Chapter 11: Technology in Learning

Overview

E-learning ecologies point the way to the largest shift in the systems of modern education since the nineteenth century. Everything may change—configurations of space, learner-to-teacher and learner-to-learner relationships, the textual forms of knowledge to which learners are exposed, the kinds of knowledge artifacts that students create, and the way the outcomes of their learning are measured. This may be an opportunity to reach towards what we have been calling in this book, transformative or reflexive pedagogy. On the other hand, we may introduce a whole lot of technology into schools, and nothing will change in institutional or pedagogical senses. Educational technologies, in other words, can be used as a force for reform. On the other hand, they may to bring to life again and reproduce didactic pedagogy. Technology is pedagogically neutral. It can bring about change, but that is not necessarily the case.

The Roles of Technology in Learning

Technology Does Not Necessarily Change Learning

This chapter explores a phenomenon we call 'e-learning ecologies'. We use the ecology metaphor because a learning environment is in some senses like an ecosystem, consisting of the complex interaction of human, textual, discursive and architectural dynamics. These take a coherent, systemic form.

Traditional classrooms, with their linear arrangement of seating and desks, their lecturing teachers, their textbooks, their student workbooks, their classroom discussions are learning systems. They are technologies for the communication of knowledge.

Moving from one of these classrooms to the next, the modes of interaction are familiar and predictable because they are so systematically patterned. After a while, they seem 'normal.' However, these are strange human artefacts that were not put together into this configuration until the nineteenth century. They quickly became universal and compulsory sites of socialization of mass-institutionalized education. But will these institutional forms survive long into the twenty-first century? Is it time for them to be reformed? And if change is to come, what will be the role of new technologies of knowledge representation and communication in bringing about change?

This chapter explores transformations in the patterns of pedagogy that accompany e-learning, or the use of computing devices to mediate or supplement the relationships between learners and teachers, to present and assess learnable content, to provide spaces where students do their work, and to mediate peer-to-peer interactions.

So our questions of e-learning ecologies become these: how can they be different? And, why should they be different? We address these questions in this chapter by exploring three dimensions of learning:

- dimension 1: students learning with technology — or the kinds of activities in which students are involved as the use technology in learning

- dimension 2: teachers working with technology — or the kinds of curriculum designs teachers create in technology-mediated learning environments
- dimension 3: assessing learning with technology — or the way learners, teachers and education systems measure the effectiveness of student learning.

This chapter builds on research undertaken by the 'new learning' research group at the University of Illinois. The work of the group has been in part conceptual; to create an analytical framework with which to differentiate those aspects of educational technology that reproduce old pedagogical relations from those that are genuinely innovative and generative of new kinds of learning. However, our work has been in equal measure practical. We have been working in schools, from elementary to college and university, experimenting with the practicalities of new learning ecologies. A focal point of this work for our team has been a research and development program that has resulted in the creation of the *CGCGScholar* platform, supported by a series of research grants from the Institute of Educational Sciences in the US Department of Education, the Bill and Melinda Gates Foundation and the National Science Foundation (Figure 11.1).[1]

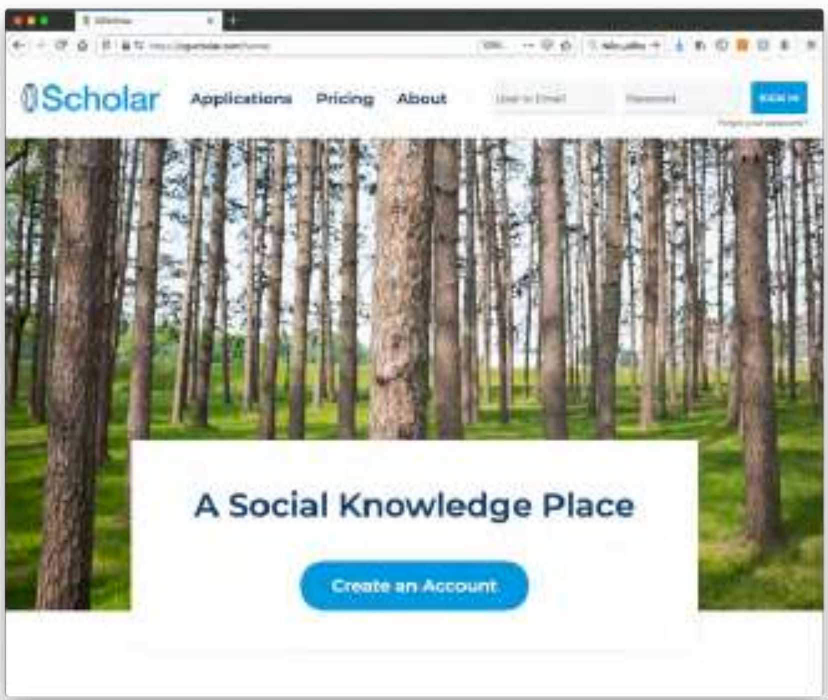


Figure 11.1: The CGScholar platform

Our focus in this chapter is what one of the inventors of modern computing, Alan Turing, called 'computing machinery', to highlight the thing-ness attributed to machines.[2] To be specific, we want to examine the ways in which and the extent to which computing machines can provide an artificial complement to the intelligence of teachers and students in the processes of pedagogy and assessment.

However, technologies can be created to serve various agendas, and then, in their application, they can be used in quite different ways, some obvious, some based our imagination of alternative uses and better human lives. Technologies do not (simply) determine the patterns of our action. They offer us affordances, or a range of different modes of action. The machines can be set to very different kinds of work. Some uses apply and intensify traditional, didactic ways of learning, teaching and assessing. Other uses—sometimes using the same foundational technologies—open out transformative modes of pedagogy, curriculum and assessment that we have in this book called 'new learning'.

Mechanising Learning

In a 1954 article published in the *Harvard Educational Review,* B.F. Skinner foreshadowed the application of 'special techniques ... designed to arrange what are called 'contingencies of reinforcement'. 'An inexpensive device,' Skinner announced '... has already been constructed'.[3] The teaching machine that Skinner designed still used analogue technologies similar to the mechanical cash registers and calculators of the time (See Figure 11.5). Some assumptions about pedagogy and assessment were written deeply into the machine. A lone child is presented material, a question is posed by the machine as substitute teacher, the student gives an answer, and then she or he is judged right or wrong. If right, she can move on; if wrong she must answer again.

The next step was to apply these principles to learning that used computers.

FIG. I. A recent model of a teaching machine for the lower grades. The machine operates on the principles described in the accompanying article. Material is presented in a window with a few letters or figures missing. The pupil moves sliders which cause letters or figures to appear. When an answer has been composed, the pupil turns a crank. If the answer was right, a new frame of material moves into the window and the sliders return to their home position. If the answer was wrong, the sliders return but the frame remains and must be completed again. (This is a later version of the device described in Skinner's 1954 paper.)

Figure 11.2: B.F. Skinner's teaching machine

A Brief History of Computer-Mediated Learning

The technologies that Turing called 'computing machines', were first applied to learning with the creation in 1959 of the PLATO (Programmed Logic for Automatic Teaching Operations) learning system at the University of Illinois. The University had been designing and testing the ILLIAC mainframe computers since 1951, and the PLATO system on ILLIAC was the first time a computer had been used for an educational application (Figure 11.3). 'Application', however, is a misnomer because the computer could not simply be applied to education. It had to be (re)designed to align with the social construction that is education. This was the first time a computer was used as a mediator in human-to-human messaging, the first time they had been used as a conduit for written language. This was the first time that visual displays were needed, so the plasma screen was invented. To represent visuals, a graphics application generator was created. Synthetic sound was created. This was where the first simulations, games, synthesized music and online chat were created (Figure 11.4).[4]

Figure 11.3: The ILLIAC mainframe computer, 1959

Figure 11.4: A PLATO workstation, 1980

The PLATO story is instructive. The ‘objects’ of the technology were constituted by social need, and education was at the centre of their initial design. The moral of the story for educators it to take the lead in technology development, and not to simply apply hand-me-down technologies.

Through the decades following, PLATO’s foundational technologies have been transferred into the everyday lives of billions of people, initially in the form of personal computers. These were subsequently connected up via the wires of the internet, and then wirelessly via a panoply of ‘smart’, mobile devices. These have changed our lives, and are changing education.

