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## **Learning where it counts: an ecological argument for online education**

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**Abstract:** The implementation of learning technologies for online instruction and relevant testing raises issues concerning the ready availability and use of external reference materials that students may consult during evaluation but are not commonly found in in-class courses, such as the internet, class notes, and so on. Yet, the presence of such materials may be ecologically valid with respect to daily cognitive performance in any domain (e.g., reasoning and decision-making in everyday life). This paper reviews three related theories of cognitive science as they argue for an integrative cognitive system that includes external artefacts, and thus go beyond 'internal' processes as the sole purveyors of cognition. The paper then uses these theories to frame an argument that the use of online learning technologies could be considerably more ecologically valid than in-class testing based on this integrated external cognitive approach. The paper ends with some suggestions on improving online testing and increasing its ecological validity by embracing the view that cognition extends beyond the brain.

**Keywords:** online; ecological validity; external cognition; learning; online testing.

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## **1 Learning where it counts: an ecological argument for online education**

There is an ancient Chinese proverb that states: “the faintest ink is more powerful than the strongest memory”. It is a stark reminder that human artefacts in many cases do what, without them, a single human’s mental processes could not achieve. The same may be said about the extensive information technologies that dictate our daily affairs in this century. Industrialised modern societies continue to adapt in various ways to integrate these technologies, perhaps having reached a point now at which we most certainly could *not* do what we do without them. Our education systems in particular are beginning to change the means by which students are learning. For example, online courses and degrees are growing rapidly, opening new opportunities to students to improve their education and careers. A recent Sloan Consortium national survey (Allen and Seaman, 2010) found that almost five million students in the USA took an online course in 2008, representing a 17% increase from previous years (compared to only 1.2% increase in overall student admissions). Twenty-five percent of college students register in at least one online course, and over 50% of public and private institutions see online degrees as strategically important [Allen and Seaman, (2010), pp.1–2].

Yet such technologies bring about many questions regarding the benefits and deficits with, for example, using online training and testing, rather than traditional in-class techniques. In the case of online testing, it could be argued it is flawed because it lacks the regulation that an in-class paper-and-pen test entails (e.g., proctoring). Students in online testing can just quickly refer to resources available to them (e.g., the internet, a textbook), and may not learn or retain much of anything in such a context, forgetting what they’ve learned as soon as they have completed the test. In fact, the same Sloan study cited above found that faculty administrators considered less than one-third of their faculty body to take online instruction seriously (Allen and Seaman, 2010). Interestingly, many, if not all, colleges require incoming students to take the ACT or GRE before admission is granted, putting their faith in educational testing service (ETS) and its online tests to confirm the potential of each student. The ETS is a very successful and widely used online testing service. ETS is an excellent example of the usefulness in online testing, providing tests not only for college placement, but also language literacy and writing proficiency. Colleges and universities require an online test to be admitted, but do not fully implement them in their classrooms. In this paper, we argue that the above proverb suggests a different attitude towards online testing (our focus here) and other potential online course issues. We argue using theory in cognitive science that, when carefully designed, online tests may be more ecologically sound, and more consonant with a student’s expectations in the modern, technological world.

The specific purpose of this paper is to argue that online testing and evaluation may provide a means to render evaluation more ecologically sound from a so-called ‘distributed’, and ‘external’ perspective on cognition. In what follows, we first discuss three main theories of interest: distributed cognition, active externalism, and transactive memory. We will then use these theories to argue for the improved ecological validity of online testing, and that it has distinct advantages over traditional in-class testing. Though we speak in general terms in regards to testing and evaluation, our suggestions are applicable to a wide variety of topics and subjects while using theories of cognition to drive our argument. We provide examples from our own field (psychology) to help bolster our suggested features and their real-world applicability.

