Clinical Interview 1: Analysis

UTeach Step 3

**Knowing and Learning in**

**Mathematics and Science**

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It is quite a common statement to be heard, that the ultimate ambition of man is to understand. However, when one hears that phrase or some refactored variant thereof, he or she often will interpret that as understanding of the world. And yes, we think we can all agree that an understanding of our universe is necessary and highly sought after, but in chasing that goal, we neglect another understanding: that of ourselves, and fail to realize that better understanding ourselves inside and out will accelerate us toward understanding everything else. So, we should shift to trying to better understand ourselves, and out of all of the fields that the human mind and body encompass to be understood, the way in which we learn, apply, and especially understand, competes fairly high in the ranks for the most important out of them. For this goal of turbo-boosting the progress of man by understanding how we apply, an approach for accomplishing this is to study the differences between those who apply their knowledge in an expert manner, and those who do not so.

This pair has conducted two interviews on a topic in computer science called “algorithmic complexity.” One interview was conducted on a novice who was recently introduced to the concept. For the other interview, we chose to question the one that instructed the novice on the relevant material. This is done for a reason – to show how the novice and the expert would explain and apply the exact same material as it is transferred from the expert to the novice directly. When analyzing these differences, the contrast in interpretations and the causes of that contrast should be clearer than had this student-teacher relation not been present. This will allow us to more confidently identify the patterns of novice and expert thinking. The subjects were also asked questions about their opinions on the topic and its place in public education. The analysis will be performed on the interview questions individually.

**Introducing the Topic**

To clearly understand the results of the interviews, knowledge of the basics of the topic is suggested. The expert’s responses provide a good crash course but allow us to summarize. Machine algorithms require a determinable but complicated amount of discrete resources: memory and time, the stockpiles of which are limited. To make algorithm optimization easier, computer scientists developed a way of modeling the average resources an algorithm will consume as the size of the input increases. These models are very easy to analyze algorithms with because it allows us to clearly classify some algorithms as better, and certain phenomena have arisen since the conception of the practice. In these interviews, the phenomenon we discuss is the NP “paradox,” which is detailed in the responses.

**Analysis**

**Question 1:**

The first questions asked in the interviews requested that the participants explain the concepts of algorithmic complexity and complexity classes. The expert’s response to this question is an immediate wall of words. This is the first and most apparent difference between that results of the two interviews. It is also one of the most intuitive differences, which is specifically that experts exhibit the ability to retrieve relevant information from memory effortlessly (Wieman, 2008). The expert laid out his interpretation of the definition of algorithmic complexity and complexity classes in a very streamlined fashion that included plenty of relevant detail and examples while also providing a look into his train of thought. For example, when he gave the example of the constant-time complexity class, he asked the rhetorical question from the perspective of an unknowledgeable party, “How could you have such a thing?” which flowed directly into his example (Lines 18 – 21). This is a great example of experts exhibiting higher quality trains of thought when exploring the structure of the topics within their understanding (Ericsson, 2007).

When the novice was asked this question, not only did he take a long pause to gather and organize the relevant information in his head as novices do (Wieman, 2008), but he also lacked confidence in his answer, as is apparent in the response, “I want to be careful about exactly the way I answer that question (Lines 22 – 23).” This is an example of the lack of confidence that is common in novices when compared to experts in similar situations (Spence, 1997). Another apparent difference is that the novice got stuck in this question quite often, in which case he would be assisted in moving forward by the interviewer (Lines 29, 34, and 36-37), or he would give a completely wrong answer (Line 35, he accepted my guiding response as his answer to my question, which is false). This shows the most intuitive difference between a novice and an expert, which is that the expert knows more correct information, almost by definition. Even though the novice was a student of the expert and was therefore delivered the same material that the expert had at his disposal, the novice did not necessarily understand the material or any semblance of an organization thereof in his mind. This may not necessarily be a consequence of naivete, however; because it is not strictly necessary that an expert be able to teach his field, but that he know it (Bransford, Brown, Cocking, Donocan, & Pellegrino, 2000).

