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Experts amongst us: What do we know about them?

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Abstract
Experts are identifiable individuals whose performances show consistent patterns of advanced level achievement on objective measures over time. Empirical research into the traits of such individuals began in 1899, and a substantial database has accumulated, across some 90 different skill areas and professions. Developing expertise changes the way the mind processes information, and becomes a genuine handicap when striving to teach skills to newcomers. However, a body of research informs us that classroom teaching constitutes a significant skill domain, and the traits identified are consistent with what is known about expertise across scores of other professions and skill domains.

Introduction
In this paper we attempt to relate what is known about the traits of expert teachers to what has been documented about the nature of expert like functioning across many diverse skill areas. Whilst the study of expertise within teaching has a short history, empirical research into expertise began over a century ago when Bryan and Harter published a series of projects into how highly skilled Morse code operators progress to become masters of their craft (Bryan & Harter, 1899). This classic work is notable for creative measurement procedures but also for laying out a vernacular that steadily worked its way into common parlance (for instance, *plateaus in the learning curve*, *automaticity*, *extended practice*, *chunking*, and *task analysis*). A direct quotation from this classic work remains highly meaningful today:

> *The learner must come to do with one stroke of attention what now requires half a dozen, and presently, in one still more inclusive stroke, what now requires thirty- six. He must systematize the work to be done and must acquire a system of automatic habits corresponding to the system of tasks. When he has done this he is master of the situation in his field ... Finally, his whole array of habits is swiftly obedient to serve in the solution of new problems. Automatism is not genius but it is the hands and feet of genius*. (Bryan & Harter, 1899, p. 375)

Since that time, studies into expertise have been conducted across some 90 different areas, including, medicine, sports, computing, chemistry, engineering, chess, bridge, music, the arts, and accounting. The advent of major wars last century gave impetus to the study of expertise in navigation, aviation, photography, strategy deployment, and radar observation (Ericsson,

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Charness, Feltovich, & Hoffman, 2006). The major research tool used has been the expert-novice contrast in which genuine performances of outstanding individuals are compared to those who are skilled within the same area, but not to an advanced level. Whilst there is no formal definition of what an expert is, the common method has been to identify individuals acknowledged as representing the top decile within their field on reliable and objective measures. In truth, novices in this research model often are not beginners. For instance, the diagnostic skills of specialist physicians (as experts) might be compared with those of general practitioners (called novices for the purposes of contrast).

The traits of experts

As information about how experts operate began to accumulate, reviewers noted that certain themes emerged across the diverse areas. In pulling together scores of studies, one research group (Chi, Glaser & Farr, 1988) drew up a 7-point listing that has been used extensively ever since. They found that when experts are compared to novices:

1. Experts excel only in their own domain. Their skills are tied to context and are domain specific. Expertise hinges on knowledge the person has developed within the relevant context, rather than any general skills or ability. It has been found repeatedly that within specific areas, general ability measures, such as the IQ, fail to predict level of expertise attained.
2. Experts perceive large and meaningful patterns. They naturally chunk or group items together which allows them to discern what is relevant to them and what is not. Their perceptions are based upon recognition of previous patterns.
3. Experts develop routines which enable them to work quickly and solve many problems with little error. They have automatized many sub skills which allows them to focus exclusively on what is pertinent to any current problem without becoming overloaded.
4. Within their domain, experts possess remarkably large short term memories, often many times that of the novice performer. Sometimes, memory retention is extraordinary, well exceeding expected limits. For instance, effortlessly, chess champions may recall board positions of up to 40 pieces, provided the pieces are arranged in a genuine game pattern.
5. Experts see and represent problems at a deeper or principled level, whereas novices focus on superficial aspects. Experts are adept at recognising patterns, and possess a huge store of relevant case knowledge, accumulated over several thousand hours, to draw upon.
6. Experts spend relatively more time analysing problems carefully and qualitatively. When they encounter challenges they slow down dramatically, and will not proceed if they sense an error is likely. They may scan information quickly, but fixate far longer when a difficulty arises. Unfortunately, when faced with demands that exceed capacities, novices are inclined toward impulsivity, but in contrast, experts are often highly risk-averse.
7. Experts self-monitor. They may harbour several planned agendas, and switch between them with relative ease. They set sub-goals and monitor these closely, taking steps whenever remediation is needed. They will plan different routes to the same goal and adjust and improvise whenever a planned script is not viable.