## 2 Distributed cognition

The first theory we consider has been termed ‘distributed cognition’. It asserts that our environment plays a crucial role in our cognitive processing, with our surroundings integrated so closely in our thought processes that they should be considered part of them. Foundational work on this approach took place in the 1980s by Hutchins and his colleagues. They set out to form a new framework for understanding cognition that was not restricted by the notion that cognition takes place solely through processes ‘inside the head’. Instead, the distributed approach focuses not *just* on the internal processes taking place ‘inside’, but also on the interactions with artefacts and other human beings – our cognitive environment – on the ‘outside’ (Hutchins, 1990, 1995; Rogers, 2006).

Hutchins’s early and influential work consisted of studying the coordination in ship navigation and airplane cockpits. A passenger need not be concerned with the performance of the pilot of the plane, nor on the flight system alone, but on the interactions taking place amongst the pilots, and between the pilots and the flight system. It depends on the abilities of the pilots to take the information presented by the system and to adjust their actions accordingly, as well as the system’s ability to react to the pilots’ actions taken upon the system (e.g., turning knobs, pulling levers). Flying an airplane jet is too cognitively, as well as physically, taxing for any one person to do it, but it becomes practicable when the cognitive tasks needed for the procedures have been distributed amongst multiple people and the artefacts used to complete the tasks (Hutchins, 1992).

## 3 Active externalism

In work inspired by Hutchins and others, Clark and Chalmers (1998) proposed the theory of the ‘extended mind’, in which they argued that the ‘mind’ stretches out beyond the physiological body, involving, they argued, the world around us as we interact with it. Clark and Chalmers, philosophers, offered a thought experiment to depict this theory, involving two imaginary people named Otto and Inga. Both Otto and Inga hear about an art show taking place at a local museum. They both wish to go see this art show. However, an important aspect distinguishes the two dilettantes: Otto has Alzheimer’s disease and must write down his experiences and memories into a notebook that he keeps with him at all times. Once Otto hears about the art show, he simply refers to his notebook to find the location of the museum that he wishes to attend. On the other hand, Inga thinks about the location of the museum in her mind and then proceeds to the museum. The extended-mind account argues that both of these people essentially have searched their memory systems for some desired information. Inga works from a memory system situated within her body, whereas Otto works from a memory system situated outside it. Otto’s notebook has become a part, or extension, of his ‘mind’ and acts in a similar way to Inga’s internal memory system.

This thought experiment illustrates the notion of active externalism, portraying how using our worldly materials can be analogous to using our internal mind for highly similar functions. In recent years, smart phones are perhaps vastly more convincing as a fully integrated part of our cognitive system. For many people, it is rare, if ever, to go throughout a normal day without looking for information using these smart phones or

other portable computer systems to find pertinent information for questions we wish to answer. Forget Otto's notebook: the iPhone is already being used for this purpose by people who have Inga's intact memory.

#### **4 Transactive memory**

Perhaps our 'extended mind' does not entail only inanimate objects but can also include other biological entities, such as humans (Tollefsen, 2006). In the realm of social cognition, Wegner (1986) introduced a theory about a shared memory system among people. Just as people use external memory aids (e.g., post-it notes) as reminders (Meacham and Leiman, 1982), we can also use each other as memory aids. This use of what Wegner termed *transactive memory* allows us to ease cognitive load and devote more mental effort to the other crucial aspects of a task. Similar to the extended mind hypothesis, transactive memory suggests that when using others for information we are using them as part of our cognitive system. Knowing whom to go to for information is the necessary knowledge needed for transactive memory, similar to which inanimate object, or where in that object, to consult (i.e., Otto's notebook).

Giuliano and Wegner (1985) found that intimate couples work using a transactive memory system. Romantic couples dating for months had better recall of items than participants who were randomly paired for the experiment. It seems as though couples implicitly assign each other to specific information domains. Consider a simple hypothetical example that illustrates their results: John and Jane, who have been dating for four months. John is a trained chef and Jane is a computer engineer. Due to this 'personal expertise' (Wegner, 1986), information regarding food and recipes will be most remembered by John, and Jane's memory will do better regarding computer lingo. John has implicitly assumed that he does not need to remember information regarding computers because Jane is the expert of that domain in their relationship. He is knowledgeable about computers because of his extended memory system that includes Jane. An intimate partner is almost immediately accessible and can be trusted as a source of such expert information (Tollefsen, 2006).