Fast forward now to the twenty-first century. If technology-mediated learning is by no means new, developments of the past half-decade stand out: deep network integration of digital learning environments through ‘cloud computing’, the generation of ‘big data’ that can be connected and analyzed across different systems, and the rise of ‘artificial intelligence’ to process that data.

Widespread Application of Computers in Education
e-Learning environments fall into two categories: new institutional sites of learning, and traditional sites of learning where computers are used to support schools. Striking new institutional forms include the rise of purely online learning and ‘virtual schools’, the phenomenon of MOOCs or Massively Open Online Courses, and ‘open education. [See newlearingonline.com: Peters on Open Education.]. Traditional sites of learning are also undergoing transformation, including blended and ubiquitous learning, extending the range of classical classroom interactions beyond the physical classroom and class times, and by one-to-one schools where every student has a portable device that they can take home.

In both new and traditional sites of learning, a range of educational technologies is applied. To a large degree, the same platforms are used in both new and traditional contexts. Following are some of the key educational technologies to emerge since the introduction of computer-mediated and online learning:

1. *Learning Management Systems.* Older systems include the commercial offering Blackboard and the open source offering, Moodle. More recent commercial systems include D2L and Canvas. MOOC platforms, principally Coursera and edX, follow essentially the same pattern. Learning management systems align with the historical genre of the syllabus, laying out content to be covered and activities to be undertaken in a sequence, often ordered by time targets and deadlines. They may include readings, pre-recorded videos, discussion areas, tasks and assessments. A new feature of these systems is the possibility of learning analytics to track learner engagement, including, not only traditional assessments and teacher gradebooks, but analyses based on incidental ‘data exhaust’ including keystroke patterns, edit histories, clickstream and navigation paths, social interaction patterns. [See newlearingonline.com: Cope and Kalantzis: Big Data Comes to School.]

2. *e-Textbooks.* Replacing print textbooks, e-textbooks may include multimedia content and quizzes.

3. *The ‘Flipped Classroom’.* Low cost, easily accessible video recording and web upload of teacher lectures.

4. *Intelligent Tutors, Games and Simulations.* These guide a learner through a body of knowledge, serving content, requesting responses, making hints, offering feedback on these responses, and designing stepwise progression through a domain depending on the nature of these responses. Underlying intelligent tutors, games and simulations are cognitive models that lay out the elements of a target domain, anticipating a range of learning paths. Intelligent tutors work best in problem domains where highly structured progressions are possible, such as algebra or chemistry. They are less applicable in areas where progression cannot readily be assembled into a linear sequence of knowledge components.

5. *Discussion Boards.* These substitute for the oral discussions of the traditional classroom, supporting various forms of conversational interaction. Patterns of peer interaction can be mapped—who is participating, with whom, to what extent. Natural language processing methods can be used to parse the content of interactions.

6. *Web workspaces and e-Portfolios.* Contemporary student workspaces differ from traditional pen-and-paper student activity in a number of key respects, including expansion of the media of knowledge representation, the ease of collaborative work, and the possibility of sharing completed work in e-portfolios. These spaces also support logistically complex, highly structured interactions such as peer review. Using a single, cloud-located source, it is possible to manage what is otherwise a difficult-to-administer process of anonymization, randomization, and simultaneous review by multiple reviewers.

7. *Adaptive, Personalized and Differentiated Instruction.* Such systems monitor differential learning progress from student to student, and adapt the path and pace of learning to the speed at which the learner is progressing. This represents a break from the logics of 'one-size-fits-all', 'everyone-on-the-same-page' of traditional classrooms, continuously calibrating learning to individual needs.

8. *Machine Assessments.* Two principal kinds of machine assessment have emerged with the use of computing in education: computer adaptive testing and natural language processing. [See newlearingonline.com: Cope et al. on Technology-Mediated Writing Assessments.] Computer adaptive testing extends longstanding item response theory, where correct student response to test items varies according to what the student knows or understands (a latent cognitive trait), and the relative difficulty of the item. Computer adaptive tests serve students progressively harder or easier questions depending on whether they answer correctly or incorrectly. Such tests provide more accurately calibrated scores for students across a broader range of capacities, reach an accurate score faster, and are harder to game because no two students end up taking quite the same test. One variant of these assessments, computer diagnostic testing, allows for the coding of topic areas within a test, and disaggregation of scores within the subdomains addressed by the test. In another major form of machine assessment, natural language processing technologies are today able to grade short answer and essay-length supply-response assessments with reliability equivalent to human graders.

None of these technologies is particularly new. Indeed, in a sense, the future of education represented by these shifts in educational media has been a long time coming.

'Big Data' in Education

First, a definition: in education, 'big data' are:

1. the *purposeful or incidental recording* of activity and interactions in digitally-mediated, network-interconnected learning environments—the volume of which

is unprecedented in large part because the datapoints are smaller and the recording is continuous;
2. the *varied types of data* that are recordable and analyzable;
3. the *accessibility and durability* of these data, with potentials to be: a) immediately available for formative assessment or adaptive instructional recalibration, and b) persistent for the purposes of developing learner profiles and longitudinal analyses; and
4. presentations of *data analytics*—syntheses based on the particular characteristics of these data, for learner and teacher feedback, institutional accountability, educational software design, learning resource development, and educational research.

In the 2000s, two new subfields in education emerged in the learning sciences: 'educational data mining' and 'learning analytics'. The principal focus of educational data mining is to determine patterns in large and noisy datasets, such as incidentally recorded data (e.g. log files, keystrokes), unstructured data (e.g., text files, discussion threads), and complex and varied, but complementary data sources (e.g., different environments, technologies and data models) [See newlearingonline.com: Baker and Siemens on Educational Data Mining and Learning Analytics.] Although there is considerable overlap between the fields, the focus of educational data mining is unstructured data in computer-mediated learning environments, whereas the focus of learning analytics is to interpret data in environments where analytics have been 'designed-in', such as intelligent tutors, adaptive quizzes/assessments, peer review and other data collection points that explicitly measure learning.

Artificial Intelligence in Education
What is 'artificial intelligence,' and how might it be applied in education?

Perhaps the most famous measure of machine intelligence is the Turing Test in which a computer and a person is each hidden behind a screen, and another person is asking them both questions via a teletype machine so the source of the answers is indistinguishable. [See newlearingonline.com: Cope and Kalantzis on The Turing Test.] If the person asking the questions cannot tell the difference between a human and a machine response to a question, then the machine may be taken to exhibit artificial intelligence.[5]

The response of language philosopher John Searle was to set up the Turing test in a hypothetical 'Chinese room.' Behind the screen is a person who knows Chinese and a computer that can give the correct answer to the meaning of the Chinese character by using look-up tables. Just because the computer's answer is correct and in this sense is indistinguishable from the competent human, does not mean that it understands Chinese.[6]

Rather than these sorts of test of mimicry and deception, we want to suggest a different definition of AI. Computers are cognitive prostheses, extensions of our human capacities to think and act, but of an entirely different order from human intelligence. They are incredibly smart because they can do things that it would not be practicable or even sensible for humans to do. These things are dumb to the extent that they are limited to memory retrieval and calculation. Data are converted to number followed programmatically by algorithmic deduction. Computers can retain large amounts of trivial data and quickly do a huge number of calculations which no human in their right mind would attempt—so in this sense only, they are smarter than humans. In other words, it is no virtue of a computer to be smart like a human. It is the computer's virtue to be smart in a way that no human ever can be, or would ever want to be.

Here's an example from our research and development work. We have developed an analytics tool in *CGScholar* that tool tracks and document student performance, 'as-you-go' and in three areas, knowledge (intellectual quality), focus (persistence), and help (collaboration). The visualization in Figure 11.5 is drawn from an analysis of the work of 87 students. Over an 8 week course the Analytics worked its way over 3.3m datapoints and offered over 14,500 pieces of meaningful, actionable machine feedback and machine-supported human feedback. This visualization was never more than a few hours old, and every student had access to a visualization of their own progress towards course objectives.

When the Analytics presents this information to the teacher, they gain insight into individual learners and the progress of the whole class that would have in the past been very hard to see. And for the learner, there is rich and detailed feedback that supports their learning as well as incremental progress data that tells them how well they are doing.