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It becomes apparent that experts experience their world somewhat differently as a result of developing a rich and extensive knowledge base. They process information differently to others who are functioning in the same world, but without the benefit of such a huge long term memory knowledge base. Recent studies have been able to use methods such as computer presentation and high speed camera work to study how expertise in sports fields emerges (Hodges, Starkes & MacMahon, 2006). For instance, one interesting attribute found in expert golfers is the quiet-eye period. Before an important shot, professionals were found to take more time especially when focussing on the distant target. This behavioural trait was found to develop with increasing experience. Quiet-eye training has now been introduced into professional training in many diverse areas including sports programmes, police work, and air traffic control (Vickers, 2007).

Studies in the sports areas revealed that experts possess an enhanced capacity to anticipate what is about to take place. Experienced hockey players move to positions where the ball is likely to move, and elite baseball batters, cricketers and tennis players all use information given out by their opponents well before the ball begins its travel. A baseball hitter cannot actually see the ball travelling toward him or her, so the decision to swing, and exactly how to swing, is cued entirely by monitoring the pitcher's movements (Takeuchi & Inomata, 2009). Frequently, these studies reveal that what experts say about their skills is not what the camera records. One bemusing finding is that all of us are 'expert' at catching balls, but possess no insight as to how we are able to achieve this totally automatic feat (Reed, McLeod & Dienes, 2010).

How does expertise develop?

Although the average intelligent person can learn the rules of chess to play a rudimentary game within an hour, it requires around 10 years of concentrated experience to produce a chess master (Ross, 2006). It is thought that expertise is the product of several thousand hours of skill development, possibly 10,000 hours, or 3 hours a day for a decade. Such practice is called deliberate practice, a term now given a distinct technical meaning. Deliberate practice is the time the mind is targeted upon achieving well defined sub goals in a regular and programmed sequence. It has to take place under condition of challenge, mindful goal setting, and objectively calibrated feedback. Under a deliberate practice regime there has to be a constant (e.g., daily) re-calibration occurring between effort and achievement, with a conscious focus upon closely attainable sub goals.

This type of structured deliberate practice differs dramatically from recreational practice which does not focus on objective measures of skill development or upon immediately attainable sub goals. Recreational practice allows a person to perform an act with automaticity, even possibly at a mindless level. Automaticity poses special problems for anyone striving to become expert. Once it kicks in, the skill stops developing. Thus, you will play golf for three hours a day for 10 years but never improve your handicap if the activity is being practiced mindlessly, or for the pleasure of being in the fresh air. The experience may be rich and fulfilling, but the elements of deliberate practice are missing. This distinction was shown in stark relief in a study of professional and amateur singers. Amateurs sang for pleasure, focussing on emotional factors and fulfilment, whereas the professionals were

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driven by technique and technical perfection (Grape, Sandgren, Hansson, Ericson & Theorell, 2002).

Expertise cannot be equated with experience since length of service, or seniority, fail to predict genuine performance levels. It is apparent that for many of us, length of time in employment can even occasion slight deterioration in work performance. This drop-off effect has been shown, for example, in aspects of medical diagnostics and auditing (Ericsson, 2008). If practice automatically results in skill improvement, then such findings make little sense.

The crucial aspect about experts is that, by definition, they exhibit high levels of performance reliably and constantly over time. In many areas this is just not possible. In the field of stock broking, for example, individual brokers have good years and bad years. There is little, if any, continuity across years, and people in this field do not perform better with experience or seniority (Kahneman, 2011). Several studies have found that the average person, the 'man or woman in the street', outperformed experienced brokers in putting together financial portfolios (Gigerenzer, 2008). In certain fields it is impossible to study expertise since individuals who reliably achieve at a high level cannot be located.

