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ABSTRACT

Corporate and educational settings increasingly require decision-making, problem-solving and other complex cognitive skills to handle ill-structured, or heuristic, tasks, but the growing need for heuristic task expertise has outpaced the refinement of task analysis methods for heuristic expertise. The Heuristic Task Analysis (HTA) Method was applied to three settings to generate improvements and more detailed guidance, and to identify variations in the method for different situations. The three settings were group counseling, tutoring on writing skills, and selecting artwork for a product line. The formative research methodology was used to test the method and generate improvements. The three studies produced some common and some unique findings and recommendations. A tentative revision to the HTA method is proposed. (Contains 10 references.) (Author/AEF)

# Formative Research on the Heuristic Task Analysis

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## Abstract

*Corporate and educational settings increasingly require decision-making, problem-solving and other complex cognitive skills to handle ill-structured, or heuristic, tasks, but the growing need for heuristic task expertise has outpaced the refinement of task analysis methods for heuristic expertise. The Heuristic Task Analysis Method was applied to three settings to generate improvements and more detailed guidance, and to identify variations in the method for different situations. The three settings were group counseling, tutoring on writing skills, and selecting artwork for a product line. The formative research methodology was used to test the method and generate improvements. The three studies produced some common and some unique findings and recommendations. A tentative revision to the HTA method is proposed.*

## Introduction

As our society in general and the workplace in particular become more complex, we are finding that a greater number of the activities that people undertake are relatively more heuristic in nature than ever before. Whether in K-12 education, higher education, corporate training, or any other context, to help people learn the heuristic elements of an expert's know-how, we must be able to identify those heuristics.

In analyzing heuristics, we find it helpful to think in terms of two major kinds of expertise—domain and task expertise. *Task expertise* relates to the learner becoming an expert in a specific task, such as managing a project, selling a product, or writing an annual plan. *Domain expertise* relates to the learner becoming an expert in a body of subject matter not tied to any specific task, such as economics, electronics, or physics (but often relevant to many tasks). (Reigeluth, 1999, p. 435).

Both procedural and declarative knowledge are important elements of both kinds of expertise. In this research, we focus on task expertise. For task expertise, we find it helpful to think in terms of two major kinds of tasks: procedural and heuristic. *Procedural tasks* are "tasks for which experts use a set of steps, mental and/or physical, to decide what to do when, such as a high school course on mathematics or a corporate training program on installing a piece of equipment for a customer. *Heuristic tasks* are "tasks for which experts use causal models—interrelated sets of principles and/or guidelines—to decide what to do when, such as a high school course on thinking skills or a corporate training program on management skills." (Reigeluth, 1999, p. 435).

The distinction between procedural and heuristic tasks is similar to the distinction between well structured and ill structured domains (Fredericksen, 1984; Resnick, 1988; Simon, 1973). In reality most tasks are neither purely procedural nor purely heuristic, but some combination of the two. We have relatively powerful methodologies for analyzing the expertise that underlies procedural tasks (i.e. the mental and physical steps upon which an expert relies). But we do not have good methodologies for analyzing the expertise that underlies heuristic tasks. This situation is exacerbated by the reality that heuristic knowledge is frequently tacit rather than explicit—that is, experts are often unaware of the heuristics that guide their performance. Therefore, there is a strong need to develop task analysis methodologies for identifying the knowledge that underlies heuristic tasks. The full paper reviews literature related to heuristic task analysis. Then it describes three research studies that have been conducted to improve one of those methodologies. This paper is a summary of the full paper.

## The Heuristic Task Analysis Method of Elaboration Theory

The Elaboration Theory (Reigeluth, 1999; in press) offers the Heuristic Task Analysis (HTA) method as part of its Simplifying Conditions Method (SCM) for task analysis. This more general method of task analysis is conducted by asking the question, "What is the simplest version of the task that an expert has ever performed?" and "What is the next simplest version?" and so forth. As each version is identified, its place in the learning sequence is simultaneously determined. Therefore, the SCM task analysis method is an integral part of the method for designing an instructional sequence. Furthermore, since most tasks have a combination of procedural and heuristic elements,

the procedural and heuristic task analysis methods are integrated into a single process. For these reasons and because this method offers a fair amount of guidance for the task analysis process, we chose this method for our research. Hence, it is described in greater detail next.

