HCI
Chapter 8
DATA ANALYSIS, INTERPRETATION, AND PRESENTATION

INTERACTION DESIGN

Beyond Human–Computer Interaction

Fourth Edition

Summarized by:

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Instructor

The main aims of this chapter are to:

- Discuss the difference between qualitative and quantitative data and analysis.
- Enable you to analyze data gathered from questionnaires.
- Enable you to analyze data gathered from interviews.
- Enable you to analyze data gathered from observation studies.
- Make you aware of software packages that are available to help your analysis.
- Identify some of the common pitfalls in data analysis, interpretation, and presentation.
- Enable you to be able to interpret and present your findings in a meaningful and appropriate manner.

Introduction:

- Most analysis, whether it is quantitative or qualitative, begins with **initial reactions or observations from the data**.
- This might involve **identifying patterns or calculating simple numerical values such as ratios, averages, or percentages**.
- This initial analysis is followed by more detailed work using **structured frameworks or theories to support the investigation**.
- A common mistake is for the investigator's existing beliefs or biases to influence the interpretation of results.
- Another common mistake is to make claims that go beyond what the data can support.
- An investigator should remain as **impartial and objective as possible** if the conclusions are to be believed, and **showing that your conclusions are supported by your results is an important skill to develop**.

8.2 Qualitative and Quantitative

- **Quantitative data** is data that is in the form of numbers, or that can easily be translated into numbers.
  - For example, the number of years' experience the interviewees have, the number of projects a department handles at a time, or the number of minutes it takes to perform a task.
- **Qualitative data** is not expressed in numerical terms.
  - For example, qualitative data includes descriptions, quotes from interviewees, vignettes of activity, and images. It is possible to express qualitative data in numerical form, but it is not always meaningful to do so.

8.2 Qualitative and Quantitative

- **Quantitative analysis** uses numerical methods to ascertain the magnitude, amount, or size of something; for example, the attributes, behavior, or opinions of the participants.
  - For example, in describing a population, a quantitative analysis might conclude that the average person is 5 feet 11 inches tall, weighs 180 pounds, and is 45 years old.
- **Qualitative analysis** focuses on the nature of something and can be represented by themes, patterns, and stories.
  - For example, in describing the same population, a qualitative analysis might conclude that the average person is tall, thin, and middle-aged.

8.2.1 The First Steps in Analyzing Data

Data gathered and typical initial processing steps for the main data gathering techniques

	Usual raw data	Example qualitative data	Example quantitative data	Initial processing steps
Interviews	Audio recordings. Interviewer notes. Video recordings	Responses to open questions. Video, pictures. Respondent's opinions	Age, job role, years of experience. Responses to closed questions	Transcription of recordings. Expansion of notes. Entry of answers to close-ended questions into a spreadsheet
Questionnaires	Written responses. Online database	Responses to open questions. Responses in 'further comments' fields. Respondent's opinions	Age, job role, years of experience. Responses to closed questions	Clean up data. Filter into different data sets. Synchronization between data recordings.
Observation	Observer's notes. Photographs. Audio and video recordings. Data logs. Think-aloud Diaries.	Records of behavior. Description of a task as it is undertaken. Copies of informal Procedures	Demographics of participants. Time spent on a task. The number of people involved in an activity. How many different types of activity are undertaken	Expansion of notes. Transcription of recordings. Synchronization between data recordings

8.3 Simple Quantitative Analysis

- Averages and percentages are fairly well-known numerical measures.
- Three different types of average and which one you use changes the meaning of your results.
  - These three are: mean, median, and mode.

Mean

• average of all observations in the sample
• calculated "central" value of a set of numbers

When not to use the mean

Staff	1	2	3	4	5	6	7	8	9	10
Salary	15k	18k	16k	14k	15k	15k	12k	17k	90k	95k

mean salary for the ten staff is $30.7k

most workers have salaries in the $12k to 18k range

mean is being skewed by the two (outliers) large salaries

Median

- middle number (in a sorted list of numbers)
- separates the higher half of a data sample from the lower half

How to Calculate the Median

- CASE 1 : **Odd** number of observations

65	55	89	56	35	14	56	55	87	45	92

- rearrange that data into order of magnitude (smallest first)

14	35	45	55	55	56	56	65	87	89	92

- pick the middle value

How to Calculate the Median

- CASE 2 : **Even** number of observations

65	55	89	56	35	14	56	55	87	45

- rearrange that data into order of magnitude (smallest first)