Experts as teachers: Is there an empathy gap?

One finding emerging repeatedly in the literature is that experts often fail as good teachers, at least when it comes to communicating within their specific area (Feldon, 2007). They routinely underestimate how difficult a task is for the newcomer, and have even forgotten how difficult it was for them to develop their own skills earlier (Hinds, 1999; Wittwer, Nückles & Renkl, 2008). Even when attempting to make it simple for others, they fail to convey information in a step-by-step manner, and omit information a novice would find valuable (Hinds, Patterson & Pfeffer, 2001). Experts frequently are poor at describing in words what they are actually doing. They tend to assume that others are aware of the same discriminations they find glaringly obvious. They will employ a vocabulary that can be unfamiliar to others and possess knowledge encapsulated in ways understood only by those already familiar with their field.

Hinds (1999) referred to such problems as the '*curse of expertise'*. In a related vein, there is a known phenomenon referred to as the '*curse of knowledge'* evident when knowledgeable individuals appear relatively unable to recognise the attitudes , beliefs, and perspectives of individuals who do not possess the same knowledge (Birch & Bloom, 2007). In one study researchers found that preservice teachers with a strong background in mathematics failed to make sensible decisions about teaching sequences within mathematics, an effect they attributed to an '*expert blind spot'* (Nathan & Petrosino, 2003).

The discovery of expertise in teaching

However, in the field of classroom teaching, expertise can be identified once student achievement gain is used as the objective measure. If such criteria are applied, then there is substantial evidence that classroom teaching represents a genuine skill domain. Analyses at the level of the class have indicated certain teachers were associated with elevated gains in levels of their students' achievement, and did so with some consistency. This finding has

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been seen across nations such as Australia, New Zealand, Britain, Germany, and America (Hattie, 2009; Rowe, 2003 & 2006). In correlational terms, year to year consistency in achievement gains at the classroom level lies within the moderate range, with some teachers regularly being associated with high achievement gains.

By conservative estimates, around 25 to 30% of the variance in student achievement stems from teacher effects, a figure has been appreciated since the mid-1960s. In many analyses this number climbs far higher. It is commonly found that the average teacher is associated with an impact on standardized tests each year somewhere between 0.2 and 0.4, expressed as effect sizes (Hattie, 2012). But some teachers are found consistently to be associated with yearly gains of 0.6 and greater effect sizes on student attainment data. Several studies report a correlation between teacher effectiveness and experience, but this effect is statistically low, and appears restricted to the first half decade of their teaching careers (Hattie, 2009 p.118). As noted earlier, years of experience simply does not predict expertise in any known area.

It became apparent by the 1980s that it was possible to document teacher expertise in depth by comparing recognised experts with other teachers who were competent and experienced, but not expert. On the basis of identification through consistent class level achievement gains, individuals could be identified, and their activities observed and recorded. Initial studies stemmed from the University of Pittsburgh, headed by Gaia Leinhardt (Leinhardt, 1987; Leinhardt & Greeno, 1986). Around this period the expert-novice design was also used by a group at Arizona State University under David Berliner (Berliner, 1986, 1992 & 2004). The topic of teacher expertise has steadily accumulated a significant body of research over the past 2 decades. Some of the findings are highlighted in Table 1 expressed in line with the known attributes of expertise reviewed earlier.

The use of the laboratory method

Expertise research, in both teaching and other areas, has employed both naturalistic classroom observation and the laboratory method. Expert functioning can be uncovered through asking people to relate to simulated conditions. The laboratory then enables a level of control in that teachers are responding to the same cues (e.g., video on a computer screen). Aspects such as response patterns and timings are measured accurately, for instance with high speed cameras. The Berliner group carried out several laboratory studies with expert high school teachers. Using videotapes of classes in operation as stimuli to assimilate and interpret, they discovered that expert teachers possessed the ability to read classroom life to a remarkably high level and pick up nuances overlooked by other teachers (Sabers, Cushing & Berliner, 1991).