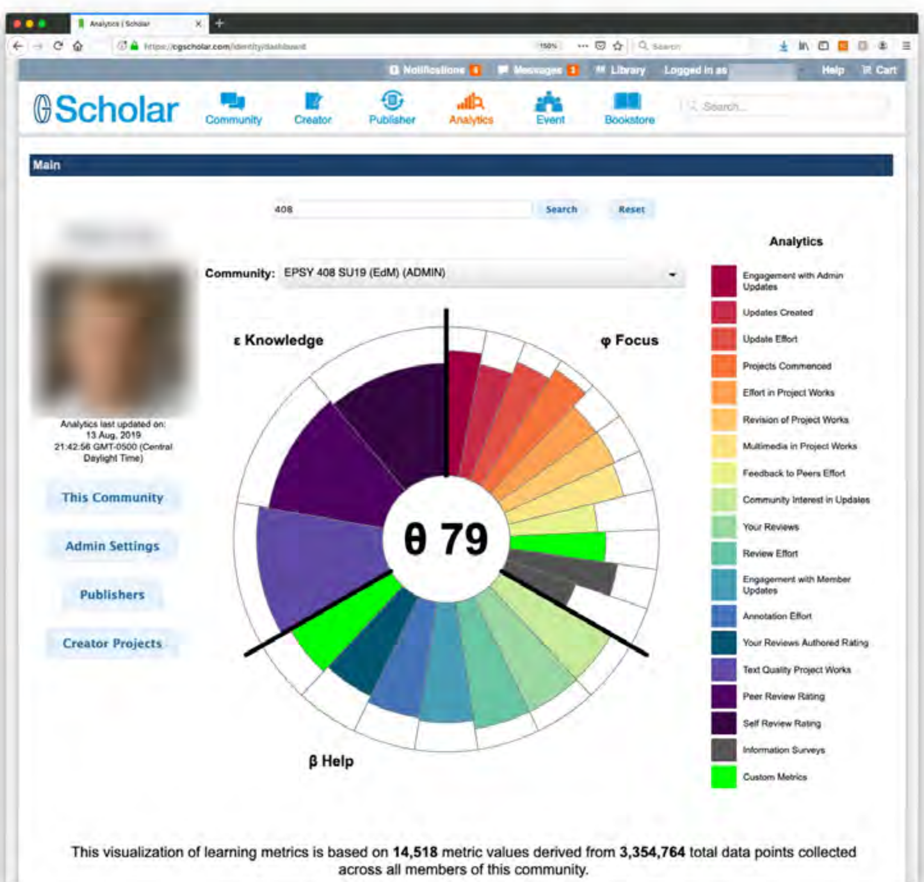


Figure 11.5: CGScholar's Analytics, whole class view. The target values and weighting of each measure is determined by the instructor in settings. Each student has the same view of their own data.

So computers do not in any helpful sense mimic human intelligence; at best they supplement human intelligence by doing things that humans never could or would or should do. Humans dig better with a shovel and a bulldozer (digging prostheses) than by hand; they form an embodied partnership with their digging prostheses. So, too, computers can serve as cognitive prostheses, extensions of our thinking whose processes are little like our thinking but that we can use to supplement our thinking.

This, then, is a broad definition of artificial intelligence—more calculation than humans could feasibly manage. There are also narrower definitions which identify artificial intelligence by its methods, assuming that as these methods of calculation develop, their results can become more human-like—machine learning, deep learning in neural nets, and quantum computing:

- *Machine Learning* uses statistical methods to make predictions based on observed patterns. In supervised machine learning, an image or text is tagged (as an instance) or classified (with a concept) using labels applied by human 'trainers.' Statistical methods are used to find the same patterns in new instances of the image or text. In unsupervised machine learning, statistical patterns are identified by the computer, and human trainers are asked to label the text or images where these patterns occur, surprisingly perhaps, or unsurprisingly.

- *Deep Learning and Neural Nets* are multilayered statistical sequences, identifying patterns in patterns. To work, they require vast amounts of data and computing power. Multiple layers of network analysis produce results that are less intuitively explicable than the single layer patterns of first order machine learning—in deep learning, in the second and subsequent layers of reasoning the machine is teaching itself by recalculating its own calculations. While the comparison with the human brain is seductive, the laborious, procedural sequencing of binary calculation is nothing like the simultaneous neurochemistry of the embodied, environment-sensing brain. It's just a machine, and just mathematics.

- *Quantum Computing* is still largely speculative, applying ideas from quantum mechanics to computing, so that the bits of 0 and 1 are replaced with qubits, where 0 and 1 are interchangeable and determinable as probabilities rather than definite numbers. Given the continued reliance on binary computers, quantum computing should be understood as an extension of the mathematics of binary computing and probabilistic statistics, though many existing machine learning algorithms are already probabilistic.

Using Technology to Replicate the Modern Past

Dimension 1: Students Learning with Technology

We opened this chapter with the provocative proposition that everything might change in education with the application of educational technologies. But also, in a pedagogical sense nothing might change. Technologies are pedagogically neutral. They can reproduce any and all of didactic, authentic, and transformative pedagogies that we outlined in Chapter 2 of this book.

Here are key features of what we call didactic pedagogy:

1. The *balance of control of a learning environment is with the teacher.* The communicative architecture is one of knowledge transmission, along the lines of Figure 11.6. The spatial architecture remains essentially unchanged, as illustrated in Figure 11.7.

2. There is a *focus on cognition,* and mostly at times, one particular aspect of cognition, *long term memory*—measurable via the artifact and ritual of closed-book, summative examination.

3. The focus is on the *individual learner* because long term memory is singularly individual.

4. There is an emphasis on a narrow range of epistemic processes by means of which a learner can *demonstrate that they can replicate disciplinary knowledge*—which in this pedagogical mode is limited to remembering facts, appropriately applying definitions, and correctly deducing answers by the application received theorems, and faithful application of the 'procedures of the discipline.' This is pedagogy of mimesis or knowledge replication.

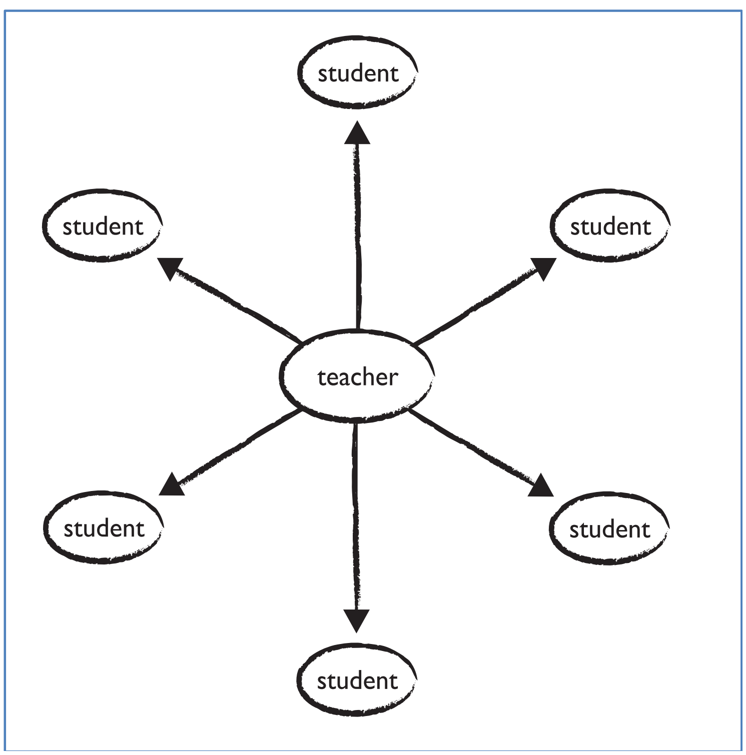


Figure 11.6: Role configurations in didactic pedagogy

Here are some relatively recent educational technologies, and the ways in which, the measures we listed above, in some fundamental respects, they return learners and teachers to didactic pedagogies.

- *The Learning Management System* reinforces a didactic role for the instructor, reviving the expository logic of the textbook as it lays out course content, section by section, delivering content such as video lectures or quasi-textbook reading materials. As the course unfolds week by week, tests of memory may provide a retrospective view of what has been learned. The focus is still individual learning, and the replication of disciplinary knowledge. Learning management systems need not be used this way—they can be used in other ways, and increasingly are. However, this is commonly the default mode of delivery.