## The SCM's Heuristic Task Analysis Method

The following are some details on the SCM's heuristic task analysis method. They are an elaboration of the process described by Reigeluth (1999).

**Phase I. Prepare for Analysis and Design**

1. **Prepare.** Lay the groundwork for your analysis and design.
   - 1.1 Establish rapport with a task expert.
   - 1.2 Explain the analysis process you will be using.
   - 1.3 Ask the task expert about the nature of the task in general.
   - 1.4 Identify the characteristics of the learners in general.
   - 1.5 Identify the delivery constraints of the task in general.

**Phase II. Identify the First Learning Episode**

2. **Identify the simplest version.** Help the task expert to identify the simplest version of the task that is fairly representative of the task as a whole, and to describe the conditions that distinguish that version from all other versions.
   1. You may want to use some **other criteria** in addition to simple and representative, such as common and safe
   2. Ask the task expert to recall the **simplest case** she or he has ever seen. The simplest version will be a class of similar cases. Then check to see how representative it is of the task as a whole.
   3. It may be helpful to start by identifying some of the **major versions** of the task and the **conditions** that distinguish when one version is appropriate versus another.
   4. Thinking of different conditions helps to identify versions, and thinking of different versions helps to identify conditions. Hence, it is wise to do both simultaneously (or alternately).
   5. There is no single right version to choose as the "simplest." It is usually a matter of trade-offs. The very simplest version of the task is usually not very representative of the task as a whole. The more representative the simple version can be, the better, for it provides a more useful schema to which learners can relate subsequent versions.
   6. It may be wise to go through this process with several task experts before going on to Step 3. You may find it necessary to take steps to resolve differences of opinion about which is the best "simplest version" to use.
3. **Analyze the organizing content.** Analyze the organizing content for this version of the task.
   - 3.1 Ask the task expert to think of **one specific performance** of the task to analyze, or to videotape a performance for you to review with the expert during the analysis.
   - 3.2 Use a **top-down approach** to analyzing the content (the knowledge upon which the expert's performance is based). In other words, start by identifying the general categories of knowledge that an expert uses, then proceed to analyze each.
     7. Ask the task expert:
        - to **describe each decision** that the task expert made,
        - to **identify the kinds of knowledge** that the task expert drew upon to make the decision, and
        - to **describe the specific knowledge** within each kind of knowledge that the task expert used.
     8. The kinds of knowledge are likely to include:
        - **steps** (procedural knowledge),
        - **guidelines** or **rules of thumb** (heuristic knowledge),
        - **explanatory models** (which explain why the guidelines work),
        - **descriptive models** (which describe the phenomena with which the task expert interacts), and
        - **metacognitive/decision rules** (which the task expert uses to decide which steps, guidelines, and descriptive knowledge, to use when).
     9. It is generally helpful to start by asking the task expert if there are any **steps** or phases of activities that are always performed for this version of the task. If so, perform a procedural task analysis to identify the sequence of steps and to see if any of those steps can be broken down into substeps, but those substeps must be ones that an expert thinks of and uses routinely in performing that version of the task.
     10. For guidelines, use the following process:
         1. Identify the ***goals*** for this specific performance of the task under its conditions.

2. Identify all the important ***considerations*** for attaining each goal. Considerations are the major categories of causal factors that influence performance of the task. If there are a lot of causal factors for a consideration, it is useful to identify subconsiderations for it.
3. Identify all the important ***causal factors*** for each consideration (or subconsideration).
4. Analyze each causal factor to identify all ***guidelines*** (prescriptive principles or "rules of thumb") that an expert uses to account for this consideration.

11. For explanatory **models**, use the following process:
12. For each guideline, ask the task expert for the reasons why s/he believes it works.
13. For interrelated guidelines, you are likely to identify a set of related reasons that constitute a causal model or models. Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
14. For descriptive **models**, use the following process:
    1. Ask the task expert what phenomena influenced this particular performance of the task. Try to identify all causal relationships that characterized those phenomena. Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
15. For metacognitive/**decision rules**, use the following process:
    1. Find out what rules the task expert used to decide when to use which steps, guidelines, and descriptive models during the specific performance of the task being analyzed.
16. It is wise to query the task expert about any of these kinds of knowledge that are not initially described to you for each decision the task expert made in this specific performance of the task.

