Transcript of Kenneth Yates's video presentation "Introduction to Cognitive Task Analysis (CTA)"

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This brief video gives you a overview of cognitive task analysis or CTA. We are first going to start with the definition of CTA:

"CTA extends traditional task analysis to capture information about both the overt observable behavior and the covert cognitive functions behind it to form an integrated whole"

Then I'm going to provide a little historical background or context for CTA and then a discussion of why CTA is important. Within that discussion we're going to talk about expertise and how it's acquired and what we call the *double-edged sword of expertise*, and then finally we're going to talk about the implications for instruction when you base content of instruction on the results in the product of CTA, some of the applications that CTA has been used in for the past 25 years and what are some of the studies that have measured the effectiveness of CTA based instruction.

What is the history of CTA?

We might say that CTA had its origins in the ancient Greek literature. There's a conversation between Plato and Socrates asking how was virtue acquired, and they go back and forth quite a bit on this question. It is never really answered totally by Plato and Socrates but, interestingly enough, Aristotle came along and said that virtue is acquired and learned by practice, but *the best person to follow is a model of a virtuous person*.

So this interesting idea here is then that Aristotle may have proposed the first CTA: *follow a virtuous person and find out what they do to be virtuous*.

Well, in the later years (that's going to jump quite a bit of time here to the medieval times) we often see the arrangement of the apprentice and the master. And the apprentice was the person who's *accepted* by the master only after passing many tests, would work side by side the master for the purposes of learning how to conduct that trade and with practice and practice the apprentice became a journeyman and eventually became the master. And this was fine for tasks we can mostly observe, how to bake bread in this example, but I often wonder about whether or not that apprentice asked "how did you change the recipe?", when the customer asked for bread that was sweeter for example. Well, that probably required some thought and some additional instructions from the master to the apprentice.

Let's fast-forward again to the Industrial Revolution. In the Industrial Revolution we had again the *emphasis being on physical tasks*, physical tasks of assembling an automobile. This became routine and automated because you were doing basically one task. The product came down the assembly line to you and you inserted a particular part. In fact you probably became a master or an expert at installing that part with complete accuracy. There were studies done back in those days to try to capture how physical tasks were conducted and performed and to see whether or not there's any wasted time.

Well, nowadays our tasks are quite different. Our tasks are more *mental*. Now, we come to work with a tie and a shirt on. We let machines do the work. So what goes on in work is actually more about *what is going on in our heads*, hence the *cognitive task analysis*.

So cognitive task analysis really is defined by extending what we observe, the observable tasks or steps in performing a task if you will, and also we're interested in capturing what the mental

processes are, what are the thoughts the analyses, the decisions, the judgments that are being made prior to actually performing that task. So now we have an *extension of behavioral task analysis* to what we call *cognitive task analysis* because we're dealing with all things in the mind.

So, as the number of *cognitions* if you will, the number of variables, the number of judgments and decisions that we're making increase, we might say that then this task that we want to replicate becomes *more complex*, it becomes more difficult. So perhaps we have another definition for a *purpose* of cognitive task analysis which is

"to capture how experts perform complex tasks and solve difficult problems."

Why is CTA Important?

So why is CTA important? Well, to understand why CTA is important let's first take a look at how *expertise*, how *knowledge* and *skills* are acquired and how you reach different levels of expertise until you become from apprentice up through into a master, you have mastery of a skill.

So it might be said that *all knowledge really starts as declarative knowledge*. A simple definition of declarative knowledge may be that it's *knowledge that it's conscious, knowledge that you can say or tell somebody*. So all knowledge really starts with declarative knowledge and in fact all skills start with declarative knowledge as well. *Skill or procedural knowledge* then could be an application or doing something, it's actually performing a step.

So, *procedural knowledge and declarative knowledge are two types of knowledge and declarative knowledge forms the foundation for procedural knowledge*. Procedural knowledge then is what you do or apply. So how is expertise acquired? Well, if all knowledge starts as declarative knowledge we might follow the *three stages of automaticity* suggested by cognitive scientist *John Anderson*, the first stage being the ***cognitive stage***.

And there you are very conscious, if you will, of the steps you are taking, "you do this in step one and then you do this in step two". It's something that is very conscious in your mind, it's *explicit*. But as these steps are repeated and practiced to successfully reach the conclusion or the goal of that step, the ***associative stage*** takes over and in the associative stage you are basically adopting steps that lead you to a successful goal achievement and you discard those steps that do not. So you, depending upon the goal that you want to achieve (and we're talking about on a very micro level here), you are going through this associative stage of automating steps that achieve a goal and discarding the steps that do not. So the practice and practice of this then turns into the ***autonomous or automated knowledge*** and in that ***stage*** you're not even thinking about the steps. You're performing the task automatically if you will, or implicitly, or unconsciously.