- *The Flipped Classroom* transfers to a recording the monological, synoptic lecture genre. Of course, there are differences. The idea behind the flipped classroom is not to waste valuable in-person time, and to leave space there for interaction while learners and teachers are together. The learner also has a modicum of control not possible in a live lecture—to play the recording when it suits them, to run the lecture at double speed when the pace of spoken language is slower than the speed of thought, or to go back over bits that they did not fully understand on the first hearing. However, these differences are minor compared to the effect of preserving the lecture as a medium for the transmission of knowledge.

- *The e-Textbook* may add a little to the print textbook, such as moving images or adaptive multiple choice tests at the end of each chapter, but the basic textual form is the same as it was at the time of its invention in the century after emergence of the printing press. Just as textbooks have done for centuries, the e-textbook summarizes knowledge, lays it out in a systematic order, and speaks in the singular, authoritative, teacherly voice of the author.

- *Intelligent Tutors and Games* march students through domains that require the correct application of procedures—classically and most effectively mathematics, or the mechanics of language, or empirical science. To the extent that they are adaptive and personalized, and to the extent that they operate on small cycles of behaviorist response (stimulus-response-sanction/reward), their focus is on individualized cognition. This individualization is heightened when students can work at their own pace, separate from peers. Here the relationship of learning to learnable content is one computer to a lone mind.

- *Computer Adaptive Tests* are extensions of item-based testing (see Chapter 10). Items need to be just hard enough to be able to differentiate those students who understand what is being delivered (the concept of 'theta,' or understanding) and those who don't. But they work on the basis of a simple epistemology: that facts can only be right and wrong; that deductions can only have one correct answer; that concepts can only have one congruent meaning. In an item, there can only be one correct answer. The other alternatives are 'distractors,' designed to be plausible but wrong. There is no way of knowing whether the learner’s plausible but wrong response is based on thinking that is nevertheless insightful, or whether their correct answer was based on false premises or instinct without adequate underlying reasoning. The computational mechanisms may be more advanced, but the epistemological premises remain unchanged.

These are just some of the media by means of which didactic pedagogies may be brought back to life. The technology has changed, but this does not change the pedagogy in any fundamental way.

Figure 11.7: Computers come to the classroom, but the spatial and pedagogical architecture stays the same

Dimension 2: Teachers’ Working with Technology
Didactic pedagogies created two key aspects of teachers’ work:

1. The teacher was master of a communicative architecture located in *the same time and space*—the time of the cells in the timetable allocated to each subject, and the space enclosed by the four walls of the classroom.

2. The teacher’s communications to learners were *one-size-fits-all*—their lectures, the textbook selections they set, the activities they required students to undertake, the tests that they set. Not only does this deny learners a large measure of agency; it assumes they are all the same, or that by absorption of transmitted knowledge,

they would become the same. The didactic classroom was a pedagogical architecture of sameness and a social architecture of homogeneity.

When technology comes along, neither of these fundamentals necessarily change. Learners have to march through the syllabus at the same pace, as laid out in the learning management system. They passively watch the same 'flipped classroom' videos in the same way they would have listened to the teacher's face-to-face lectures. The print textbook has become an e-textbook, but still works on the principle that one size fits all. Intelligent tutors and games assume everyone will learn at the same time. In other words, technology reproduces the basic architectures of didactic education.

Dimension 3: Assessing Learning with Technology

With its focus on long-term memory, assessment in the regime of didactic pedagogy is individualized. Tests are designed to isolate individual memory from its past social sources and present surrounds.

Figure 11.8: Learning as individual memory, the paradigm of didactic pedagogy

Some of the more recent technologies intensify this process further. Computer adaptive and personalized learning bring continuous assessment of memory and skills into learning. Learning is thus further mechanized in a relationship between the lone learner moving forward on their learning on the basis of the test answers they give to their machine.

Didactic assessment processes, as high-tech as they may have become, still test memory, or the replicability of 'skills' in the form of non-negotiable epistemic routines. Curriculum (a time for memorizing and skill-building) is still mostly separated from assessment (a time to demonstrate memory through recall and the successful application of skills in the form of correct answers). Learning management systems and e-textbooks present content, then test in order to make cognitive inferences. Intelligent tutors lead learners through hierarchical knowledge sequences, helping them to remember these as replicable 'skills'. Even if cycles of memorization and recall are small, the two processes remain separated.

The norm-referenced, 'standardized' assessments of didactic or mimetic pedagogy position learners in a cohort in a way that presupposes inequality, and to this extent constructs inequality. For the few to succeed, the many need to be mediocre, and some must fail. This is the mathematical logic of the normal distribution curve. And some tests come to be called 'high stakes' because they really do determine life destiny; they really do manufacture inequality. The machine assessments and sophisticated psychometrics of today merely extend the human structuring of inequality through education, via processes that are now all the more effective for being more thoroughly mechanized.

Constructivism and Constructivism: More Recent Times

Dimension 1: Students Learning with Technology

There has been a long and storied response to didactic pedagogy, from the lyrical complaints of great writers and famous people who hated school, to theorists and practitioners of progressive alternatives. In Chapter 2, we referred to some of the prominent theorists and practitioners of what we called 'authentic pedagogy': Jean-Jacques Rousseau, Maria Montessori and John Dewey. More recently, critiques of didactic-mimetic pedagogies have been grouped under the term 'constructivism.'

Frequently, computer-mediated learning is characterized as, in its nature, constructivist. However, as we have just argued in the previous section of this chapter, as often as not computer-mediated learning is a reversion to didactic pedagogy. If anything, this intensifies its deficiencies as a mode of participation in knowledge. But, more than this, as a concept, the origins and meanings of constructivism are unclear, and it also fails to capture possibilities in the era of digital learning that we want to characterize as transformative or reflexive pedagogy.

Piaget is credited as the founder of constructivism (see Chapter 6). His theory of child learning is premised on a bio-developmental sequence of stages of learning, from sensorimotor or pre-language, to pre-operational language and thought, to concrete operations or logical thought and, finally, by mid-adolescence, to the formal or propositional operations embodied in abstract reasoning. Constructivist theory claims that once a learner's brain has developed to a certain stage of 'readiness,' the learner themself must build their capacities to think in the ways characteristic of that stage. This the learner does by figuring things out for themselves. They do this by actively working backwards and forwards between the mental processes of accommodation (taking on board new things as they experience them) and assimilation (making sense of new experiences in terms of what they know already). The learner's mind will only achieve a new stage of development if, when they are ready, they construct that particular understanding of the world. Learning does not come naturally. Mental capacities are no more than potentialities, which the child has to turn into cognitive reality by doing the mental work required to conduct a particular 'operation'—hence, 'constructivism.' The child constructs their own mind in conditions of bio-cognitive potential at each stage in their development.

Piaget's constructivism is:

1. centered on the individual mind of the singular child, where learning is driven by the motivated ego;

2. cognitivist, with a focus on brain and mind;

3. universalist and thus homogenizing, as if there are no differences of any significance in the processes of development between cultural, linguistic, class, gender or other social variations.[7]

4. the process of constructivism works to replicate in the learner's mind a received world; and

5. that epistemic depth is a function of biophysical stage of development, and is limited to a narrow range of schooled intelligences.

These three are the more obvious features of constructivism that we wish to take to task, and these are frequently mentioned in critiques of Piaget.

Some commentators say that Piaget's constructivism is of a cognitive variety, while there is another, complementary constructivism, of a socio-cultural variety, as enunciated by Lev Vygotsky.[8] Others maintain that constructivism is an entirely different paradigm from socioculturalism and the differences should be named as such.[9] We agree with this second view.