3.3 Ask the task expert to think of similar **performances** of the task that constitute a single version of the task. Use each such performance to broaden the steps, guidelines, explanatory models, descriptive models, and metacognitive/decision rules so that they represent the knowledge bases the task expert uses to deal with all performances for that version of the task.

3.4 If time and resources permit, find a second task expert with whom to repeat this entire process (Steps 1–3.3) to identify any alternative views of the task and the knowledge that underlies its performance. It may even be wise to repeat this process with several more task experts. And you may want to go back and ask each task expert what s/he thinks about the perspectives of the other task experts, in an effort to reconcile conflicts and select among alternative ways of thinking about and performing the task.

The HTA method has not been rigorously tested and therefore is in need of further research. However, the most important research issue is not the validity of the HTA method, for, like most methods, it is likely to work some times but not always, and to varying degrees. Rather, given the immaturity of our knowledge about how to analyze heuristic tasks, what is needed most at this point is developmental research—research that is intended to further develop and improve the method. Therefore, our research question is, "In what ways can the HTA method possibly be improved?" To answer this question, it is also necessary to find out what parts of the method are working well and what parts are not working so well. Furthermore, to improve the HTA method, it will likely be important (1) to change parts of the method, (2) to provide more detailed guidance about how to accomplish particular parts of the method, and (3) to identify variations in the method for different situations, such as different kinds of tasks or even different kinds of task experts.

To answer these research questions, we conducted a series of three developmental research studies. These are described next, followed by some general conclusions.

## Study 1: The HTA Method Applied to Group Counseling

The purpose of this study was to improve the HTA method and guidance for use of that method. Thus, the formative research methodology was adopted with emphasis on exploring how the HTA method can be improved when applied to group counseling.

Formative research is a kind of developmental research or action research that is intended to improve design theory (Reigeluth & Frick, 1999). In contrast to research on descriptive theory, which emphasizes validity or how well the description matches the reality of "what is," research on design theory is more concerned with preferability, the extent to which one method is better than other methods for achieving certain goals under certain circumstances. By creating or identifying an instance of a design theory and collecting formative data to improve

that instance, one may develop better understanding of how the theory works in the field and thus be able to propose improvements for the theory, which of course would need to undergo further testing.

**Task.** Group counseling was selected as the task to which to apply the HTA method. Group counseling is a combination task with both procedural and heuristic elements. It is procedural in that the activities of the group leader are largely determined by the stages that a group goes through (i.e., forming, norming, storming, and performing), and the leader cannot help the group to progress to the next stage without performing certain tasks (steps) at each stage. However, at a deeper level of analysis, the knowledge required for the leader to decide when and how to intervene is not a set of steps but a set of guidelines and principles, which are heuristic knowledge.

**Participants.** This study involved three participants as task experts in group counseling. Expert #1 was a professor in the Counseling Department in the Indiana University School of Education and was the most experienced of the three task experts. The other two were doctoral students in the same department. They were all experienced in conducting "personal growth" group counseling, and their expertise ranged from three to more than 20 years.

**Data Collection Methods**

**Interview.** Semi-structured in-person interviews were used as the primary data collection method. The second author conducted six interviews between September and November, 1999. Each interview took 30-90 minutes and was audio taped for analysis. The purpose of the interviews was to find ways to improve the HTA method for eliciting, analyzing, and representing the expert's heuristic knowledge for performing the task of "personal growth" group counseling. The investigator played two roles, one as a task analyst proficient in the HTA method and the other as researcher searching for ways to improve the HTA method. As task analyst, the investigator developed a set of interview questions (see Appendix A) for the interview based on the HTA method, but as researcher the investigator was not restricted to the predefined questions. Depending on the expert's response, the researcher revised the HTA method for the next interview. Thus, the overall interview process was flexible and reflective in nature.

**Videotapes**. Because of the confidential nature of group counseling, direct observation or videotaping of an expert's task performance (as called for by the HTA method) was not allowed. Instead, the researcher (as analyst) used a series of instructional videos that simulated group counseling sessions for beginning group leaders, to provide the analysts with a concrete case.

**Data Analysis and Interpretation Methods**

The HTA method is an iterative process: finishing the first round of HTA is not the end of the study but the beginning of the second round of HTA; and the end of the second round is, again, the beginning of the third round; and so on. The investigator went through two rounds of HTA in this study.