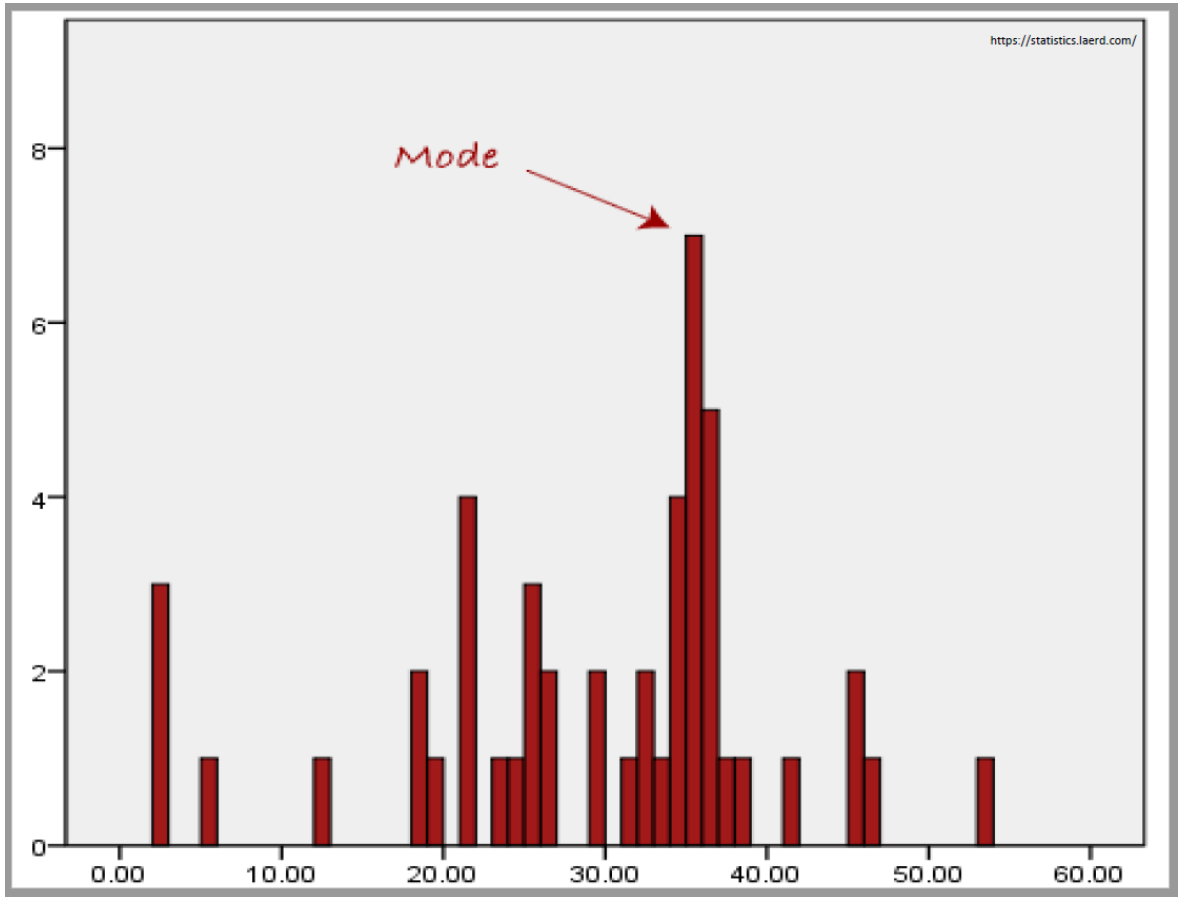
14	35	45	55	**55**	**56**	56	65	87	89

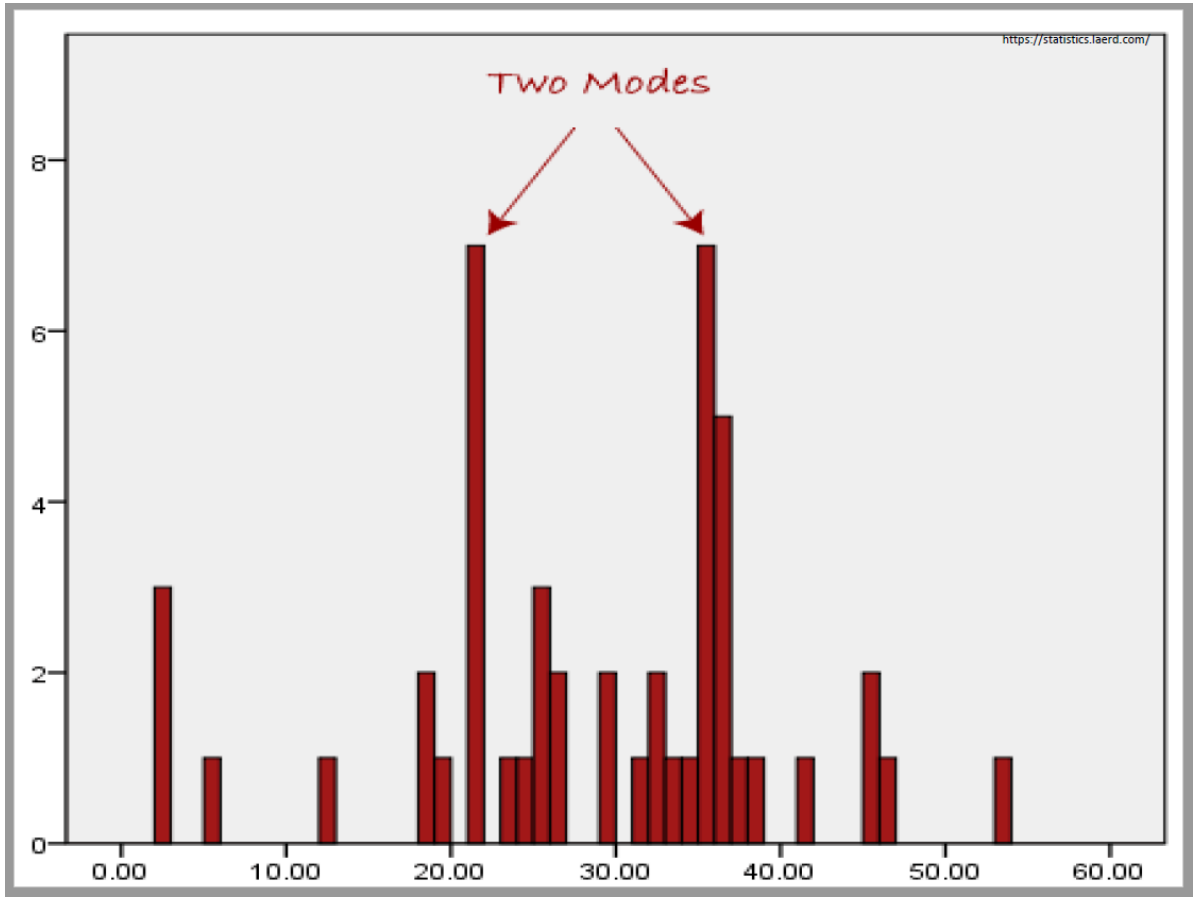
- Get the mean of the two middle values

Median = (55+56)/2 = 55.5

Mode

- value that appears most often in a dataset
- used for categorical data in determining which is the most common category