**Question 2:**

The second question simple asked that the subjects recall an example of an NP-class problem, the definition of which they were tasked with recalling in the previous question. Looking at the expert’s transcript, there does not seem to be an instance where a question is asked like this. The reason for this is because as he answered the previous question and explained all the details and implications of complexity classes, he was giving examples along the line. This exemplifies that experts are naturally able to recognize the patters of their field in various problems (Bransford, Brown, Cocking, Donocan, & Pellegrino, 2000). Because the expert answered the first question this way, the second question was asked somewhat as an extension of the first, tasking him with explaining NP in the same way he had explained the other classes (Line 31).

On the novices turn to perform this mental task, he was asked the question as written. Surprisingly, he was unable to give an example of an NP problem. The novice could recall no example of this concept whatsoever and found himself only able to recall one example of an exponential-class problem from the lectures given by the expert. This reveals two things about the novices thought pattern. Primarily, it reveals that the novice had never been tasked to trying to apply this concept onto anything. The other thing that is revealed, though, is a bit more intriguing, which is that the scope of the novice’s ability to apply the concepts in this topic is limited to examples given in class by the expert. This is a prime example of a novice lacking the ability to transfer effectively (Gentner, Loewenstein, & Thompson, 2003). In the end, the novice was given examples of NP problems that were, ironically, given in the lectures (Lines 67 & 75).

**Question 3:**

The third question involved the subjects explaining the difference between NP and NP-Complete, which is a special subclass of the NP problems. This purpose of this question was to show if the subject had the topic material organized internally, which is a trait of expertise (Wieman, 2008). Those with that structure should be able to declare the subset relationship of the NP-Complete problems to the NP problems, and that the status of the former is highly dependent on that of the prior. The expert passed those expectations with flying colors, declaring that subset relationship almost verbatim, and briefly yet thoroughly explaining the controlling effects that the NP-Complete problems have on the NP class.

The novice response was like that of the expert in that the novice implied that the NP-Complete problems are a subset of the NP problems. He also briefly dipped our toes in what the relationship between these two classes are, but it is here that we see a novice mistake. The novice states that NP problems can be transformed into NP-Complete problems. This statement is wrong because the novice is mistaking the simple addition or removal of a layer of information on a problem for a brand-new problem where the NP-Complete problem is not present. The concept, however, works in such a way that the NP-Complete problems are always contained within the NP problems. This subtle change in the novices wording shows that the novice has replaced the actual definition of the NP-NP-Complete relationship with a slightly altered version that matches his superficial understanding of the topic, which is characteristic of naïve learning (Kozma & Russell, 1997).

**Question 4:**

The remaining questions that were asked upon the subjects were open-ended and ambiguous questions with a lot of room for opinions. For this question specifically, the grand objective is to see how the subjects view the subject area at hand in terms of importance and transferability. When the expert was asked this question, he immediately began to discuss why this topic is important not just for the computer science discipline, but also for the modern world of computers in general. He offered an example scenario that affects all of us, which was debit/credit card transactions, and how small changes in algorithmic complexity make that kind of querying technology possible. He also talked about why this is important within the computer science discipline. It is such because problems in computer science have a general complexity associated with them – most of which have corresponding solutions. If these problems can be proven to be at the most efficient complexity level, then computer scientists can stop researching ways of making them more efficient and move their focus onto other problems. These exemplify cases where those with expertise are more easily able to identify instances of their topics in the structure of real-world scenarios (Bransford, Brown, Cocking, Donocan, & Pellegrino, 2000).