**Triangulation.** To enhance the thoroughness of the data, this study involved three experts as data sources. Each of them played somewhat different roles during the interviews. During each round of data collection, expert #2 provided the initial structure of the task setting and knowledge base. Then experts #1 and #3 reviewed the knowledge elements, verified them, and provided additional information. There were a few times when the three experts did not agree with one another. In such cases, expert #1's judgment was accepted, as he was the most experienced group counselor.

**Member checks**. After each interview with an expert, the researcher transcribed the interview and took the summary and interpretations to the next interview for review. Through this process, the experts corrected errors or misconceptions by the researcher, and the researcher asked additional questions to clarify the information.

**Consultation**. During the data collection and analysis process, the researcher regularly met with the other three researchers in this study and consulted them in designing the interview protocol and analyzing the data.

**Results and Discussion**

The first round of data collection involved initial interviews with three experts. Instead of finishing with one expert and then starting with another, the researcher worked with the three experts simultaneously (but separately) due to their time schedules. This approach involved some tradeoffs. It worked well in the sense that the researcher could get the three experts to reach consensus on the simplest version of the task early in the HTA process. However, communicating with all three experts simultaneously was not easy for the researcher, and the researcher had to spend most of the time during the interviews explaining to each expert the previous interviews with other experts. Even though the task was a common one, the experts still had difficulty explaining the detailed decision-making process when the task had originally been defined by another expert. Facing this problem, the

researcher decided to use an existing instructional video series (with which all three experts were familiar) as a frame of reference, instead of trying to build a new scenario based on each expert's experience.

The second problem was that the researcher lacked expertise in the task of group counseling. The researcher found that, to be able to push the expert to further elaborate his/her automatized (and hence subconscious) task expertise, the analyst needed to speak the same language as the expert and be able to prompt when the expert had difficulty in finding the right words. Without a certain level of expertise in the task, the researcher as task analyst had difficulty doing those jobs smoothly.

The third problem was related to the difficulty of categorizing the types of knowledge underlying each decision made by the expert during the task analysis. The purpose of identifying the five types of knowledge identified by the HTA was to make sure that the expert did not overlook one of the important types of knowledge, but the benefits of distinguishing among the types seemed to not be worth the extra time required in this case.

The second round of HTA incorporated some new methods to deal with the problems found in the first round. First, the researcher summarized key incidents from the video series on index cards and used them as a reference during the interviews with the experts. This was very helpful in three ways: (1) it helped the experts to recall details about the task performance process, (2) it helped both analyst and experts to see the flow of the task performance process and get back on track when the experts got off-task, and (3) it saved a lot of time in revisiting previous points. One expert commented that the index cards forced him to be more precise during the review and revision process. Second, the researcher as analyst used a bottom-up approach (identifying knowledge first, then categorizing it as to type) rather than the top-down approach (identifying knowledge within each type) suggested by the HTA method.

Based on the findings of this study, the following changes are proposed as possible improvements and described in detail below: (1) incorporate various interview and observation techniques into the HTA process, (2) provide different guidelines for analysts with different levels of task expertise, (3) provide different guidelines for working with task experts with different levels of expertise, and (4) provide reference material during the interview with task experts.

## Study 2 - The HTA Method Applied to Tutoring on Writing Skills

As in Study 1, the purpose of this study was to improve Reigeluth's HTA process by using the formative research methodology. This study followed the steps suggested by Reigeluth and Frick outlined in study 1.

**Task.** The heuristic task chosen for this study was tutoring university undergraduate students who needed extra assistance with their writing skills. Specifically, the task concerned the decision-making process in which an expert writing tutor engages to determine the direction and focus of the tutoring session. By its very nature, a tutoring session requires a lot of heuristic expertise, because it is determined more by events that occur during the tutoring event than by any predetermined procedural steps. What occurs during the tutoring session depends on both the writing situation and the tutee. The writing situation includes why the tutee is being tutored, the relationship between the tutee and the teacher, the interest level of the topic being written about, and the number of drafts already written. The tutee includes any previous experiences, both positive and negative, that the tutee brings to the tutoring session.

**Participants**. Two experts were chosen based on their level of expertise and the approval of their supervisors. Both experts had extensive experience tutoring all levels of writing students, and both were highly recommended by their writing center supervisors. A third tutor was also recommended and interviewed as a potential participant in this study. However, the recommendation came without the experience and evaluation credentials listed above, so he was not included in this study.