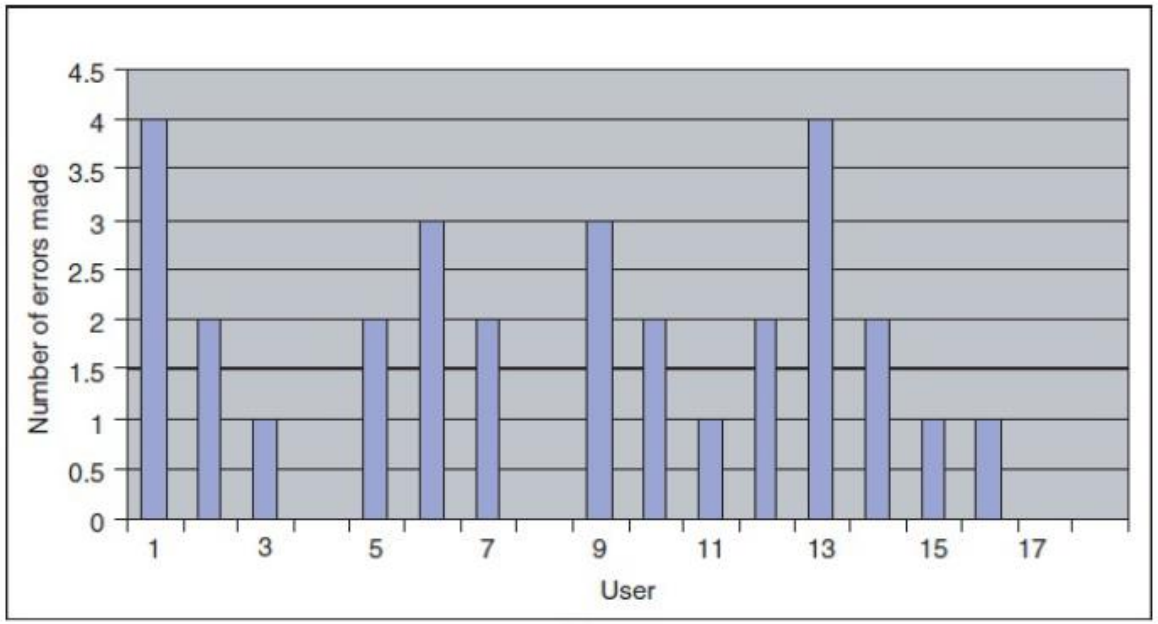
8.3 Simple Quantitative Analysis

- For simple collation and analysis, spreadsheet software such as Excel is often used as it is commonly available, is well understood, and offers a variety of numerical manipulations and graphical representations.
- Initial analysis might involve finding out averages, and identifying any outliers, i.e. values that are significantly different from the others.
- Producing a graphical representation of the data helps to get an overall view of the data and any patterns it contains.

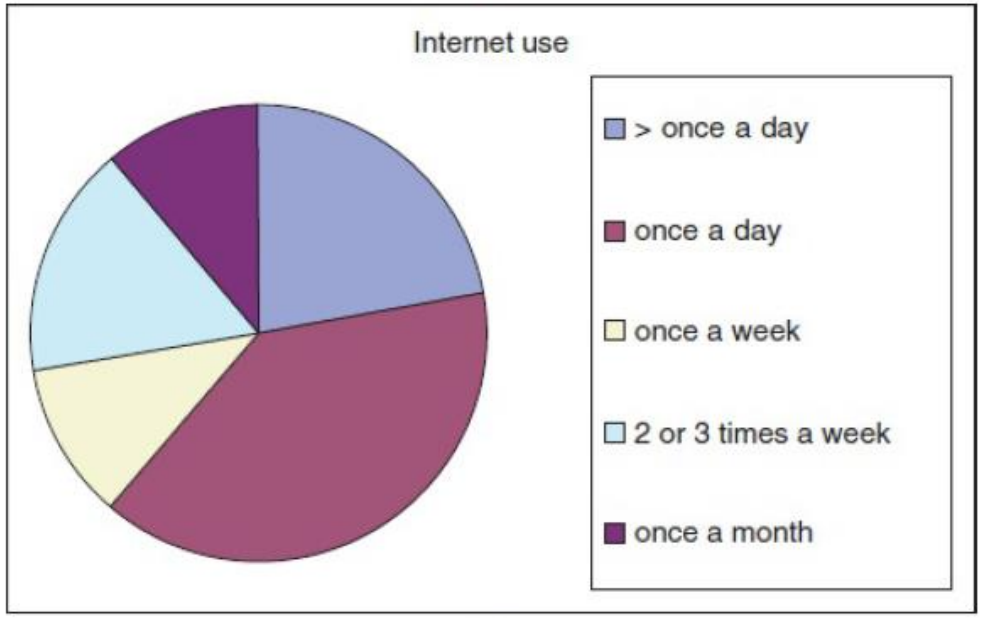
Respondent	Strongly agree	Agree	Neither	Disagree	Strongly disagree
A		1			
B	1				
C				1	
. . .					
Z					1
Total	5	7	10	1	3

8.3 Simple Quantitative Analysis

Internet use						
User	**More than once a day**	**Once a day**	**Once a week**	**Two or three times a week**	**Once a month**	**Number of errors made**
1		1				4
2	1					2
3			1			1
4	1					0
5				1		2
6		1				3
7	1					2
8		1				0
9						3
10	1				1	2
11				1		1
12			1			2
13		1				4
14		1				2
15						1
16				1		1
17		1				0
18		1			1	0
Totals	**4**	**7**	**2**	**3**	**2**	**30**
					Mean	**1.67** (to 2 decimal places)



(a)



Weighted Mean

	A	B	C	D	E	F	G	H	I	J	K	L
1	Weighted Mean											
2	Item	7	6	5	4	3	2	1	Total (389)	WM	Interpretation	
3	ICT Motivation 1	80	146	69	52	23	7	12	389	5.357326478	Agree	
4	ICT Motivation 2	105	135	63	44	23	8	11	389	5.480719794	Agree	
5	ICT Motivation 3	119	153	57	29	20	7	4	389	5.732647815	Agree	
6	ICT Motivation 4	99	130	72	41	24	13	10	389	5.411311054	Agree	
7												

=((B3*7)+(C3*6)+(D3*5)+(E3*4)+(F3*3)+(G3*2)+(H3*1))/389

1	1.80	Strongly disagree
1.86	2.60	Disagree
2.72	3.50	Somewhat disagree
3.58	4.30	Undecided
4.44	5.20	Somewhat agree
5.3	6.10	Agree
6.16	7.00	Strongly Agree

8.4 Simple Qualitative Analysis

- The first step in qualitative analysis is to **gain an overall impression of the data and to start looking for patterns**.
- Some patterns will have emerged during the data gathering itself, and so you may already have some idea of the kinds of pattern to look for, but it is important to confirm and re-confirm findings to make sure that initial impressions are not biasing analysis.
- For observation data, the guiding framework will have given some structure to the data.
- There are three simple types of qualitative analysis :
  - Identifying recurring patterns and themes, categorizing data, and analyzing critical incidents.
  - These are not mutually exclusive and can be used in combination.