Vygotsky, we would argue, was not a constructivist, either in name or in the Piagetian sense. As a matter of the empirical history of ideas, although 'constructivism' was a term widely in use in the art, architecture and literature of the Soviet Union in Vygotsky's time, he did not use this concept to describe his psychology.[10] He could have, but he didn't. Nor did his contemporary followers and colleagues, principally Alexander Luria.[11]

Vygotsky also expressed his deep differences with Piaget. The deficiencies Vygotsky identified in Piaget are today the deficiencies we would identify in the concept of constructivism when applied to learning, digital or otherwise. For a reflexive pedagogy, we want to take a number of essential ideas from Vygotsky, and apply them to the emergent possibilities of digital learning. Taking the points we mentioned above:

1. Vygotsky opposed Piaget's primal egocentrism, a starting point in child development from much society imposes itself. And in Piaget, even the social is acquired through a process of individualized self-absorption. In its place, Vygotsky proposes a transition from exteriorized speech (the child speaking aloud to themselves), to the inner speech of representation (speaking silently to oneself in thought).[12]—both of which are eminently social processes indicative of different stages in the emergence of learning in the life of the child.

2. The difference between Piaget and Vygotsky, say Cole and Wertsch, is not that the former excludes the social, and the latter the individual, because both include the social and the individual in their accounts.[13] The difference, then say, is the focus on mind in Piaget in contrast to media in Vygotsky. When a child speaks their thinking aloud, it is with words acquired from the culture, in a social language that orders the world in a particular way. When they move their thinking to inner speech, they have internalized the social through a transposition of externalized speech into thought. Nor for Vygotsky are such media confined to speech. They may also include, toys, symbolizing objects, drawings, and other tools for representation. In any event, the media for meaning are all materialized, in sound, image, and objects. The inner speech or mental visualizations of thought are replays in the mind (mental representations) of experiences that have in the first instance been expressed in material media. Vygotsky on Piaget: 'the relations between a child and reality that are missed in his theory. The process of socialization appears as a direct communication of souls, which is divorced from the practical activity of a child. The acquisition of knowledge and logical forms involved are considered as products of the adjustment of one set of thoughts to another. The practical confrontation with reality plays no role in this process. …Denying the objective character of causality…, Piaget assumes the idealistic and psychologistic position'.[14] In our counterpoint to constructivism, with Vygotsky we are going to suggest that we should focus pedagogy and assessment on the material artifacts of knowledge that provide direct evidence of cognition, not that elusive thing, cognition itself.

3. In Piaget, assimilation and accommodation are essentially linear processes of internalization. To be sure, internalization positions the learner as an agent in the internalization process, but this essentially imposes the task of replication of social meaning on them. Social imposition is self-imposition. This remains a pedagogy of linearity (social meanings transmitted to the accommodating individual) and replication (social meanings that the individual dutifully assimilates). This is as far as constructivism goes. In our reflexive pedagogy, we are going to propose a process of recursive co-design.

4. In his constructivism, Piaget speaks to the universal stages of development, as if learner differences were incidental or irrelevant. The effect is to create pedagogical architectures of sameness, as if every learner will follow the same path. This represent a failure to recruit identities for learners whose lifeworlds do not neatly coincide with the culture of institutionalized schooling—to learn, you need to feel you belong in the learning, and some kinds of learners feel they belong in the game of standardized institutional learning more than others. It also represents a failure to harness learner differences as a productive resource for learning. We call the epistemological alternative 'productive diversity.' Vygotsky and Luria, on the other hand, speak to the historical, social and cultural specificity of different forms of thought, of which schooled thought is just one peculiar example.[15]

5. Assimilation is a kind of absorption of conceptual processes, being able to re-enact successfully by oneself procedures that have been demonstrated. A learner can reach the right answer, on their own. This is not what we will call epistemic depth. Vygotsky traces the intricate dynamics of movement from aggregative, associative 'complex' thinking to conceptual thinking. [See newlearingonline.com: Cope and Kalantzis on Vygotsky's Conceptual Thinking.] Conceptual thinking involves the development of transferable meaning schemas—disciplinary practices, epistemological frames and ontologies. We have called these 'knowledge processes' (Chapter 1).

6. There is nothing to disagree with constructivism's critique of didactic pedagogy. However, from the perspective of what we call a reflexive pedagogy, in some respects constructivism does not go far enough. In other respects, it introduces new problems. Critics have seized on the limitations of constructivism, sometimes with justification, though oftentimes as a plea to go 'back to the basics' of didactic pedagogy. While agreeing with the truism that learning must be an active process, Anderson, Reder and Simon say that self-construction of knowledge, reinventing the proverbial wheel, can be slow and painful: 'it may be costly in time, and when the search is lengthy or unsuccessful, motivation commonly flags.' In a subject such as mathematics, instruction in theory can often be more effective than self-discovery of mathematical principles.[16] Kirshner, Sweller and Clark analyze the root causes of what they contend to be 'the failure of constructivist, problem-based, experiential and inquiry-based teaching.' One of these is the failure to present to learners 'necessary schemata that allow them to meaningfully and efficiently interpret information and identify the problem structure. Schemata accomplish this by guiding the selection of relevant information and the screening out of irrelevant information.'[17](Kirschner, Sweller and Clark 2006: 83)

Dimension 2: Teachers' Working with Technology

'Connectivism' is a concept created by George Siemens and Stephen Downes as the focus of the first-ever MOOC (Massively Open Online Course). Its point of reference is a critique of constructivism: 'A central tenet of most learning theories is that learning occurs inside a person. Even social constructivist views, which hold that learning is a socially enacted process, promotes the principality of the individual (and her/his physical presence – i.e. brain-based) in learning. These theories do not address learning that occurs outside of people (i.e. learning that is stored and manipulated by technology).' As an alternative to the individual, Siemens proposes the network as the basis for a theory of learning in the digital age: 'A network can simply be defined as connections between entities. Computer networks, power grids, and social networks all function on the simple principle that people, groups, systems, nodes, entities can be connected to create an integrated whole.'[18] [See newlearingonline.com: George Siemens on Connectivism.]

Stephen Downes says that connectivism is formed of 'the connections between the individual members of society, resident in no single one of them, but rather a property of the society working as a whole.' It encompasses a wide range of points of view. Individual contributors are autonomous, with 'the individual knowers contributing to the interaction of their own accord, according to their own knowledge, values and decisions.' It is interactive. And it is open, where new perspectives can be registered.[19]

It is hard to disapprove of the principles of social learning represented by connectivism. However, they apply with greater validity to informal, incidental social learning than to a domain that we might, for its distinctive characteristics, call 'education.' Missing from connectivism is an analysis of what we would call 'pedagogical scaffolds.' These remain the domain of the learning designer, learning coordinator, and learning evaluator—the teacher, in other words, in a relationship of co-design with learning spaces (classrooms and learning management systems), and disciplinary content sources. Education cannot just happen the spontaneous association of learners. In contrast to informal learning, education is learning by design.

Dimension 3: Assessing Learning with Technology
Computer-mediated learning does bring about change that might be characterized at times as constructivist or connectivist, but in each case with the limitations intrinsic to each. In the area of assessment, computer adaptive tests cater to learner differences more effectively than pen-and-paper tests, but the still assume straightforwardly right and wrong factual or procedural answers. Games and intelligent tutors can trace the learning paths of the active, agentive learner, but still along the same path. The only differentiation may be the pace at which the learners proceed. In other words, there are some incremental changes in the processes of assessment characteristic of classical didactic pedagogies, but these remain limited.

Reflexive Pedagogy: New Learning

Dimension 1: Students Learning with Technology
What is potentially new and transformative about e-learning ecologies? We have two 'nothing' answers to this question. The first 'nothing' we've just addressed—educational technologies can be used as a medium for didactic pedagogy. And for some domains, and in some instances this may not be a bad thing, for instance where repetition and memory is still important—to learn a new language, or to get better at arithmetic.

Our second 'nothing' answer is that educational technologies at their best can do little more than to realize long held aspirations for education, traceable from Rousseau to Dewey, Montessori, Tagore and many of the other thinkers and practitioners to whom we have referred in this book. If they make a difference, it is just to make these aspirations more achievable in practice.

However, we also want to offer an 'everything' answer to our question of how things might change. Educational technologies could support the most fundamental change in ecologies of learning since the invention of the modern school and its mass-institutionalization in the nineteenth century. A pedagogical paradigm change is possible—a change from didactic to reflexive pedagogy.

To make a prediction of 'everything' is not to make a promise, because who knows? We could easily slip back into a world where didactic pedagogy rules again. To try for 'everything' is to set an agenda for educational transformation. It is to make a promise to ourselves as educators. We want to propose that reflexive pedagogy, enabled by an emerging wave of educational technologies, can create e-learning ecologies that will be more engaging for learners, more effective, more resource efficient, and more equitable in the context of learner diversity.