In the case of experts, their perceptual and memory strategies differed from the average experienced teacher when asked to watch films of classroom lessons. Experts focus upon information about lesson structures, teacher demands and expectations, and students' work dispositions. In contrast, experienced but non-expert teachers focused attention on what they could see on the screens, without necessarily attempting to relate this information to the underlying teaching goals behind the lessons being observed. For example, non-experts noticed and could recall surface details such as students' clothing. Experts failed to notice many surface details. Instead, their attention was focussed on deep structures such as time

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lines, and the extent to which the teacher on the screen was making sensible instructional decisions.

Table 1.

Matching expertise factors with actual findings in the teacher expertise literature

Known expertise attribute	**Actual finding about expert teachers (ET)**	**Researchers**
Experts excel only in their own domain.	ETs teach their area extremely well, but are far less skilled outside of their curriculum areas.	Berliner
Experts perceive large and meaningful patterns.	ETs plan lessons as interlinked sequences with different means of achieving same goals. They concentrate on tasks relevant to goals. In eye fixations, they scan quickly, regularly, and efficiently.	Borko Leinhardt
Experts can work quickly and solve problems with little error.	ETs will explain complex ideas with astonishing clarity, using short time blocks. They use instructional methods with precision.	Leinhardt Hattie
Within their domain, experts possess remarkably large short term memories.	ETs retain a mental script of key aspects that take place during lessons, but ignore irrelevant details.	Berliner
Experts see and represent problems at a deeper or principled level.	ETs recognise and interpret classroom events incredibly efficiently. ETs steer activities towards classroom goals. They diagnose the need for instruction and feedback at the level of individual needs.	Berliner Hattie
Experts spend relatively more time analysing complex problems carefully and qualitatively.	ETs plan for different contingencies that could happen. When learning a new topic they read and research it well before teaching. They assist students to think about a problem before providing solutions. They set worthwhile challenges, and when dealing with able students quickly shift across from surface to deep learning tasks.	Borko Hattie
Experts have very strong skills in self-monitoring.	ETs able to 'stop and start' lessons most efficiently. They listen intently at students to obtain feedback on their learning. They have developed highly effective strategies for controlling student attention. They anticipate possible problems so can respond to keep momentum flowing.	Leinhardt Borko

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One remarkable laboratory finding was that experts, in contrast with others, were remarkably accurate at inferring student comprehension from non-verbal cues. However, this was true only when these teachers were familiar with the students seen on the films. Hence, their awareness of individual student learning was specific and depended on their relationship with that student, rather than existing in generalizable knowledge form. In short, the experts knew their students as individuals with unique quirks and expressions, and could read these individual reactions quite unconsciously. Expert teachers become highly sensitive towards what their own students are learning and thinking.

Observing expert teachers in action

There have been many studies into how expert teachers function in the classroom. For instance, in one large American study, the classroom skills of middle school teachers, mostly teachers of English Language Arts, were monitored as part of the program initiated by the National Board for Professional Teacher Standards (Hattie, 2009; Smith, Baker, Hattie & Bond, 2008). It was possible to contrast 31 experts against 34 experienced but non-expert teachers. A considerable body of data, including interviews, observations, student responses and work samples, was collected and analysed using trained raters. A number of crucial differences emerged. For one thing, the experts were adept at shifting their students' work products over from surface to deep response requirements. Hence, the students of such teachers were found to be working on tasks likely to promote deep conceptual understandings for the majority (over 80%) of their class time.