## Data Collection Methods

**Interview**: As in study 1, the main data gathering method was the personal interview, and the researcher both elicited heuristic knowledge (analyst role) and conducted formative research (researcher role). Two interviews were conducted within one week of the tutoring session that was being analyzed. Both of the interviews were conducted within one week of the tutoring session that was being analyzed. Because of the tutors' lack of time to spend on this research, each interview was limited to approximately 60 minutes. Prior to the interviews, each of the tutors was sent emails describing terms used, definitions, an outline of the interview questions, and a brief explanation, written in their terms, of the purpose, expected results, and use of this research.

Before the actual interview, the researcher reminded each tutor of what was sent to them earlier and asked if any terms or points needed to be clarified. At this time, the researcher also pointed out to each expert writing tutor that a) it was unclear whether the task about to be analyzed was actually based on heuristic knowledge and b) it was

unclear whether the questions would be able to access that knowledge. This was done to reduce any anxiety that the writing tutors might experience if they could not produce information that the researcher desired.

Based on the first interview, the HTA methodology was altered slightly for the second interview so as to assist the tutor to better recall the tutoring situation. The analyst had the tutor respond to specific questions about the actual tutoring experience, the tutee's characteristics, and the tutee's essay prior to having the tutor recall and reflect on her decision-making processes. He then had the tutor identify the decision areas to focus on during the tutoring session. Afterwards, he had the tutor choose the concern that was most available to her. This, then, became the subject of the heuristic task analysis.

**Data Analysis and Interpretation Methods**

There were no follow-up interviews or member checks as in Study 1 to determine the validity of the tutors' responses due to the writing tutors' lack of time to spend on these tasks. However, because of the researcher's expertise in this area, he concluded that the data collected was not spurious. At the conclusion of each interview, the experts were asked to review and modify what was recorded during the interview. The researcher asked each expert for ways to improve the interview process and to comment on its effectiveness in eliciting the knowledge underlying their decision-making thought process. Both offered suggestions about ways to help them recall the previous tutoring situation and about the limitation of focusing on only one aspect of the tutoring process. The second expert confirmed what the first had concluded. After each interview, tentative changes were made to the HTA process.

**Results and Discussion**

In the interview after the first application of the HTA method, the first tutor mentioned how the process helped him think about his own tutoring strategies. He also mentioned that having to recall from memory a tutoring session that was done even within the last seven days was not easy. The tutor suggested the following refinements to the HTA method. 1) The top-down process seemed effective. 2) Because the tutor experienced some difficulty recalling the specific tutoring session, the analyst (researcher) asked some specific questions about the tutee, the paper, and the tutee's reactions to the tutor's suggestions. Both tutors said this helped them get into the flow of the previous tutoring session, and the researcher observed a marked increase in awareness and confidence after assisting the tutor's recall. 3) 5x8 cards were effective in that the tutor referred back to them to align his insights into the tutoring process with previous statements. 4) The tutor, when identifying the guidelines, focused more on how to hold an effective tutoring session than on what influenced his decision to focus on a specific tutoring objective. In addition, 5) the researcher suspected that the results of the HTA might have been richer if the task expert (tutor) had been given more control over the decision point selection process.

In summary, an important concern involves the task expert's tendency, when explicating the guidelines, to focus on the goals and not on the decision points for attaining the goals. During both instantiations, the writing tutors gave the guidelines they used for deciding on the goals of the tutoring situation rather than giving guidelines for deciding how to attain a goal during the tutoring session. When this occurred, the researcher gently prodded the experts to focus on the decision points rather than the goals. However, when the experts could not provide that information, the researcher decided to review previous sections and then ask that question again. After the experts referred to the goals again, the researcher decided not to push them any further, seeing that they both were unable to provide that information. Another concern involves the first expert's difficulty in recalling the tutoring session despite the fact that the session occurred only one week prior to the interview. Measures taken to assist the second expert's ability to recall the tutoring session showed a dramatic improvement.