Beyond constructivism and connectivism, we characterize transformative or reflexive pedagogy as follows:

1. There is a shift in the balance of agency between an instructor and a learner, where *the learner has considerable scope and responsibility for epistemic action*, albeit within the frame of reference of an activity sequence that has been scaffolded by the instructor. Knowledge activity is dialogical, with backwards and forwards movement between instructor and students, and students and students—see Figure 11.9. The sources of knowledge are not monological (the artificially singular, synoptic voice of the lecturer or textbook writer). Rather, they are multiple—the great variety of authentic and problematically varied knowledge sources now immediately accessible in the universal library that is the internet, and beyond that, the lived experience of learners.

2. The focus is on *the artifacts and knowledge representations constructed by the learner and the processes of their construction*. In an age where knowledge is always accessible via personal digital devices, long term memory is not so important. Long term memory will develop, but that will be an incidental and inessential consequence of deep engagement in a discipline. There is no longer a need to emphasize long term memory in pedagogy. For, if a fact cannot for the moment be remembered, it is always possible to look it up in an instant. If a procedure cannot be remembered, there is an app that will execute that procedure—a calculation, series of directions, a data mashup. The objectives of learning are different in an age where we have these ubiquitous devices, these cognitive prostheses. The measurable object of learning now shifts from long term memory to knowledge processes and their documentation in the form of epistemic artifacts or knowledge representations—the report, the worked solution, the recorded activity, the model, the design. This, in other words, involves a shift in emphasis from cognition to epistemic artifacts, a phenomenon that we call 'ergative' or work-focused pedagogy.

3. The focus is on *the social sources of knowledge.* Knowledge is not a matter of what I know as an individual. It is my capacity to navigate the wide epistemic world at my fingertips; it is my ability to discern critically what is salient and what is not; it is commitment to acknowledge the social provenance of my knowledge by means such as citations and links; it is my ability to work with others to create collaborative knowledge where the sum of the knowable is greater than the individual contributions of colleagues in-the-knowing; it is my capacity for synthesis; and it is my ability to extend creatively socially acquired knowledge.

4. By now, we will have brought to education *a wider range of epistemic processes*. In a reflexive pedagogy, we don't need to abandon evidence in the form of facts,

conceptual clarity with finely calibrated definitions, or deductions grounded in theorems. However, these always sit within a wider epistemic frame of reference, where evidence is contextualized by argument to justify the supportability of a claim, where non-trivial claims are always provisional and open to rebuttal, and where in our disciplinary practice knowledge is dynamic and evolving.

In these senses, the pedagogy we are describing here is reflexive, by way of contrast with didactic pedagogy, which is essentially mimetic.

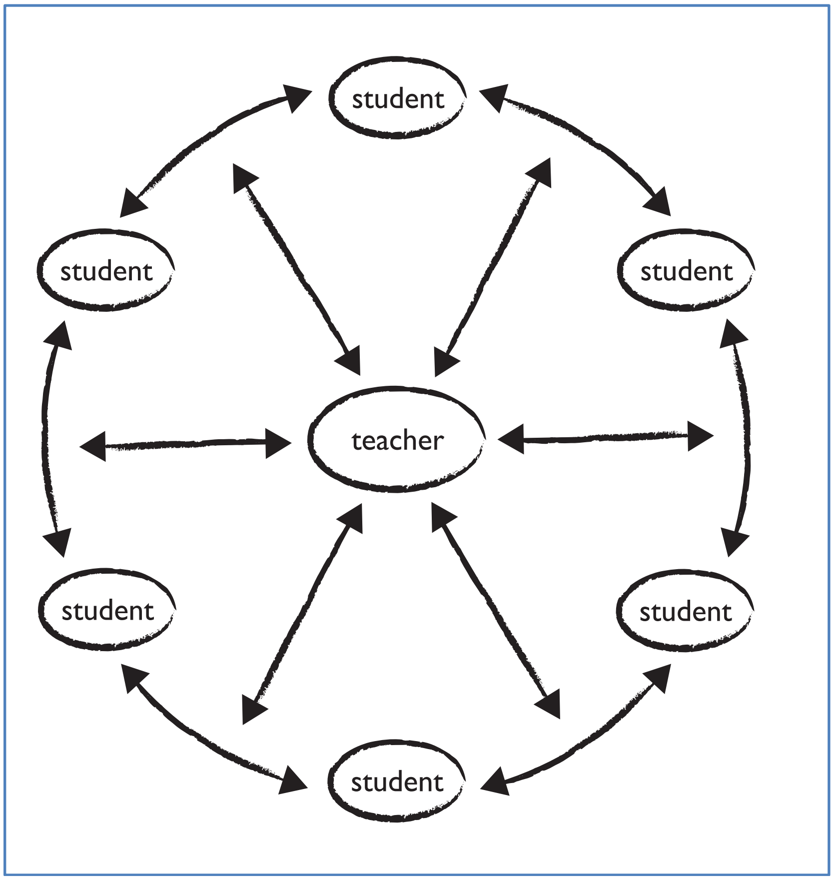


Figure 11.9: Role configurations in reflexive pedagogy

In this section of chapter, we are going to explore seven new learning affordances opened up by new media: ubiquitous learning, active knowledge production, multimodal knowledge representations, recursive feedback, collaborative intelligence, metacognitive reflection and differentiated learning. None of these aspirations is new — many in fact, are in spirit as old as the progressive or authentic pedagogy of Rousseau, Montessori and Dewey. However, computers and digital media facilitate an economy of effort that makes these ideals more pragmatically realizable than in the past. Not that the technology itself is intrinsically a catalyst for educational change. To reiterate, the very same technologies that offer these practical openings for educational transformation, can also be used to breathe new life into the most didactic of pedagogies, even intensifying the legacy processes of transmission of content, stimulus-response learning behavior modification, and rigid standardized testing. For this reason, we want to explore some of the ways in which new media can bring new learning to practical realization.

