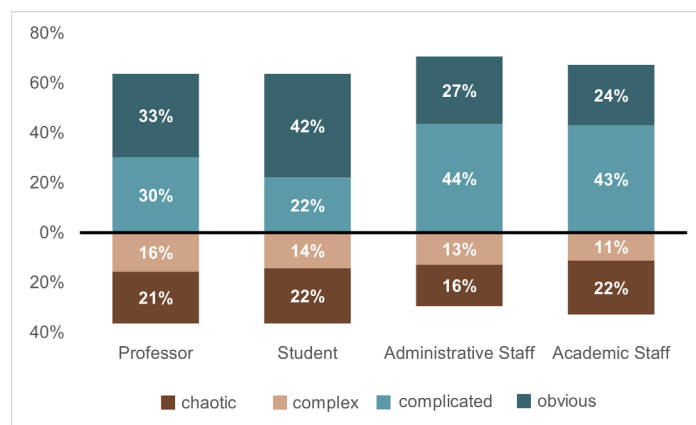


Figure 9. Cross-scenario and cross-evaluator cumulative frequency of persona-related complex classifications

Interestingly, not only administrative staff (which could be attributed a high level of expertise in formal processes) but also students were associated with lower complexity expectations. This may be attributed to the high frequency of these use cases for such user groups.

### 4.3 Analyzing Complexity-Generating Properties

A second questionnaire was then used to determine the contribution of system characteristics to the perception of complexity in the two scenarios identified above as most complex. Figure 10 provides an overview of the results.

## EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT FOR ANTICIPATING THE COMPLEXITY OF INTERACTIONS

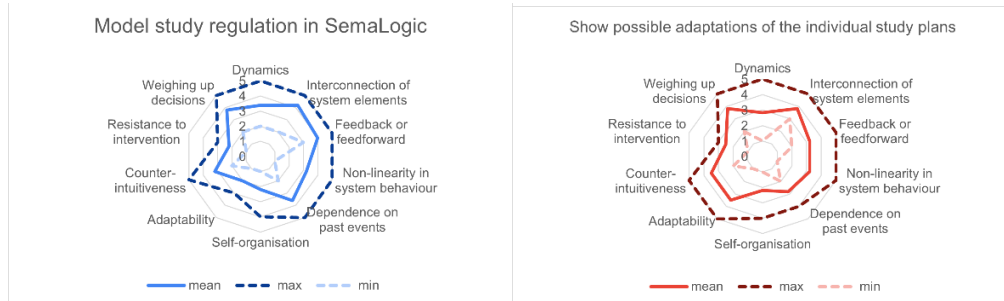


Figure 10. Expression of complexity-generating characteristics (mean values) for two scenarios identified as complex

Adding to the answer to research question 1, several system characteristics were identified that are particularly influential and need to be addressed in the redesign. It is also particularly revealing to look at the minimum and maximum values assigned by the participants. In some cases, there is broad agreement that improvements should be made in this area, for example with regard to logical dependencies (feedback/feedforward or dependence on past events) when formally modelling a study regulation. Better visualization or step-by-step guidance is required here.

It is worth noting that the response rate was significantly lower than for the first questionnaire. The excessive demands placed on participants, as observed in the previous questionnaire, a) in view of the less differentiated description of scenarios and personas and b) particularly among students and administrative staff, seem to have had an even greater impact here. One of the administrative staff members, despite having been regularly involved in the agile design process of the system for four years, stated: ‘I don't really feel qualified to evaluate the points.’

Regarding research question 3, participants stated comparatively lower satisfaction. All participants rated the tool as only partially or slightly helpful. One participant even stated: ‘Helpful is perhaps the wrong word, since we have formalized the problem and analyzed it so thoroughly.’ The need for a user-centered approach to complexity perception was apparently negated here in view of the functional perspective taken in designing the system behavior.

### 4.4 Deducing Consequences

The analysis does not identify any particular complexity expectations in administrative use cases or among administrative staff, but it does reveal numerous scenarios that are classified as complicated and require a high degree of specialist knowledge. Supplementary training measures on the use of AI, as required by the AI Act anyway, therefore appear advisable for this user group.

For the user group of professors, high expectations of complexity are expressed particularly frequently. This may also be due to the fact that processes for modeling study regulations or providing study advice are rarely carried out. Therefore, revisions to the system (e.g., onboarding, wizards, tooltips) and support in the form of templates seem to be useful. This is particularly important in view of the advisable future integration of the developed assistance systems into the standard portfolios of the manufacturers of student information systems. In

addition, exchange forums for the transfer of good practices, both within the university and across institutions, are useful.

Due to the imminent end of third-party funding, the findings cannot be put into practice in the current project, but they form a valuable empirical basis for further activities.

## 5. DISCUSSION OF RESULTS

With regard to the first two research questions, it was possible to identify certain scenarios and user groups from the perspective of the development teams in the examined case studies that could be particularly complex. Together with an in-depth analysis of the characteristics that generate complexity, dedicated measures could be derived in both projects to adequately address this complexity.