1. Identifying Recurring Patterns or Themes/Identifying Themes

- **Thematic analysis** is considered an umbrella term to cover a variety of different approaches to examining qualitative data. It is a widely used analytical technique that **aims to identify, analyze, and report patterns in the data** (Braun and Clarke, 2006).
- More formally, a theme is something important about the data in relation to the study goal.
- A theme represents a pattern of some kind, perhaps a particular topic or feature found in the data set, which is considered to be important, relevant, and even unexpected with respect to the goals driving the study.
- Themes that are identified may relate to a variety of aspects: behavior, a user group, events, places or situations where those events happen, and so on.
- Each of these kinds of themes may be relevant to the study goals.
  - For example, descriptions of typical users may be an outcome of data analysis that focuses on participant characteristics. Although thematic analysis is described in this section on qualitative analysis, themes and patterns may also emerge from quantitative data.

1. Identifying Recurring Patterns or Themes/Identifying Themes

- The next step is to look more systematically for themes across participants' transcripts, seeking further evidence both to confirm and disconfirm initial impressions in all of the data.
- This more systematic analysis focuses on checking for consistency; in other words, **do the themes occur across all participants, or is it only one or two people who mention something?**
- Another focus is on finding further themes that may not have been noticed first time. **Sometimes, the refined themes resulting from this systematic analysis form the primary set of findings for the analysis, and sometimes they are just the starting point**.
- Once a number of themes have been identified, it is usual to step back from the set of themes to look at the bigger picture.
  - Is an overall narrative starting to emerge, or are the themes quite disparate?
  - Do some seem to fit together with others? If so, is there an overarching theme?
- Can you start to formulate a meta-narrative, that is, an overall picture of the data? In doing this, some of the original themes may not seem as relevant and can be removed. Are there some themes that contradict each other? Why might this be the case?
- This can be done individually, but more often this is applied in a group using brainstorming techniques with sticky notes.

8.4 Simple Qualitative Analysis

1. Identifying Recurring Patterns or Themes/Identifying Themes

- A common technique for exploring data, identifying themes, and looking for an overall narrative is to create an **affinity diagram**.
- The approach seeks to organize individual ideas and insights into a hierarchy showing common structures and themes.
- Notes are grouped together when they are similar in some fashion. The groups are not predefined, but rather they emerge from the data.
- This process was originally introduced into the software quality community from Japan, where it is regarded as one of the seven quality processes.
- The affinity diagram is built gradually. One note is put up first, and then the team searches for other notes that are related in some way.
- The affinity diagram, which is used in contextual design (Beyer and Holtzblatt, 1998; Holtzblatt, 2001) is one common technique used in qualitative analysis.

8.4 Simple Qualitative Analysis

Identifying Recurring Patterns or Themes

De Angeli *et al* (2004) collected data through field observations and semi-structured interviews to investigate the use of ATMs (automated teller machines) in Mumbai, India. As part of their data analysis they used affinity diagrams to cluster issues into themes.

8.4 Simple Qualitative Analysis

Figure 9.4 Section of an affinity diagram built during the design of a web application

Source: Smith (2018). Used courtesy of Madeline Smith

8.4 Simple Qualitative Analysis

2. Categorizing Data

- **Inductive analysis** is appropriate when the study is exploratory, and it is important to let the themes emerge from the data itself.
- Sometimes, the analysis frame (the set of categories used) is chosen beforehand, based on the study goal. In that case, analysis proceeds deductively.
  - For example, in a study of novice interaction designer behavior in Botswana, Nicole Lotz et al. (2014) used a set of predetermined categories based on Schön (1983)'s design and reflection cycle: **naming, framing, moving, and reflecting**.
  - This allowed the researchers to identify detailed patterns in the designers' behavior, which provided implications for education and support.

8.4 Simple Qualitative Analysis

2. Categorizing Data

- Using the **think-aloud technique**. The think-aloud protocol was recorded and then transcribed before being analyzed from various perspectives, one of which was to identify usability problems that the participants were having with the online environment known as Nestor Navigator (Zeiliger et al., 1997).

Figure shows: Excerpt from a transcript of a think-aloud protocol when using an online educational environment. Note the prompt from the observer about halfway through. Source: Armitage (2004). Used courtesy of Ursula Armitage

I'm thinking that it's just a lot of information to absorb from the screen. I just I don't concentrate very well when I'm looking at the screen. I have a very clear idea of what I've read so far . . . but it's because of the headings I know OK this is another kind of evaluation now and before it was about evaluation which wasn't anyone can test and here it's about experts so it's like it's nice that I'm clicking every now and then coz it just sort of organizes the thoughts. But it would still be nice to see it on a piece of paper because it's a lot of text to read.

Am I supposed to, just one question, am supposed to say something about what I'm reading and what I think about it the conditions as well or how I feel reading it from the screen, what is the best thing really?

Observer: What you think about the information that you are reading on the screen . . . you don't need to give me comments . . . if you think this bit fits together.

There's so much reference to all those previously said like I'm like I've already forgotten the name of the other evaluation so it said unlike the other evaluation this one like, there really is not much contrast with the other it just says what it is may be . . . so I think I think of . . .