## Study 3: Selecting Artwork for a Commercial Product Line

The third study tested the HTA method in a corporate setting. As in the previous two studies, formative research was the methodology, using a designed case to generate possible improvements in the HTA method. Corporate executives want a "big bang for their buck," and analysis is often looked upon as a time-consuming activity with questionable impact. The aim of this study was to develop a rapid, high-impact version of the HTA method for corporate settings. Thus, the study was designed to provide insight into the following research questions: (1) How can the speed and effectiveness of the HTA method be improved for eliciting, analyzing, and representing heuristic knowledge from experts in corporate settings? (2) What guidance could be added to the method to assist analysts in corporate settings? The time constraints for this study dictated that the research be limited to a single interview cycle with one task expert, lasting no more than a total of three to four hours.

**Task.** The heuristic task chosen for this study was deciding whether a submission of artwork was suitable for one of the company's product lines. This was a judgmental decision-making task requiring a fair amount of experience and know-how. The task expert verified that the task was important to the company, that she was

considered to be an expert at the task, and that it was not easy to articulate the expertise required to perform the task. The heuristic nature of this task was verified by an expert in the HTA method.

**Participant.** The task expert was recruited by calling a local business that had collaborated with the Instructional Systems Technology Department at Indiana University in the past. A manager in the design department enthusiastically agreed to participate in the study. The expert and the analyst discussed possible complex decision-making tasks over the telephone and came to an agreement on an appropriate task.

**Data Collection, Analysis, and Interpretation Methods**

**Interview.** The researcher/analyst conducted two audio taped, one-and-a-half-hour interviews with the participant (task expert) in a conference room at the expert's place of business. The analyst/researcher referred to an interview sheet (described below) to ensure that he was adhering to the guidelines of the HTA method, although he also allowed the interview to be somewhat unstructured as seemed appropriate to gather the heuristic knowledge and data for improving the HTA process. After one-and-a-half hours he reached a saturation point in terms of gathering the essence of the task and the key heuristics and concluded he could not effectively continue the analysis without first going back to his office and organizing the information collected. The expert agreed to continue the interview the following week. The analyst/researcher logged "significant chunks" of the audio tape on 3" x 5" cards. His criterion for "significant chunks" was any piece of knowledge that fit into one or more of the types of knowledge listed in the HTA method. He examined these knowledge elements to determine what missing ones he needed to ask about in the follow-up interview. Then in the role of researcher, he re-examined the interview results for deviations from the HTA method to see where the method was effective in eliciting heuristic expertise and where deviations were helpful. He discussed his preliminary findings with Reigeluth and worked with him to plan the second interview.

**Results and Discussion**

**Speed of the HTA method.** The analyst/researcher found a number of areas in which the speed of the HTA method might be enhanced. Two are discussed in this section. The others are the result of improving the effectiveness of the method and are discussed in the next section. The analyst/researcher noticed that almost an hour was spent identifying the simplest version of the task and distinguishing it from other possible versions. This can be important for training purposes, as outlined in the SCM methodology. However, in a business context, there can be other purposes for conducting the heuristic task analysis. The results of such an analysis can be used to generate job aids for experts, to help designers structure knowledge-management systems, and for other purposes. If training is not the primary purpose, then the analyst might choose to spend less time identifying the simplest version and other versions (Step 2. Identify the first learning episode). Such information might still be useful for distinguishing experts and novices, even though sequencing course material is not of concern. In this study, the analyst/researcher concluded that this step could have been concluded with significantly less time (approximately 20 minutes less), without diminishing the quality of the results.

**Recommendation**: Unless using the HTA method specifically for training purposes, perform Step 2, "Identify the simplest version," only if needed to distinguish between experts and novices or as one way of helping the expert access tacit knowledge. As the expert examines various instances of a task in search of heuristics, it may be helpful to distinguish between simpler and more complicated versions.

**Effectiveness of the HTA method.** The HTA method seemed to be effective in its primary function of eliciting heuristic knowledge from the expert. The types of knowledge delineated in Section 3.2 of the HTA Method were found to adequately cover the range and types of task knowledge described by the expert. The analyst/researcher did, however, have problems managing the two tasks of classifying the expert's knowledge and directing the interview to dig deeper into the expert's tacit knowledge. More practice with the methodology should alleviate this. The analyst/researcher noticed during the analysis that certain verbs used by the expert were indicators of tacit knowledge. Examples of these verbs are: *know*, *like*, *feel*, *see*, *determine*, *understand*, and *decide*. When the analyst/researcher asked the expert why she liked a certain piece of art, she struggled at first to find reasons, but eventually she isolated specific characteristics that distinguished artwork she liked from pieces that she did not find acceptable.