The overall findings were as follows:

- experienced experts possess pedagogical content knowledge that is far more flexibly and innovatively employed in instruction;
- they are more able to improvise and so alter instruction in response to contextual features of the classroom situation;
- they understand at a deeper level the reasons for individual student success and failure on a given academic task;
- their understanding of students is such that they are more able to provide developmentally appropriate learning tasks that engage, challenge, and even intrigue students without boring or overwhelming them;
- they are more able to anticipate and plan for difficulties students are likely to encounter with new concepts;
- they can more easily improvise when things do not run smoothly;
- they are more able to generate accurate hypotheses about the causes of student success and failure;
- they bring a distinct passion to their work (see Hattie, 2009, p. 261; Hattie, 2012, p. 29).

The expert teachers scored more highly than the experienced teachers on a number of measured attributes. But for simplicity, these attributes can be grouped in terms of three major dimensions: (a) setting goals and using challenge to bring out the best in their students' efforts, (b) monitoring student learning and using such feedback to assist their teaching decisions, and (c) drawing on strong levels of curriculum knowledge which allowed

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them to adapt teaching to the individual context and be able to diagnose instructional requirements quickly.

To watch such expert teachers during classroom instruction periods is to be singularly impressed with their capacity in making a series of integrated decisions juggling managerial and instructional aspects seamlessly. The observers in this research often commented on the orchestration and organisation of the experts' classrooms, and the virtual absence of student misbehaviour. These are rooms wherein students are too busy and goal-oriented to act out, and where misbehaviour occasions disapproval from other students.

One aspect that often surfaces when interviewing expert teachers is that they readily will talk about classroom events that could, or just might, happen. It is as though they are mentally prepared for possibilities, however remote. They anticipate the type of errors their students could show. Several early studies noted that highly experienced teachers appeared to have poorly developed lesson plans, at least as furnished on paper. But what was occurring was that the more experienced a teacher became the more such plans became familiar scripts and routines in the head. However, they are not fixed scripts, but ones that permit considerable variation and improvisation (Borko & Livingston, 1989; Livingston & Borko, 1989). Their knowledge base is highly procedural in that many of their skills have a basis in making available a range of viable actions, rather than in believing there exists just one 'correct' way to handle any one current problem.

In sum: Expert teaching as interpersonal sensitivity

There is now a considerable body of knowledge informing us that (a) not only can expert teachers be identified through valid measures, but also (b) that such experts display psychological traits known to underpin expertise in other professional fields. These notions are especially pertinent given the well validated notion that acquiring expertise knowledge within a given domain can actually create difficulties for that person when attempting to teach relevant domain knowledge to a novice. The empathy gap from novice to expert can become too wide for the expert to sensitively diagnose. Situations easily arise where a novice and an expert end up equally frustrated. Although we do not know of any such studies, it is possible that many excellent teachers experience problems when it comes to transmitting their skills and expertise to less skilled teachers. Superb teachers do not invariably turn into respected teacher educators.

When we read into this literature it strikes us that teaching is a high intensity interpersonal activity demanding sensitivity to the feedback information learners give out continuously. Particular human beings have been able to develop elevated sensitivity to the learning needs of the student. Analysis of both the laboratory projects and classroom observation data inform us that expert teachers do not merely respond to arbitrary cues on call. Instead, they improvise, but in a calculated and measured manner. They scan their class every few seconds and read students' body language. There is constant adjustment and adaptation, which is made possible only through drawing upon knowledge of the material to be taught, and the individual dispositions of the students. Their expertise enables these teachers to direct and shape the classroom world and skilfully entice their students into becoming motivated learners sharing the same learning goals as the teacher. To get to this point entails

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considerable knowledge, responsiveness to feedback, deliberate practice, and personal investment over at least 5 to 10 years of development.

According to Leinhardt, '*Teaching is the art of transmitting knowledge in a way that ensures the learner receives it'* (1987, p.225). We find this a remarkably insightful observation. The ability to use words, demonstrations, and feedback, to explain complex ideas and concepts to young humans who may lack initial motivation and knowledge, is not a skill to treat lightly. Transmitting knowledge does not mean just talking at students as that is only a minor aspect of the process. Instead, this is a process that rests upon keen levels of intelligence, interpersonal sensitivity and professional skill.

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