This does not only happen in romantic couples, but also in work environments as well. People who work together tend to have specialisations in a variety of domains and each member has personal strengths and weaknesses. Transactive memory allows the group to easily assign tasks to individual group members based on these established strengths and weaknesses, optimising work output (Ren et al., 2006). Though each individual member may not be considered an expert in multiple domains, the group as a whole has overall expert knowledge across these differing domains. The property that the knowledge of each member is both highly variant and redundant is one of both transactive memory and distributed cognition. Transactive memory research provides empirical evidence that we indeed do this with other people in the working world (Rogers and Ellis, 1994; Ren et al., 2006).

#### **5 Online testing/evaluation and ecological validity**

Colleges across the USA are adding more online options for their students. More classes are being offered online, and in some cases entire degrees can be pursued online. A

number of classes at the authors' institution have created a hybrid environment that meshes a face-to-face classroom with online testing. One version of the general psychology class requires students to complete weekly online quizzes that require an understanding of the material in the textbook. Application questions dominate these quizzes with definition questions being scarce. Some classes require students to complete exams online as well as participate in online discussion boards. While some professors and instructors embrace the usage of online assessments, there are still professors and administrators who believe that students are not gaining the full knowledge from online classes that they would gain from being in a classroom setting [see Allen and Seaman, (2010), p.3]. Online classes, and more specifically online testing, are hard to regulate, with students having the ability to use their textbooks, notes, and the internet while being tested. There is no way to fully control the resources students are using to complete their tests and raise their scores. However, we argue that what is trying to be regulated and restricted should not be thought of as 'cheating materials', but rather are extensions of the students' cognitive system: 'cognitive materials'. The theories of distributed cognition, active externalism, and transactive memory would all predict that the resources used by students are not *just* cognitive aids, but they are in fact a part of the student's normal cognitive functioning in real-world contexts.

Clark and Chalmers's (1998) (Clark, 2004) criteria of 'extended mind' can be applied to the use of textbooks and notes during online testing. Their first criterion states that the source being used must be "readily available and typically invoked" [Clark, (2004), p.6]. The notes that a student takes during lectures (both in class and online) are analogous to Otto's notebook of memory.

The second criterion involves the trustworthiness of the source being used. Scrutinising a student's notes may have strong similarities to scrutinising his/her memory or knowledge because just as a student's notes are written into a notebook, the student's memories are 'written' into the long-term memory storage, with each susceptible to inaccuracies and miscommunication. Additionally, any textbooks are definitively accepted as being credible sources during courses. Students prove their knowledge and ability by being tested on knowledge often exclusively from a textbook, yet during testing the students are separated from this part of their cognitive system which has been used to build the knowledge base and are forced to rely on rote memorisation to answer questions. Crystallising such characteristically large amounts of information may tax a student's cognitive system, and potentially discourage the student from thinking more creatively or critically beyond the text's contents. Part of the trouble with this process is that it is so unnatural. Rote memorisation separates the natural synergy between a student's internal and external memory systems, as suggested by transactive memory research (this is not to say that some rote memorisation may be important. We discuss this issue further below).

The third criterion relates to the accessibility of the source in use (Clark, 2004). Textbooks are structured in such a way as to make topics easily referenced, through logically structured table of contents, an alphabetic index, and occasionally thorough glossary. Classes often follow a particular path or organisation based on the textbook and if students can remember to what chapter/topic a question relates, then he/she can easily find that topic in his/her notes or textbook to find an answer. In fact, understanding this structure is not a trivial matter for students. A student who can rapidly consult a textbook for specific information is likely to have an understanding of the overall topical structure

of course content, perhaps having a 'high-level' understanding of the subject matter as a whole. This high-level understanding is, arguably, a kind of mature understanding of the overall form and content of a field that instructors try to instil in students.