The novices response was a bit more theoretical. While the expert’s focus when answering this question was on the whole concept of algorithmic complexity, the novices focus was on the NP problem scope. His examples were more about what could happen in this field if an NP problem is proven to belong to the exponential or the polynomial class, rather than what has happened with proofs of over-complex algorithms in the past and how those realizations have improved our modern-day computing power. This matches up with a theory that novices hold their ambitions to a higher and more broad scope of the respective discipline (Lynch, Coley, & Medin, 2000). It is possible that the novice entered the discipline with prior knowledge on that subject and has simply applied the new knowledge to that preconceived information.

**Question 5:**

The fifth question was a two-part question where the subjects were asked to speak about their opinions on having people both inside and outside the focus, and at different age groups, be taught and develop an understanding of the topic. In asking the subjects this question, the ambition is to shed some light on the difference between how the subjects view the topic’s place academically; both in subject area and in complexity. The two parts of the question were asking how they felt about focused students or professionals of the field being taught this, and then how they felt about this being taught to students in primary or secondary education.

The expert’s response to the first half of the question was as expected of one who teaches the topic to prepare professionals in the field. He began discussing the curricula that computer science and cyber engineering students at Louisiana Tech follow and asserted that it is a good thing that computer science students are obliged to understand the concept, and that the cyber engineering curriculum should be adjusted to make it the same for those students (Lines 88-89 & 91-94). When the novice’s response was similar, but the scope of his answer was directed more towards the benefit of having professionals understand it in the field as opposed to having students learn the material. This is a phenomenon that does not seem to have much research behind it, but it seems that the novice’s recent experience as a student of the topic narrows his reasoning to exclude considering the use of the information in a situation that he has recently passed through because he understands it to be that way. The expert’s response also follows this logic in that he did not make any reference to actual professional application of the material, which may be caused by a similar effect where he ignores his own situation due to it being a part of his routine as a professional of the field. This has been an example of where experts and novices think alike instead of differently as usual, and probably has more to do with general human thought as opposed to expert thought.

The second half of the question did not find such a similarity between the two parties. The expert, in answering this question, detailed a clear connection between this topic area and a certain level of basic logical cognition that could be applied in teaching logical skills to developing children (Lines 106 – 115). He did this by making a link between one of the more fundamentally optimized search algorithms, the binary search, to a game that children play with each other and sometimes in school, simply called the “higher-lower game (Lines 109-111).” When the novice was approached with this question, his response was void of those connections. His response was limited to teaching this to students who had already set themselves on a motivated track towards understanding the field (Lines 143-148). A very important thing to notice about his response is that he limited this to exclude teaching it to young students who “wasn’t capable of learning it (Line 144).” This shows that experts and novices have very different ideas about who is able learn the material, especially in mathematical fields like this one (Glaser, 1999). When comparing whole responses, this also becomes an example of an attribute of expert thinking, which is that experts can notice their topics in the underlying foundations of other processes (Wieman, 2008).

**Summary and Applications**

This analysis has shed light for us on many of the attributes of experts and novices in practice and has helped give a visualization of those traits that we have discussed in class with real examples. Experts and novices do not just know different amount of material, and it is not simple a skill gap that novices overcome to evolve into an expert. They think about their practices in fundamentally different ways, and they sort the details of their focus in different orders such that the experts can see more of their field in any given environment. When entering a new field, one starts as a novice. Therefore, it is important to maintain a plastic perspective about one’s execution of a practice to improve their understanding and really reach the expert level.

This is true for teaching as it is for any other field. To teach a subject effectively – at the expert level – one must achieve expertise in teaching. Those teaching must be constantly monitoring the practices of their topic lectures by keeping an abstract view of their teaching habits to do so (Berliner, 1986). When we enter the classroom as a teacher for the first time, we will be novices. Expertise will only be gained by constantly analyzing ourselves and measuring ourselves against the findings presented here and the principles we have learned therefrom, over many years of engaging in practice. If we decide that we want to see students become experts in the fields that they follow, then it will be important for us to follow through with that metacognitive analysis, so that we may project our own expertise onto them.

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