Maybe it would be nice to have other evaluations listed to see other evaluations you know here, to have the names of other evaluations other evaluations just to, because now when I click previous I have to click it several times so it would be nice to have this navigation, extra links.

8.4 Simple Qualitative Analysis

2. Categorizing Data

This excerpt was analyzed using a categorization scheme derived from a set of negative effects of a system on a user (van Rens, 1997) and was iteratively extended to accommodate the specific kinds of interaction observed in these studies. The categorization scheme is shown

Figure shows: Criteria for identifying usability problems from verbal protocol transcriptions Source: Armitage (2004). Used courtesy of Ursula Armitage

1. **Interface Problems**
   - 1.1. Verbalizations show evidence of dissatisfaction about an aspect of the interface.
   - 1.2. Verbalizations show evidence of confusion/uncertainty about an aspect of the interface.
   - 1.3. Verbalizations show evidence of confusion/surprise at the outcome of an action.
   - 1.4. Verbalizations show evidence of physical discomfort.
   - 1.5. Verbalizations show evidence of fatigue.
   - 1.6. Verbalizations show evidence of difficulty in seeing particular aspects of the interface.
   - 1.7. Verbalizations show evidence that they are having problems achieving a goal that they have set themselves, or the overall task goal.
   - 1.8. Verbalizations show evidence that the user has made an error.
   - 1.9. The participant is unable to recover from error without external help from the experimenter.
   - 1.10. The participant suggests a redesign of the interface of the electronic texts.
2. **Content Problems**
   - 2.1. Verbalizations show evidence of dissatisfaction about aspects of the content of the electronic text.
   - 2.2. Verbalizations show evidence of confusion/uncertainty about aspects of the content of the electronic text.
   - 2.3. Verbalizations show evidence of a misunderstanding of the electronic text content (the user may not have noticed this immediately).
   - 2.4. The participant suggests re-writing the electronic text content.

Identified problems should be coded as [UP, << problem no. >>].

8.4 Simple Qualitative Analysis

3. Critical Incident Analysis

- **Critical incident analysis** is one approach that helps to identify significant subsets of the data for more detailed analysis.
- This technique is a set of principles that emerged from work carried out in the United States Army Air Forces where the goal was to identify the critical requirements of good and bad performance by pilots (Flanagan, 1954).
- It has two basic principles:
  - (a) reporting facts regarding behavior is preferable to the collection of interpretations, ratings, and opinions based on general impressions.
  - (b) reporting should be limited to those behaviors which, according to competent observers, make a significant contribution to the activity.

8.4 Simple Qualitative Analysis

3. Critical Incident Analysis

Example:

- Tuomas Kari et al. (2017) used the critical incident technique in a study of the location-based augmented reality game Pokémon GO.
- They were interested in identifying the types of behavior change that playing the game induced in players.
- To do this, they distributed a survey through social media channels asking experienced players to identify and describe one outstanding positive or negative experience.
- The 262 valid responses were themed and categorized into eight groups.
- Apart from expected behavior change such as increased physical activity, they also found that players were more social, found their routines more meaningful, expressed more positive emotions, and were more motivated to explore their surroundings.

8.5 Which Kind of Analytic Framework to Use?

Framework	Data	Focus	Expected outcomes	Level of granularity
Conversation analysis	Recordings of spoken conversations	How conversations are conducted	Insights into how conversations are managed and how they progress	Word-level, or finer, for instance, pauses and inflection
Discourse analysis	Recordings of speech or writing from individuals or several participants	How words are used to convey meaning	Implicit or hidden meanings in texts	Word, phrase, or sentence-level
Content analysis	Any form of "text" including written pieces, video and audio recordings, or photographs	How often something is featured or is spoken about	Frequency of items appearing in a text	A wide range of levels from words, to feelings or attitudes, to artifacts or people
Interaction analysis	Video recordings of a naturally occurring activity	Verbal and non-verbal interactions between people and artifacts	Insights about how knowledge and action are used within an activity	At the level of artifact, dialogue, and gesture
Grounded theory	Empirical data of any kind	Constructing a theory around the phenomenon of interest	A theory grounded in empirical data	Varying levels, depending on the phenomenon of interest
Systems based frameworks	Large-scale and heterogeneous data	Large-scale involving people and technology, such as a hospital or airport	Insights about organizational effectiveness and efficiency	Macro-level, organizational level

8.5 Which Kind of Analytic Framework to Use?
1. Conversation Analysis

- ***Conversation analysis*** **(CA)** examines the semantics of a conversation in fine detail. The focus is on how a conversation is conducted (Jupp, 2006).
- This technique is used in sociological studies, and it examines how conversations start and how turn-taking is structured, together with other rules of conversation.

8.5 Which Kind of Analytic Framework to Use?
1. Conversation Analysis

01	SUS	i'd like to play beat the intro in a minute
02	LIA	[oh no:]
03	SUS	[**alexa**][(**1.1**)] **beat the in[tro**
04	CAR	[°yeah°;]
05	LIA	[°no:::...°
06	CAR	(0.6) it's mother's day? (0.4)
07	SUS	it's ( ) yep (.) listen (.) you need to kee*p*
08		on eating your orange stuff (.) liam
09		(0.7)
10	CAR	and your green stuff
11	SUS	**alexa (1.3) alexa (0.5)=**
12	CAR	=°and your brown stuff
13	SUS	**play beat the intro**

An extract of the conversation between the family and Alexa, marked up for conversation analysis
Source: Porcheron et al. (2018), fragment 1. Reproduced with permission of ACM Publications

8.5 Which Kind of Analytic Framework to Use?
2. Discourse Analysis

- ***Discourse analysis*** focuses on dialogue, in other words, the meaning of what is said and how words are used to convey meaning.
- **Discourse analysis** is strongly interpretive, pays great attention to context, and views language not only as reflecting psychological and social aspects but also as constructing them (Coyle, 1995).
- An underlying assumption of discourse analysis is that there is no objective scientific truth. Language is a form of social reality that is open to interpretation from different perspectives.
- **Discourse analysis** is useful when trying to identify subtle and implicit meaning in what people are writing about, what is trending, what is fake news, and so on. It can be used with data from interviews; in social media such as Facebook, Twitter, and WhatsApp; and in emails.