The final criterion states that the source must be "previously endorsed or used by the subject" (Clark and Chalmers, 1998). The student may not have initially endorsed the textbook, but implicitly does so by using it to carry out class activities. The professor has endorsed and probably used the textbook in preparation of the class and feels that it is suitable for student's learning. The notes of a student have definitely gained his/her endorsement. In short, endorsement is related to all such external materials.

At this point in our discussion, one may envision a student sitting at his/her computer taking an online test and searching throughout a textbook, and perhaps a notebook, to find the answer to every question on a test. This would certainly not constitute a dynamic cognitive coupling with the environment. Such a student shows no inkling of 'learning' or 'knowledge' except knowing how to look in an index or table of contents and what they mean. Just like our internal memory system, learning is not mentally putting a hand into a box and pulling out the answer – it's certainly more complex, constructive, and dynamic.

On the other hand, this is not to say that rote memorisation is never beneficial. It is likely important in many situations. When paramedics are faced with emergencies that call for split-second decisions, their rote memorisation of what to do in a situation is more ecologically valid than waiting until he/she has been able to confirm the decision via a handbook or colleague. There are moments in which an immediate answer is crucial. Though every situation for a paramedic is not a matter of life or death, this occupation itself requires he/she have a deep understanding of basic medicine for quick decisions. In a less dire situation, academic presentations evoke questions in search of an immediate answer, usually for clarity. This situation requires the presenter to search only the biological cognitive system for answers. Though a life may not be at stake, the reputation or a prospective job for the presenter may be dependent upon the presentation and the presenter's ability to provide in-depth and knowledgeable answers, providing proof of the presenter's expertise in a stated area. These examples emphasise the importance of rote memorisation, but these examples still require a deeper understanding of a larger concept. This deeper understanding is having the ability to go beyond simply answering the question and being able to provide an explanation as to *why* it is the answer. It is this deeper understanding used along with rote memorisation that differentiates an integrative cognitive system from a non-integrative system involving a student with a textbook.

So we should make a distinction between what does and does not constitute an 'integrated cognitive system' when the system includes a student and textbook. First let us look at what does not constitute such a cognitive system. We will refer to this student as the 'textbook as oracle' student. For this student, the textbook is a magic book that points directly to an answer. This student displays no evidence of ingrained learning of the concepts or topic of inquiry, but simply opens his/her book and sees an obvious answer. This type of attitude towards the textbook as a book of answers and solutions should be avoided, for it traps the student into a routine of "look up the answer and then forget it". There should be no doubt that this type of textbook relationship meets all of the criteria of the active externalism, but the student's learning of the concept is not enhanced in any way, nor is this enhancement required for answering the question. Even someone unfamiliar with the course is able to handle questions the answers of which are easily

referenced in such a manner with no time constraint. In any case, we would argue that the 'textbook oracle' student is an undesirable integrative cognitive system, one in which the student cannot think flexibly beyond what is in the resource itself (in a way, the student is simply a crude approximation of the textbook itself). What is important is not the ability to look in the textbook but knowing how and when to use the textbook. The textbook is not the end, but a means to the end.

What constitutes an integrated cognitive system with student and textbook is what we will call the 'textbook as integrated databank'. The student must understand and feel comfortable with the resource for it to become an integrated databank. The textbook is not the answer, but is used for confirmatory purposes or for extra detail in a rich, integrative way. This requires students to become familiar with the textbook, understanding the texture of the topics, the nuances of the chapters and its concepts, etc. This is what distinguishes the textbook from a magical, all-knowing oracle to an external memory resource integrated into a student's cognitive system.