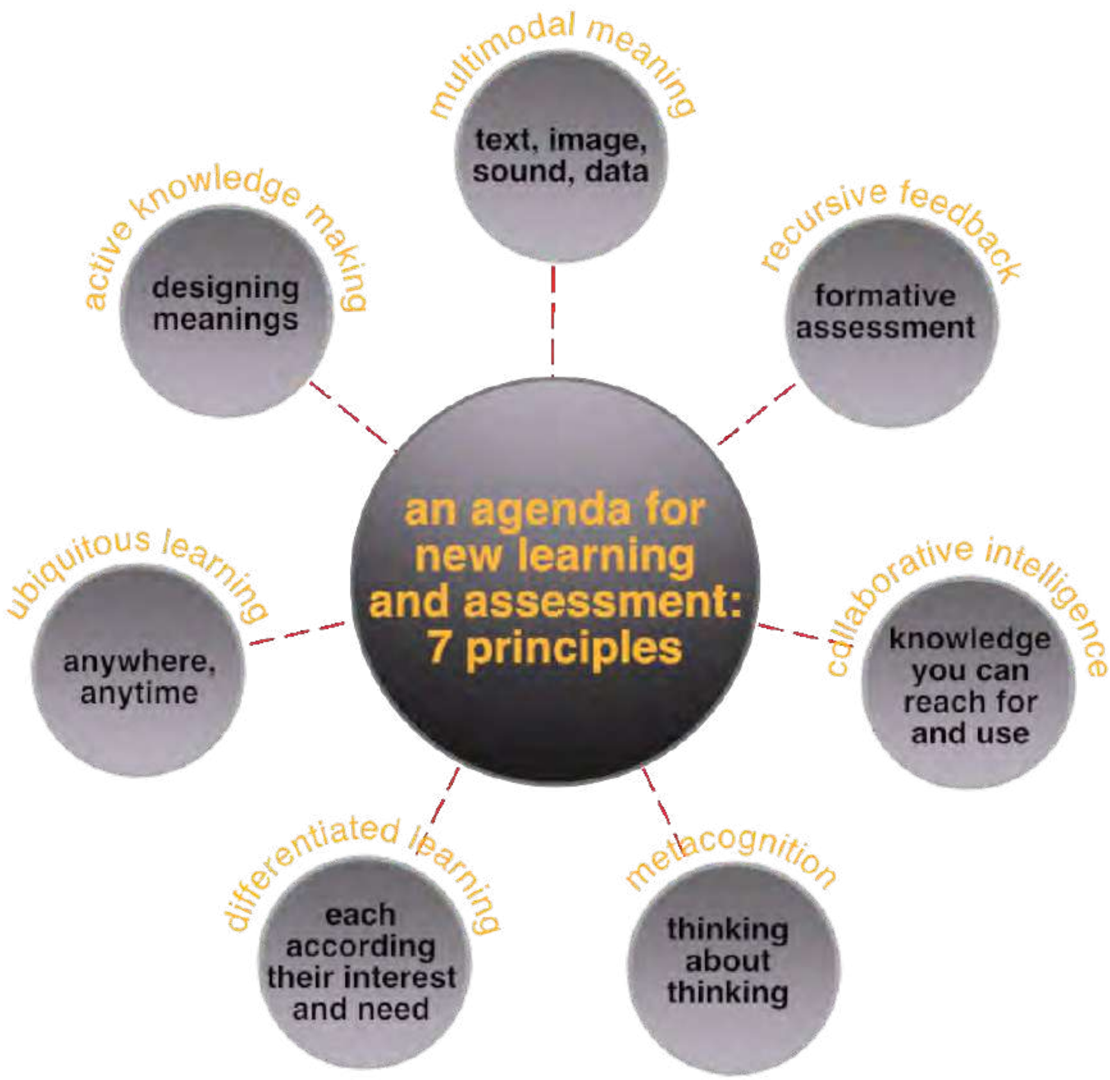


Figure 11.10: Seven new learning affordances

Following is a summary of these affordances:

	Didactic Pedagogy	*Reflexive Pedagogy*
Spatio-Temporal Dimension	Confined by the four walls of the classroom and cells of the timetable	Ubiquitous Learning: anywhere, anytime, anyhow
Epistemic Dimension	The learner as knowledge consumer, passive knowledge acquisition, memorization	Active Knowledge Making: the learner-as-knowledge producer and discerning knowledge discoverer/navigator
Discursive Dimension	Academic literacies: traditional textbooks, student assignments and tests	Multimodal Meaning: new media texts, multimodal knowledge representations
Evaluative Dimension	Emphasis on summative assessments and retrospective judgments that serve managerial purposes but are not immediately actionable	Recursive Feedback: formative assessment, prospective and constructive feedback, learning analytics
Social Dimension	The isolated learner, with a focus on individual cognition and memory	Collaborative Intelligence: peer-to-peer learning, sourcing social memory and using available knowledge tools appropriately
Cognitive Dimension	Focus on facts to be remembered, theories to be correctly applied	Metacognition: thinking about thinking, critical self-reflection on knowledge processes and disciplinary practices
Comparative Dimension	Homogenizing, one-size-fits-all curriculum, standardized teaching and assessment	Differentiated Learning: flexible, self-expressive and adaptive learning, addressing each student according to their interests, self-identity and needs

The case we are making in this chapter is that, although they offer important correctives to didactic-mimetic pedagogy, constructivism and connectivism do not in themselves adequately prepare learners in the digital era. We are positing that 'reflexive pedagogy' qualifies and extends constructivism and connectivism, while recovering some elements of didactic pedagogy for a balanced repertoire of pedagogical practices. In doing so it better reflects the expectations place up the digital learner and supports their needs. These are also the expectations of education in our times.

In the remaining sections of this chapter, we will address each of these affordances with examples and analyses.

New Learning Affordance: Active Knowledge Making

e-Textbooks mostly reproduce the relationships of knowledge and learning that accompanied the invention of the print textbook in the sixteenth century. Characteristically, learners are placed in a relatively passive relation to knowledge, which has been simplified, summarized, and ordered for them in the monological voice of the textbook writer. In the end, there is a test to see what the student has retained in long term memory. Students are configured as knowledge consumers more than they are knowledge producers. The moral of their learning is that they should comply with epistemic authority.

How could things be different in e-learning ecologies? The key is a pedagogical process we call ‘active knowledge making.’ We want to allow learners more scope for agency in their learning. Here we want to suggest a recalibration of the balance of agency. It’s not that students completely lacked agency in the didactic classroom—listening attentively involves a certain level of agency. Reading the textbook and making some sense of it involves agency. On the other hand, learning activities without scaffolds can lack focus, to the point of becoming chaotic. So the agency of learners needs to be within a framework of optimally generative constraint. The art of effective pedagogy is to calibrate just the right balance of open-ness and structure.

We are going to illustrate the points we are making here using examples from our *CGScholar* research and development project, we have designed and trialed as an alternative to the e-textbook, an artifact that we call a ‘Learning Module.’ The Learning Module is a hybrid of syllabus, lesson plan, and textbook. It is all of these things and none of them.

To describe the design, a Learning Module has a two column format: a ‘for the member’ side where the teacher speaks directly to the student, and a ‘for the admin’ side where the teacher speaks the professional discourse of education, articulating learning aims, curriculum standards and teaching tips (see Figure 11.12). The Learning Module offers three modes of interaction with and between students:

1. *Updates* that can be pushed into the student’s activity stream, including a wide range of multimedia formats. Each update prompts comments from students and class discussion. If the teacher selects the ‘unrestricted’ setting, students can also be asked to make updates that initiate discussions.

2. *Projects,* including a prompt and a rubric for peer, self and/or teacher review.

3. *Surveys,* including knowledge surveys that anticipate right and wrong answers, and information surveys that do not have right or wrong answers (such as an opinion survey).

Fig. 11.11: Learning Modules in the 'Bookstore' area of CGScholar

Fig. 11.12: The two-column format of the Learning Module

Here are the differences: whereas a textbook summarizes the world, transmitting content to learners in the single voice of the textbook writer, the Learning Module curates the world—web links to textual content, videos and other embedded media. It is multimodal. And it uses a variety of sources, requiring students to critically evaluate sources, not just to memorize content that has been delivered to them to consume. It suggests that learners may also find and curate content. Whereas a syllabus outlines content and topics to be covered, a Learning Module prompts dialogue—an update prompts class discussion; commencing a project sets in train the process of drafting, peer reviewing, revising, self- and/or teacher reviewing, and publishing a work; a survey elicits a student response. It is a medium to facilitate active and collaborative learning, rather than individualized content acquisition. And whereas a lesson plan is the teacher's private activity outline, the Learning Module can be shared with the class, and optionally published to the web, for other teachers to use within a school or beyond, thus to build a school-based pedagogical knowledge bank. For professional collaboration and learning, a Learning Module can be jointly written and peer reviewed before publication.

The underlying shift in textual architecture from a textbook to a Learning Module reflects a shift in the assumed role of the learner, a recalibration of the balance of learner and teacher agency. Moving away from the content transmission model of the textbook, the Learning Module sets up a series of reflexive, dialogical relationships with and between learners—the comments they make on an update, the peer- and self-reviews, the responses to surveys. This is a move from telling to dialogue, in which every learner must participate. The Learning Module also places responsibility on learners to be knowledge producers: when they make an update to initiate a discussion; when they create a 'work' for peer review; and when these works are published and shared in a class knowledge bank. In a sense, instead of reading the textbook, the students have been placed by the Learning Module in a position where there are now in effect writing the textbook. This represents a change in direction of knowledge flows, from hierarchical, top-down knowledge flows to lateral knowledge flows and distributed model of learners as co-creators or designers of new knowledge. This aligns with the logic of contemporary, participatory media and the skills and sensibilities for a 'knowledge society' and 'knowledge economy' (Chapters 3 and 4).

However, the process is highly scaffolded, in the design of open-ended updates, the nature of the requests that students receive to create updates, the project prompts and review rubrics, and the survey instruments. This changes in a quite fundamental way the nature of the teaching profession, from a talking profession (someone else has written the textbook), to a profession where the central medium of interaction with learners is a documented, web-deliverable, interactive learning design.

New Learning Affordance: Collaborative Intelligence

Traditionally, schooling has been based on the idea of individual intelligence, where intelligence itself is narrowly conceived as personal memory and the procedural skills of deduction. The human mind, however, is intrinsically social. Our cognitive capacities reside in the language we have inherited and the ways of seeing we have learned. Intelligence is our capacity to reach for always-available social memory and to apply available logics and computational tools. It is what we can do together in communities of practice.