8.5 Which Kind of Analytic Framework to Use?
3. Content Analysis

- ***Content analysis*** typically involves classifying the data into themes or categories and then studying the frequency of category occurrences (Krippendorff, 2013).
- The technique can be used for any text, where “text” refers to a range of media including video, newspapers, advertisements, survey responses, images, sounds, and so on.
- It can be used to analyze any online content, including the text of tweets, links, animated gifs, videos, and images.
- Similar to discourse analysis, an important aspect of content analysis is how it considers the wider context.

8.5 Which Kind of Analytic Framework to Use?
3. Content Analysis

- **Content analysis** is often used in conjunction with other analysis techniques as well.
  - For example, Weixin Zhai and Jean-Claude Thill (2017) analyzed social media data from Weibo (the Chinese equivalent of Twitter) to investigate the emotions, attitudes, and views of citizens around a rainstorm that hit Beijing on July 21, 2012, causing 79 deaths.
  - They used content analysis alongside ***sentiment analysis***, an approach that extracts emotional and subjective information from natural language.
  - From their results, they found how feelings of sorrow and sadness were shared across the entire city because of the trauma associated with entrapment indoors during the deluge.

8.5 Which Kind of Analytic Framework to Use?

4. Interaction Analysis

- ***Interaction analysis*** was developed by Brigitte Jordan and Austin Henderson (1995) as a way of investigating and understanding the interactions of human beings with each other and objects in their environment.
- The technique focuses on both **talk and nonverbal interactions** with artifacts and technologies, and it is based on video recordings.
- An underlying assumption of this approach is that knowledge and action are fundamentally social.
- The goal is to derive generalizations from videos of naturally occurring activities, focusing on how the people being observed make sense of each other's actions and their collective achievements.
- **Interaction analysis** is an inductive process, where teams of researchers suggest statements about general patterns from multiple examples of empirical observations. Rather than individual researchers conducting separate analyses and then comparing their results for consistency, **interaction analysis is conducted collaboratively**.

8.5 Which Kind of Analytic Framework to Use?
4. Interaction Analysis

- The technique focuses on both **talk and nonverbal interactions** with artifacts and technologies, and it is based on video recordings.
- An underlying assumption of this approach is that knowledge and action are fundamentally social.
- The goal is to derive generalizations from videos of naturally occurring activities, focusing on how the people being observed make sense of each other's actions and their collective achievements.

8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

- The goal of ***grounded theory*** is to develop theory from a systematic analysis and interpretation of empirical data; that is, the derived theory is grounded in the data.
- It is an inductive approach to developing theory.
- The approach was originally developed by **Barney Glaser and Anselm Strauss (1967)** and since then has been adopted by several researchers, with some adaptations to different circumstances.
- In this context, theory is: "**a set of well-developed concepts related through statements of**
- **relationship, which together constitute an integrated framework that can be used to explain**
- **or predict phenomena**" (Strauss and Corbin, 1998).

8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

- Development of a “grounded” theory progresses through alternating data collection and data analysis:
  - first data is collected and analyzed to identify themes,
  - then that analysis may lead to further data collection and analysis to extend and refine the themes, and so on.
  - During this cycle, parts of the data may be reanalyzed in more detail.
  - Data gathering and subsequent analysis are hence driven by the emerging theory.
- **Objectivity** is needed to maintain accurate and impartial interpretation of events; sensitivity is required to notice the subtleties in the data and identify relationships between concepts.
- The thrust of the analysis undertaken is to identify and define the properties and dimensions of relevant themes called ***categories*** in grounded theory.

8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

According to Juliet Corbin and Anselm Strauss (2014), this coding has three aspects, which are iteratively performed through the cycle of data collection and analysis:

1. ***Open coding*** is the process through which categories, their properties, and dimensions are discovered in the data. This process is similar to our discussion of thematic analysis above, including the question of granularity of coding (at the word, line, sentence, conversation level, and so on).

2. ***Axial coding*** is the process of systematically fleshing out categories and relating them to their subcategories.

3. ***Selective coding*** is the process of refining and integrating categories to form a larger theoretical scheme.

- The **categories** are organized around one central category that forms the backbone of the theory. Initially, the theory will contain only an outline of the categories, but as more data is collected, they are refined and developed further.

8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

The following analytic tools are used to help stimulate the analyst's thinking and identify and characterize relevant categories:

1. **The Use of Questioning:** In this context, this refers to questioning the data, not your participants. Questions can help an analyst to generate ideas or consider different ways of looking at the data. It can be useful to ask questions when analysis appears to be in a rut.

2. **Analysis of a Word, Phrase, or Sentence:** Considering in detail the meaning of an utterance can also help to trigger different perspectives on the data.