A necessary step towards creating more ecologically valid online tests is moving away from questions that allow the student to use their textbook as an oracle, frantically flipping through pages trying to find an answer. We offer four important features necessary to incorporate the testing of a student-and-textbook integrated cognitive system:

- 1 First, basic question formats, such as 'definition', 'fill-in-the-blank' and 'multiple-choice' should be reduced to a minimum, or ideally eliminated, reducing the amount of rote memorisation being tested. Though this may be difficult in some situations (e.g., large class sizes) it is essential for tapping into the student's deeper learning and understanding. This also works to eliminate the 'oracle textbook', driving students to take information learned and mould it to apply it new situations beyond provided examples in the texts. Students lose the ability to simply find a sentence that easily answers a multiple-choice question.
- 2 Second, as implied by the previous feature, thought-driven application questions should predominate these tests. This would encourage students to take concepts they have learned and apply them, rather than simple recognition or recall. Yet, the textbook/integrated databank is still important here, allowing students to use it for confirming details, serving as a reminder of background studies or ideas, etc. Offloading memory in this way may free up the 'internal' cognitive processes to carry out more critical and creative practices. These question types should encourage students to incorporate their textbook/integrated databank in their answers, providing evidence that the student has become comfortable with the book and can provide the evidence that the student understands the deeper concepts and meanings, rather than shallow recognition.
- 3 Third, the application of time constraints on testing is important. Students being aware of a time constraint can force them to become as knowledgeable and studied as possible before taking the test, reducing the amount of 'oracle textbook' searching. This also can put students in position to understand and be comfortable with his/her textbook and its design, being able to move about the textbook in a quick and efficient manner not for specific answers, but for the confirmatory and detail enriching function that is ideal.

- 4 A fourth and final feature we suggest goes beyond just testing students with questions and answers. As part of evaluating students' abilities in integrating environment and artefacts with their internal cognition, instructors should also be evaluating student's abilities to create an integrative system with other students. While our first three features can be argued as intuitive and 'common sense', this fourth feature is non-intuitive, introducing an atmosphere for a natural flow of interaction amongst students and their respective integrative systems. This forum can be set up for debates and discussions amongst the students with assigned topics and no time constraints. Without the time constraints, students have the opportunity to confirm their arguments with information and citations. When working together, we are not shut off from each other or the world, but instead use each other's strengths and weaknesses in a transactive manner to develop our ideas and goals with each member contributing knowledge from his/her respective cognition as it integrates environment and artefacts. This forum-type of evaluation allows for a genuine ecological function to be displayed amongst the students in which they will develop the abilities to successfully work cohesively with others while also developing their integrative systems with their environment.

The approach that students take to learn is heavily dependent on the environment (Garrison and Cleveland-Innes, 2005). By putting students in a testing environment that encourages students to apply concepts and topics can cause students to use a deeper learning approach, searching for meaning and comprehension. Garrison and Cleveland-Innes (2005) found that the approach that students take in an online class is strongly influenced by the structure and environment of the class. It is important that the structure of the class and evaluation focus on the students' abilities to create meaning and confirm understanding of material. The implementation of our suggested features not only allows students to develop an integrative system with environment and artefacts, but also with each other. We would argue that an online forum facilitates this greatly, beyond the constraints imposed by standard classroom contexts, and through information technology that students are in need of mastering.

Others have offered a range of novel techniques with web-based classes and testing to maximise their effectiveness, including the types of questions, the frequency and format of feedback given, and the amount of interaction between student and professor and between students (see, e.g., Johnson and Aragon, 2002; Carr-Chellman and Duchastel, 2000; Tallent-Runnels et al., 2006). The ETS is a very successful and widely used online testing service. ETS is an excellent example of the usefulness of online testing, providing tests for college placement, language literacy, and writing proficiency. Though not all may agree with the nuances of a test's interpretation, the rapid growth and use of the service is clear.

## **6 The application of extended cognition**

Throughout our paper we have argued for features that may be important to enhance students' learning in online classes without detailing how these features relate to specific topics and domains. We would argue our suggested features would be especially beneficial for teaching psychology. Some have already considered distance learning and



psychological instruction, and findings are relatively mixed about how student performance relates to in-class versions (e.g., Washull, 2001), though a meta-analysis revealed that some features of online instruction can sharply influence its effectiveness, such as asynchronous designs (Bernard et al., 2004; see also Sitzmann et al., 2006; Olson and Wisher, 2002). Yet, the structure of these courses may still change in the coming years, evidenced quite simply by the accessibility of more advanced multimedia and interactive technical components, known popularly of course as Web 2.0 (Rollett et al., 2007).