With regard to the third research question, a differentiated picture emerges. Comparing the two case studies, detailed scenario descriptions with precise personas seem to foster a more nuanced and therefore more helpful assessment of the anticipated complexity. Moreover, for both experienced user experience designers and people with little experience in software design, the results of the instrument seem to be only moderately helpful. However, for typical design teams, it appears that a deeper understanding of interaction problems can be generated as early as the conception phase of a system without the need for time-consuming user tests. In the context of modern project management, which is often described by the Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) framework, this early insight is highly valuable. While traditional, linear planning struggles in such dynamic environments, the presented instrument enables development teams to systematically reduce ambiguity regarding user expectations and structural challenges before costly implementations occur. In this way, more mature prototypes can be submitted to usability tests (which are still necessary).

Moreover, this approach reflects a significant shift within the HCI community, moving away from a narrow focus on immediate UX metrics toward more holistic concepts like User Eudaimonia. This perspective emphasizes long-term human flourishing, personal growth, and meaningful engagement through technology. In this sense, capturing the perception of interaction complexity serves as a vital additional lens. It contributes to a broader understanding of the human-technology relationship in HCI—one that goes beyond 'just' UX by ensuring that complexity is not merely hidden but managed in a way that empowers users and supports their autonomy in complex educational settings.

Nevertheless, it should be noted that this is a complex instrument with a comparatively large number of differentiated questions. On the one hand, this can overwhelm the people in the design team and, on the other hand, cause additional noise in the results. Based on the established estimate in usability design that 4 to 5 people can find over 80% of the problems in a prototype (Virzi, 1992), it might therefore be advisable to divide the scenarios to be analyzed and work on them piece by piece in smaller groups to reduce workload.

One of the limitations to be noted is the sample size. However, it is crucial to understand the nature of the presented tool: It is designed as an expert inspection method for development teams, not a broad user survey. Like Heuristic Evaluation, where a small number of evaluators is sufficient to identify most usability problems (Virzi, 1992), our results show that even a small group of domain experts (developers, educators) using the structured reflection tool can successfully uncover hidden complexities. The impact of this work therefore lies in empowering

educational design teams to perform 'situational ethics' and complexity checks efficiently within their agile sprints, without needing extensive external study setups.

Another limitation of the approach is that noise from subjective assessments cannot be levelled out by calculating mean values. For research questions 1 and 2, which directly target the projects under investigation, this effect can be offset by a qualitative approach (i.e. reflection within the design team). By considering two contrasting case studies, we have attempted to mitigate this effect for research question 3.

Further biases may arise due to the professional and personal proximity to the projects under investigation. For the first two research questions, it must be accepted that this cannot be implemented differently for a project that is still in the conceptual phase. For the third research question, reliable field access with acceptable response rates was initially considered more important than an independent group of participants.

Finally, the efforts and benefits must be critically examined. The effort involved per person consists of collecting a large amount of data and incorporating multiple perspectives. In the first step, this took about 10 minutes per user group (across all scenarios), decreasing over time. In the second step, only a few minutes per use case were required. The resulting benefit in terms of insights lies in the systematic self-reflection of the actors. Although there is additional effort at the beginning, in this case in the form of time for reflection and redesign, this can decrease as the method becomes more established and, given improved prototypes with reduced revision requirements, a positive cost-benefit ratio can be expected in the medium to long term.

## 6. SUMMARY AND CONCLUSION

The article presented an analysis tool for the perception of complexity based on an existing theoretical model, which can be used to anticipate later irritations on the user side as early as the design process of technical systems. This is particularly important in complex educational infrastructures in order to prevent cognitive overload and loss of trust.

Basically, it should be noted that an exact measurement of complexity (in the sense of reduction to a key indicator or similar) does not appear necessary; rather, a general classification of anticipated interaction situations is sufficient, since reality will ultimately differ from imagination and actual uses may also differ from those outlined in the design. It is therefore essential to review actual usage practices at a later stage. However, imagining future scenarios in advance should help to reduce subsequent irritations.

Reflecting on complexity in the sense of accompanying research is initially easier in research and development projects than in contract development. The aim is to generalize findings and test their transferability, as well as to enable research-led findings to be considered in system design. In the case studies presented, successful trials were conducted, providing valuable feedback for both the projects and the tool. However, further assistance is needed for the design teams in conducting and dealing with the analysis results. In future, work will be done to embed and support systematic feedback of the results into the tool.

In addition, a comparison of anticipated and actual uses is encouraged, especially in relation to future productive systems. The aspects of perception and orientation in complex interaction situations, which were the focus here, should also be considered in relation to emerging usage practices. Ultimately, this tool supports a form of 'situational ethics' in design: it allows creators to recognize when a rigid technical system forces users into complex dilemmas, enabling them

to resolve these tensions through better, more human-centric design choices. By making interaction complexity manageable in otherwise volatile and ambiguous development contexts (VUCA), the instrument actively contributes to the overarching HCI goal of fostering user eudaimonia. It helps ensure that educational technology serves as a transparent tool for personal growth and empowerment, rather than an untamed cognitive obstacle. The subsequent comparison of hypothetical scenarios and actual interaction situations should then also be accompanied by proven usability tools (UEQ questionnaire, UX tests, etc.).

## ARTIFACT AVAILABILITY STATEMENT

The tools presented above are available at (Moebert *et al.*, 2026). This includes two spreadsheets with questionnaires for data collection, as well as two additional spreadsheets for analysis and visualization of data as used for this article.

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EXTENDING THE USER-CENTERED DESIGN TOOLBOX: AN INSTRUMENT  
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