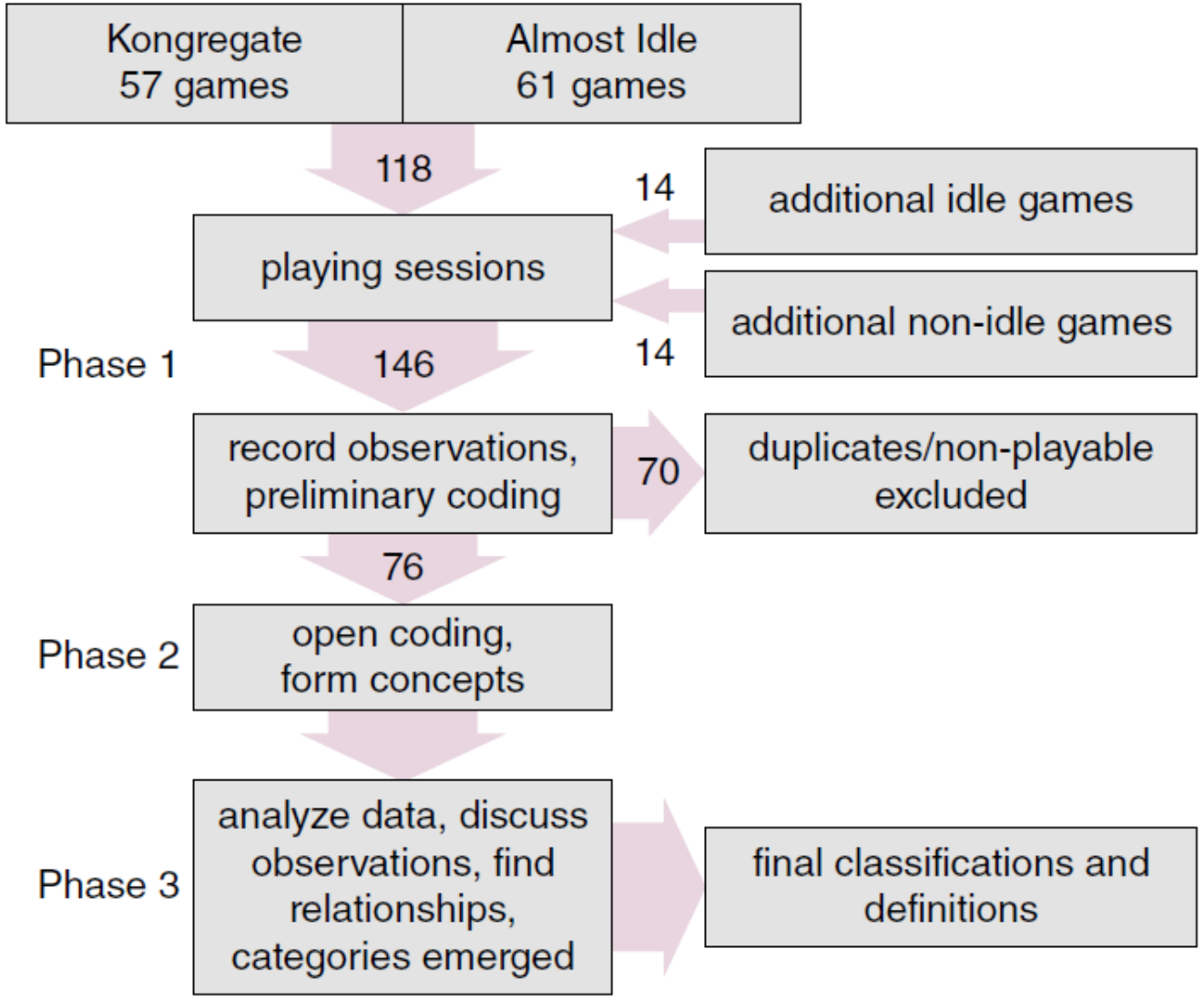
3. **Further Analysis Through Comparisons:** Comparisons may be made between objects or between abstract categories. In either case, comparing one with the other brings alternative interpretations.

Grounded theory uses thematic analysis that is, themes are identified from the data, but as data analysis informs data collection, it also relies on categorizing new data according to the existing thematic set and then evolving that set to accommodate new findings.

8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

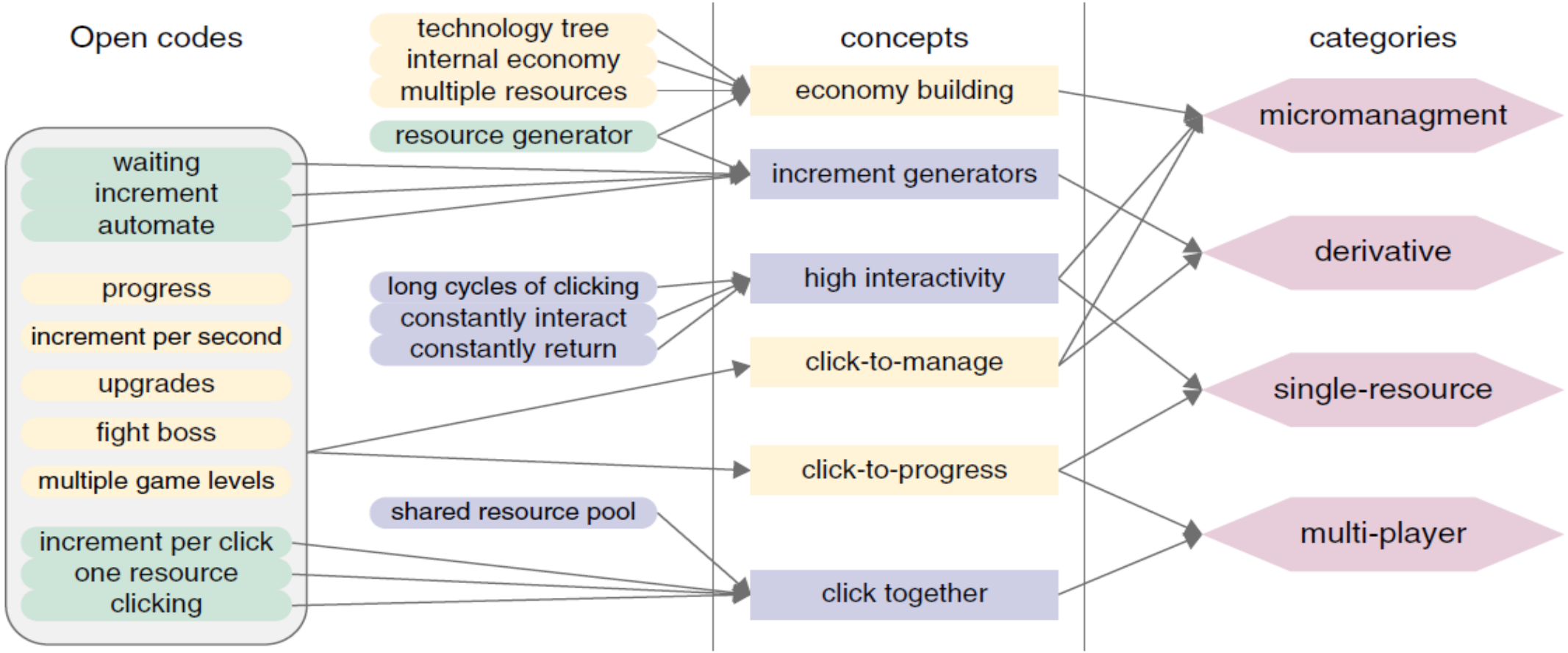
The process used by Alharthi et al., showing Phase 2 and Phase 3 using the three stages of grounded theory coding