**Recommendation**: Additional guidance should be developed on how to represent explicit knowledge. Although this analyst/researcher has only begun to research this point, such guidance could come from fields such as task analysis or the expert's specific field. One area of interesting research would be collaboration between the expert and the analyst to develop an explicit representation for knowledge deemed critical.

**Guidelines for analysts.** Throughout the two interviews, the analyst/researcher made a conscious effort to avoid academic jargon, and the expert seemed to rapidly understand everything the researcher was saying. In

moments where the analyst/researcher caught himself using a technical term, he laughed it off with the expert and used the moment to increase rapport.

## Suggestions for Improving the HTA Process

The following is a tentative revision of the HTA process based on the findings of these three formative research studies. The changes and additions are in *italics*.

**Phase I. Prepare for Analysis and Design**

1. *Decide on a task to analyze and be clear about the reasons for analyzing it.*
2. *Make sure you have enough task knowledge to have a good command of terminology and key ideas.*
   - *Review basic reference materials and try to become familiar with key concepts and jargon in the field.*
   - *It would be better to begin by identifying the simplest version of the task, rather than trying to expand the analysis to the next version.*
3. *Make sure you have enough knowledge about the uses of the task description.*
   - *If the task description will be used primarily for deciding on the content and sequence of instruction, identify the characteristics of the learners and the delivery constraints of the instruction in general.*
4. *Arrange to interview multiple experts.*
   - *Identify at least 2 or 3 experts to interview.*
   - *Plan to complete the analysis with one expert before initiating the analysis with another.*
   - *Plan to interview the least experienced expert first and proceed to interview progressively more experienced experts in order.*
   - *Ask one or more of the task experts to record their performance of a very simple version of the task, and review the recorded material in advance of the analysis; or observe the task expert's task performance.*
5. *Prepare in conjunction with the first (next) task expert.*
   - *Establish rapport with the task expert.*
   - *Introduce the HTA method to the expert.*
   - *Explain basic terms (i.e. guidelines, explanatory models, etc.).*
6. *Prepare for the interview.*
   - *Prepare interview materials (i.e., index cards to summarize critical incidents during task performance).*
   - *Practice the HTA interview process if you are not very experienced in it.*
   - *Arrange the interview logistics (e.g., reserve a conference room where you can work without interruptions).*

**Phase II. Identify the First Learning Episode**

7. Identify the simplest version. *Hold a focus group interview with multiple task experts, and help them to reach consensus on* the simplest version of the task that is fairly representative of the task as a whole. Also help them to describe the conditions that distinguish that version from all other versions.
   - You may want to use some **other criteria** in addition to simple and representative.
   - *It may be helpful to have the expert briefly discuss* ***closely related tasks*** *and clearly distinguish between the main task and the related tasks during the remainder of the analysis*
   - Ask the task experts to recall the **simplest case** they have ever seen. The simplest version will be a class of similar cases. Then check to see how representative it is of the task as a whole.
   - It may be helpful to start by identifying some of the **major versions** of the task and the **conditions** that distinguish when one version is appropriate versus another.
   - Thinking of different conditions helps to identify versions, and thinking of different versions helps to identify conditions. Hence, it is wise to do both simultaneously (or alternately).
   - There is **no single right version** to choose as the "simplest." It is usually a matter of trade-offs.
   - It is wise to go through this process with **several task experts** together and reach consensus before going on to Step 8.
8. Analyze the organizing content. *With the least experienced expert you have not yet interviewed,* analyze the organizing content (mostly heuristics and descriptive theories) for this version of the task.
   - *8.1 Review the recorded material (or any other visual aid) with the task expert.*
   - *8.2* Ask the task expert to think of and describe **one specific performance** of the selected version of the task to focus on for your analysis, or ask if a videotaped performance would be a good case for you to focus on with the expert during the analysis.

- *It is often helpful to have a videotape of a typical performance of the simplest version of the task, so you and the task expert can review it during the analysis process, but asking the task expert to recall one specific performance and keep it in mind throughout the process is a more convenient and inexpensive, albeit often less effective, alternative.*
- *If you don't have a videotape, It may be helpful to have the expert describe contextual information and particulars of the specific performance, describing how the expert began the case, how it progressed (in sequence), how participants reacted, and how the expert dealt with any problems that arose.*
- *It may be helpful to prioritize the problems/concerns that arose and the decisions/actions that the expert used to deal with them.*

8.3 *Decide whether to use a top-down or bottom-up approach to analyzing the content. If top-down, use Step 8.4 and skip Step 8.5. If bottom-up, skip Step 8.4 and use Step 8.5.*

8.4 *If top-down approach,* start by identifying the general categories of knowledge that an expert uses, then proceed to analyze each.