So a good example of this is driving, of course. When you first got behind the wheel of a car you probably said to yourself, if not out loud, "let's see, now first thing I do is turn on the ignition, the second thing I do is put my foot on the brake before I put it into gear and then I put the car into gear and then I look around". I mean going through all these conscious steps and your driving instructor or a member of your family would sit there and say "no, no, do this, do that".

So you're actually very, very conscious of the steps you are taking but as you became a more accomplished driver, turned from apprentice driver to a journeyman driver, let's say, the actual steps or the tasks of driving became automated. You now don't have to think about staying in the middle of the road, meaning here between the lanes, the designated lanes that you're supposed to drive in. That becomes automatic. There may be certain things that you do automatically as well, like green at a stoplight means you can continue going through it or go. Red means you stop, and we do these things mostly without thinking.

Expertise

So, expertise is acquired first by taking conscious declarative knowledge and combining declarative knowledge that you can say or tell into things that you do or apply. And successful associations then with practice become automated knowledge and we don't have to think about it anymore.

Experts

And thinking about expertise then, some of the characteristics of expertise or experts are that they are able to complete complex tasks very accurately and very fast, that they have a vast storehouse, if you will, of declarative knowledge that for the most part is being used automatically in the productions of steps, action steps and decision steps, to complete a task. They are great problem solvers because this knowledge is highly organized, and the schema that the knowledge is stored in long term memory allows them to look at deeper patterns or deeper structural patterns of problems rather than superficial patterns. So that the problem-solving skills that they have are more structured and more able to get to the heart of the problem if you will, rather than the trial and error or ends-means practices of novices.

Experts then are highly sought after, highly sought after as instructors in the classroom, highly sought after to write textbooks and other materials for instruction, highly sought after as consultants, highly sought after to perform complex tasks and solve difficult problems.

Education

And the purpose of education then is to replicate expertise. And in replicating expertise what we hope then is that our students are learners, whether they be in formal classrooms, in formal classrooms educational settings, business, military settings, in any setting, is that we're able to take expertise and replicate it and transmit that expertise and so that our learners become highly proficient and reach a high level of expertise in their domains.

Consequences of expertise

And this is the positive side of expertise of our *double-edged sword of expertise* but what about the negative side? Since we rely upon experts to, as I just mentioned, to inform instruction, because experts and their knowledge and skills are highly automated, experts may omit up to 70% of the actions and decision steps, the critical information that learners need to be able to replicate the performance of experts. So the automaticity that we discussed interferes with articulation of actually how the task is performed when described by an expert. So, experts really are not fully aware of up to 70%, our research shows, of their own decisions. Moreover, experts tend to underestimate the difficulty that novices may have in replicating the task that the expert has performed or is describing, and experts tend to underestimate the time to complete a task when performed by novices.

Implications for learning

Let's turn our attention then to the implications for instruction of this double-edged sword of expertise. When novices or our learners receive incomplete and or inaccurate descriptions of knowledge or the skills required to perform a task, they tend to fill in the blanks with their own misconceptions and strategies. The consequence of this is that students maintain misconceptions and they build maladaptive strategies. These strategies, they may work as a coincidence or from time to time, but do not work on a consistent basis to achieve a goal.

Applications of CTA

So Cognitive Tasks Analysis (CTA) is the method then to elicit from experts the knowledge and skills represented by the actions and decisions they make when completing a difficult and complex task.

CTA actually, in its various forms, has been around for a long time. The applications of CTA include aviation and air traffic control, as you quite imagine, systems engineering, ergonomics, cybernetics. Our studies have focused on the use of cognitive task analysis in medicine and more recently in education. We have captured how expert anesthesiologists, expert surgeons, perform complex tasks in order to be able to incorporate that into training. We've recently acquired expertise from teachers who teach reading who teach writing who teach algebra and to incorporate those into training as well.

Results

Is CTA based instruction effective? Well, in our studies when USC surgeons participated in a comparison study the ones that were given the CTA based instruction as opposed to the business-as-usual instruction learned 40% more and 30% faster. The important mistakes were reduced by 50%. In another study we examined leadership using CTA versus business as usual methods of teaching leadership and our participants received a 48% additional benefit from the instruction that was informed by CTA. Meta-analyses, which you know are studies that use the data from other studies so that the generalizability of the findings is increased, there is a meta-analysis conducted in 2004 by Lee which covered 34 studies and the main analysis findings show that there was a 46% increase in performance based on CTA instruction. More recently in 2013 meta-analysis conducted by Tofel-Grehl & Feldon, the increase in performance averaged 31%. In education, in a study recently of CTA based instruction for factoring quadratic equations, the students demonstrated a 38 percent increase in their skills on solving quadratic equations by factoring. So in conclusion then, as tasks become more complex or have higher stakes, CTA becomes more important to conduct to capture expertise, so we can transmit these action and most importantly the decision steps and the analyses and judgments experts make that are not observable but to be able to capture them and incorporate them into instruction.

Any Questions?

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