8.5 Which Kind of Analytic Framework to Use?

5. Grounded Theory

The grounded theory process showing the development of open coding, through concepts to categories



The analysis process that developed the incremental games super-category (each category above is part of incremental games). The process started with open coding of observations on idle games: multiple codes are created. Concepts are discovered through analyzing the open codes and identifying common features. This is an iterative process, where new codes are added, combined, or deleted. Each code is connected to one or more games and can be combined to form new concepts. Concepts are analyzed to find common relationships, and, thus, categories emerge. In the diagram, coloration is only to aid in reading. The left grouping is to show that all contained codes are part of click-to-manage and click-to-progress.

8.5 Which Kind of Analytic Framework to Use?
6. Systems-Based Frameworks

- Understanding how a whole socio-technical system (for example a hospital, corporation, local council, or airport) works at scale requires a different kind of analytical framework.
- Two such frameworks are introduced next: **socio-technical systems theory** (Eason, 1987) and **distributed cognition** (Hutchins, 1995), as applied through the Distributed Cognition of Teamwork framework (Furniss and Blandford, 2006).
- **Socio-technical systems (STS) theory** makes explicit the fact that the technology and the people in a work system are interdependent (Klein, 2014). Rather than trying to optimize either the technical system or the social system independently of each other, STS suggests that this interdependency be recognized, and the "system" be treated as a whole.
- The ideas behind **socio-technical theory** were first conceptualized around coal mining in the 1950s (see Trist and Bamford, 1951, for example), but it also has a long history of being applied in **hospitals and healthcare settings** (Waterson, 2014) as well as **manufacturing and social media systems**.

8.5 Which Kind of Analytic Framework to Use?
6. Systems-Based Frameworks

Ken Eason (2014) identifies five significant and enduring aspects of STS theory (Eason, 2014):

1. **Task interdependencies:** If people are focused on one large task, then the division of subtasks between them inevitably sets up interdependencies that are critical to understand. Understanding these interdependencies is particularly useful for recognizing the implications of change.
2. **Socio-technical systems are "open systems":** STS are influenced by environmental factors including physical disturbances and financial, market, regulatory, and technical developments.
3. **Heterogeneity of system components:** The overall task is undertaken by humans in the social subsystem using technical resources in the technical subsystem. Both need to be resilient. Technical components can evolve while humans can learn, develop, and change the technical components to address challenges of the future.
4. **Practical contributions:** STS theory is making practical contributions in analysis of existing systems, summative evaluation of a major change, through potentially predicting challenges before changes are made, and in designing socio-technical systems that are co-optimized.
5. **Fragmentation of design processes:** In a complex socio-technical system, there are different design processes, and these can result in fragmentation. Flexibility in specification, local focus in design, user-centered design, and system evolution will help overcome these.

8.5 Which Kind of Analytic Framework to Use?
6. Systems-Based Frameworks

Distributed cognition **and** ***Distributed Cognition of Teamwork*** **(DiCoT)** were introduced, “Cognitive Aspects,” as an approach to studying the nature of cognitive phenomena
across individuals, artifacts, and internal and external representations.

- Investigating how information is propagated through different media is a key goal of this approach, and while distributed cognition provides a good theoretical framework for analyzing systems, it can be difficult to apply in practice.
- The **DiCoT framework** was developed as a method to support the application of distributed cognition. It provides a framework of models that can be constructed from a set of collected data, for example ethnographic, interview transcripts, artifacts, photographs, and so on.

8.5 Which Kind of Analytic Framework to Use?
6. Systems-Based Frameworks

Distributed cognition **and** ***Distributed Cognition of Teamwork*** **(DiCoT)**

Underlying each model is a set of principles distilled from the distributed cognition theory. The models are as follows:

••***An information flow model that shows how information flows through the system and is transformed.*** This model captures the information channels and hubs together with the sequence of activities and communication between different team roles.

••***A physical model that captures how physical structures support communication between the team roles and facilitates access to artifacts.*** This model helps to describe the factors that influence the performance of the system at a physical level.

••**An artifact model that captures how artifacts in this system support cognition.** This model can be used to represent the key characteristics of an artifact and how its design, structure, and use can support team members.

8.5 Which Kind of Analytic Framework to Use?
6. Systems-Based Frameworks

Distributed cognition **and** ***Distributed Cognition of Teamwork*** **(DiCoT)**

Underlying each model is a set of principles distilled from the distributed cognition theory. The models are as follows:

••**A social structure model that examines how cognition is socially distributed.** This model maps the social structures to the goal structures, shows how work is shared, and can be used to consider the robustness of the system.

••**A system evolution model that depicts how the system has evolved over time.** This model provides some explanation for why the work is the way it is. Any design recommendations need to take this context into account.

8.6 Tools to Support Data Analysis

- While it is possible to perform these kinds of data analysis using only **manual techniques**, most people would agree that it is quicker, easier, and more accurate to use a software tool of some kind in the majority of cases.
- Using a simple spreadsheet application is surprisingly effective, but there are other more sophisticated tools available to support the organization, coding, and manipulation of data, and to perform statistical tests.
- Try installing QDA Miner or saturateapp

8.7 Interpreting and Presenting the Findings

- Choosing an appropriate way to present the findings of a study is as important as choosing the right analytical approach.
- This choice will depend on the data gathering and analysis techniques used as well as the audience and the original goals of the study.
- There are three kinds of presentation styles that haven’t yet been emphasized to this point: **using structured notations, stories, and summarizing**.

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