- Ask the task expert:
  a) to describe each decision that the task expert made,
  b) to identify the kinds of knowledge that the task expert drew upon to make the decision, and
  c) to describe the specific knowledge within each kind of knowledge that the task expert used.
- The kinds of knowledge are likely to include: steps, guidelines or rules of thumb, explanatory models, descriptive models, and metacognitive/decision rules.
- It is generally helpful to start by asking the task expert if there are any steps or phases of activities that are always performed for this version of the task. If so, perform a procedural task analysis to identify the sequence of steps and to see if any of those steps can be broken down into substeps, but those substeps must be ones that an expert thinks of and uses routinely in performing that version of the task.
- For guidelines, use the following process:
  1. Identify the **goals** for this specific performance of the task under its conditions. *It may help to have the expert explain the goals in task-specific terms rather than in abstract terms and to think of the goals as ideal outcomes.*
  2. Identify all the important **considerations** for attaining each goal.
  3. Identify all the important **causal factors** *that relate to* each consideration/subconsideration.
  4. Analyze each causal factor to identify all **guidelines** that an expert uses to account for this consideration.
- For explanatory **models**, use the following guidelines:
  - For each guideline, ask the task expert for the reasons why s/he believes it works.
  - For interrelated guidelines, you are likely to identify a set of related reasons that constitute a causal model or models.
- For descriptive **models**, use the following guidelines:
  - Ask the task expert what phenomena influenced this particular performance of the task. Try to identify all causal relationships that characterized those phenomena.
  - Be sure to look for multiple causes for each effect and multiple effects for each cause. Also look for chains of causes and effects, and explore probabilities for each causal factor to have each effect.
- For metacognitive/**decision rules**, use the following guideline: Find out what rules the task expert used to decide when to use which steps, guidelines, and descriptive models during the specific performance of the task being analyzed.
- It is wise to query the task expert about any of these kinds of knowledge that are not initially described to you for each decision the task expert made in this specific performance of the task.
- If the *expert uses words such as know, feel, see, understand, like, determine, and decide, that may be an indication that heuristic knowledge underlies that particular performance.*
- *It is often helpful to periodically ask the expert some questions about the chosen case, to keep the analysis focused on the flow of that version of the task.*
- *It is useful to help the expert think about ways the specific case fell short of how it should have been done and to have the expert offer guidelines for how this specific case should have been done.*

- *It is wise to have some kind of reference material to provide contextual information and cues and to help the expert be more precise. During the iterative interview process, the visual aid also helps the expert keep on track.*
- *It may be helpful to use index cards for all of these kinds of knowledge, filling them out with the task expert during the analysis process with one piece of knowledge per card, and arrange the cards in some order on a table in front of both of you, so you can easily switch from one part or aspect of the task to another.*

8.5 *If bottom-up approach, ask the expert to describe each decision that s/he made and the process through which s/he went to make each decision.*

- *After the interview, try to categorize each piece of heuristic knowledge according to these categories:* Steps, guidelines or rules of thumb, explanatory models, descriptive models, metacognitive/decision rules.
- *Be sure to "member check" the interview results with the expert in a later interview to verify/identify the types of knowledge underlying each decision.*

8.6 Ask the task expert to think of **similar performances** of the task that are within the realm of the version of the task you are currently analyzing.

8.7 Repeat this entire process (Steps 5 - 8.6) with the next least experienced task expert to identify any alternative views of the task and the knowledge that underlies its performance.

- For each more experienced expert, you should summarize the previous description of the task and ask the expert to review it, in an effort to reconcile conflicts and select among alternative ways of thinking about and performing the task.

Formative research data indicate that this revised HTA process would have been more effective for the three cases investigated here. It remains to be seen whether or not this revised process will also work well for analyzing other tasks that have heuristic elements. The data in this study indicate that much additional guidance is still needed for conducting a heuristic task analysis. It is our hope that this study will encourage others to conduct additional research to improve the available guidance for analyzing heuristic tasks.

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