Let us now consider two examples from psychology. These examples illustrate how the features we have suggested can be implemented into classes in order to boost the ecological validity. At the University of Memphis the *Thinking and Cognitive Processes* class taught by the second author is offered both online and in a lecture-style in-class setting. Both styles of the class have been set up to allow students a more interactive atmosphere compared to traditional lecture-style class. Students are given online assignments that provide opportunities for designing their own study, then using friends, classmates and family to collect data, and afterward carrying out simple data analysis – all from home on a laptop using Adobe Flash and Google Spreadsheets. This pedagogical strategy emphasises developing an integrative system among students (experimenter, participant, etc., roles). This encourages students to not only gain experience in research but also gives them a chance to display their understanding of psychological methodology and design without using simple rote memorisation on a multiple-choice test. In short, the student's home can become a real-time, hands-on laboratory, something that some cognitive textbooks have begun to market as well (Francis et al., 2003); they learn by applying the principles and empirical findings of cognitive psychology in creative yet challenging ways. They can use their textbooks and notes in any way to assist that process.

Our suggested features can also be readily applied to clinical psychology as well. Clinical psychologists do not rely solely on their internal memory and cognition, but actively seek confirmation with colleagues and relevant background literature [including the current diagnostics and statistics manual (DSM)]. In large lecture-style courses, it becomes difficult, perhaps impossible, to have small group assignments that support and promote the development of external cognition. However, in online classes (or small lecture-style classes that integrate online features) small group assignments can be easily implemented. This utilises the arguments that regard transactive memory and developing integrative relationships with classmates. A suggested assignment that would integrate these features is patient diagnosis. Students could be placed in small groups (three to four students) and given a case study to diagnose. Students gain experience in studying the DSM and interacting with others in order to critically evaluate it, rather than simply memorise it. The small group scenario encourages discussions about various psychological disorders, allowing them to develop their external cognitive systems being built to include each other and their resource material (e.g., textbook and DSM; see Meyers, 1997 for reviews on small-group activity in psychology classes).

Ashcroft et al. (2008) used a collaborative online design to teach social psychology classes. The authors collected data empirically across four years in the class and found significant gains in content knowledge. The authors used a collaborative online research and learning (CORAL) design in which students from two different universities work together on research projects. Students from one university must communicate with team

members from the other university via various technologies (i.e., internet, IM, etc.). The basis of the study was to implement social constructivism into learning and instruction. Students have the freedom to choose their own topics to learn in the class while the instructors do not assume that every student must learn the same material (Ashcroft et al., 2008; Vrasidas, 2000). The entire design of the class may be difficult to implement into all classes, but the online design for students to work together across the web provides an excellent background for the use of transactive memory and external cognition in learning technologies.

Though our examples come from psychology, all areas of study are based on critical thinking and the application of relevant methodologies. By designing classes and educational environments that foster these types of thinking and application, then we begin to better prepare students to enter into the real world, filled with the information technology in which online classes are embedded.

## 7 Conclusions

Inspired by distributed cognition, active externalism, and transactive memory, instructors can refocus online course design, including its testing and styles of evaluation, to potentially increase ecological validity – to reflect the kind of information processing and decision-making done on a daily basis with the assistance of emerging technological trends. To us this seems to be an unintuitive position, as online courses may prima facie be seen as only loose, imperfect approximations of classroom settings. But classroom settings are far less common than the contexts of engaging in cognitive activities at computer workstations in the real world, where diverse digital tools can be integrated with these activities.

If this is the case, then modern instruction may go beyond traditional passive, classroom instruction, and better tap into cognitive systems that learn by active exploration and facilitation using external artefacts (for a similar perspective on learning and environments, see Barab et al., 1999). In a digital 21st century, where information is cheap and far too voluminous, knowing where one can find vast amounts of information will be a greater commodity than having focused exclusively on memorising a fraction of it.

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