Today, through ubiquitous computing and the social web, externalized memory and computational tools are accessible that have historically unprecedented power. At the same time, work, public and community life is more manifestly energized by collaborations. In the new media, peer-to-peer collaborations, from Wikipedia to YouTube, are the product of massive social collaborations. So much for the culture of closed book examinations or isolated, individualized student work. The new media have made these ideas and practices anachronistic.

In the era of digital media, learners assemble their knowledge representations in the form of rich, multimodal sources — text, image, diagram, table, audio, video, hyperlink, infographic, and manipulable data with visualizations. These are manifestly the product of distributed cognition, where traces of the knowledge production process are as important as the products themselves — the sources used, peer feedback during the making, and collaboratively created works. These offer evidence of the quality of disciplinary practice, the fruits of collaboration, capacities to discover secondary knowledge sources, and create primary knowledge from observations and through manipulations. The artifact is identifiable, assessable, measurable. Its provenance is verifiable. Every step in the process of its construction can be traced. The tools of measurement of artifacts are also expanded — natural language processing, time-on-task, peer- and self-review, peer annotations, edit histories, navigation paths through sources. In these ways, the range of collectable data surrounding the knowledge work is hugely expanded.

Our evidentiary focus may also now change. We no longer need to seek elusive forms of evidence such as the traditional constructs such as the 'theta' of latent cognitive traits in item response theory, or the 'g' of intelligence in IQ tests. In the era of digital we don't need to be so conjectural in our evidentiary argument. We don't need to look for anything latent when we have captured so much evidence in readily analyzable form about the concrete product of knowledge work, as well as a record of all the steps undertaken in the creation of that product.

We also need to know more than individualized, 'mentalist' constructs can ever tell us.[20] We need to know about the social sources of knowledge, manifest in quotations, paraphrases, remixes, links, citations, and other such references. These things don't need to be remembered now that we live in a world of always-accessible information; they only need to be aptly used. We also need to know about collaborative intelligence where the knowledge of a working group is greater than the sum of its individual members. We now have analyzable records of social knowledge work, recognizing and crediting for instance the peer feedback that made a knowledge construct so much stronger, or tracking the differential contributions of participants in a jointly created work.

Over the course of this analysis of reflexive pedagogy, we have been moving away from a focus individual cognition, to a notion of collaborative intelligence. Jim Gee calls this notion the 'social mind'.[21] Carl Bereiter calls it 'distributed cognition'.[22] Perhaps the notion of the individual mind was ever only and at least in part an ideological illusion created by didactic pedagogy and its assessment systems. In e-learning ecologies, it becomes more necessary to recognize the social sources of intelligence. We can also actively nurture the social mind in these environments—hence a renewed focus on collaborative intelligence. There are two fundamental aspects of this new recognition of the sociability of knowledge: a shift away from knowledge memorization towards a culture of knowledge sourcing; and developing skills and strategies for knowledge collaboration and social learning.

Today, we have remarkable, world-connected cognitive prostheses at our fingertips, carrying them in our bags or keeping in our pockets. There is no fact that cannot be looked up, no calculation that cannot be made using computational and data access tools in the myriad of 'apps.' Memory may come as an ancillary part of learning and knowledge work, but it need no longer be the central pedagogical concern that it once was. If in everyday life, we have ubiquitous access to these cognitive prostheses, then assessments and pedagogies that deny us these lack 'validity,' to apply a key term from assessment theory. So, replacing the fiction that memory is my personal knowledge, learners must increasingly acknowledge the social sources of their learning, via citations and links, distinguishing clearly their own thoughts from the social knowledge upon which those thoughts are built. This is mnemonic work rather than memory work.

Another key aspect of collaborative intelligence is to structure learning systematically around peer collaborations. Here's a scenario from didactic/mimetic pedagogy: listen to the teacher's lecture about a great person, read the textbook about the great person, write an essay about that person, then get a grade from the teacher perhaps also with a short, judgmental comment. Now, by contrast, to a *CGScholar* scenario. Students choose a person they consider heroic, because the exercise is to write a biography, rather than accept the teacher's or the textbook writer's judgment about who is great (Figure 11.13).

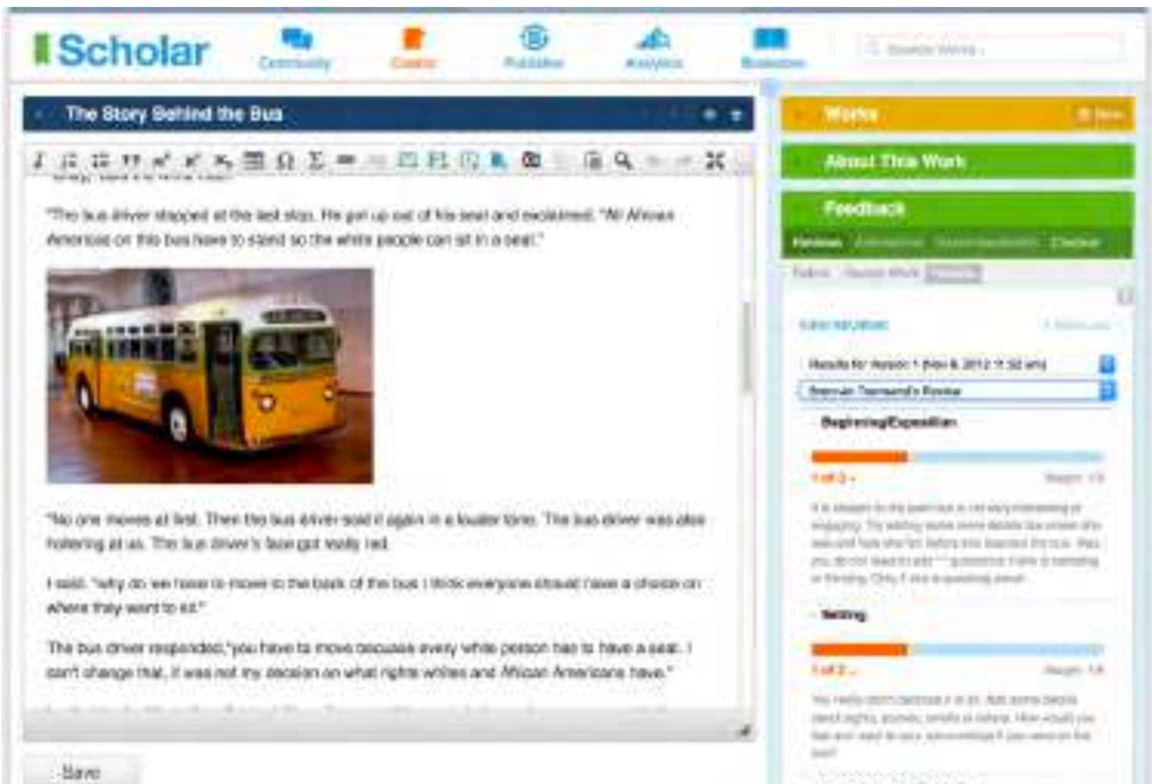


Figure 11.13: Writing biography in CGScholar's 'Creator' space.

By giving students a capacity to choose within a general (and higher level) expectation about biographical writing, students are positioned more strongly as knowledge producers. With this broadened scope for agency, comes expanded open-ness to the expression of identity and diversity—each student choses a subject and that choice expresses a certain kind of affinity, someone who inspires them. Students see the assessment rubric as they write, outlining the components of powerful informational texts in general, and biography in particular. They research multiple web sources, critically evaluating these sources. They submit drafts, then peer-review against these same criteria others' biographies. These biographies are likely of people outside their own field of vision or cultural orbit. In close reading for review, they may learn a great deal about different empirical people. As outsiders they might also be able to ask the author to elaborate on things not obvious to the writer. They might reflect on aspects of biography that they could have neglected in their own work. The might review, say, 2 or 3 other texts, then get back reviews on their own texts from 2 or 3 other people. Here we have a complex dialogical process in which the insights arise as powerfully from different subject matter and perspectives as from the common, high level criteria around the textual forms of biography.

This process is reflexive: to draft against a rubric, to review others' different texts against the same rubric, to reflect on feedback from others, and perhaps also to do a self-review accounting for the impact of feedback on their text prior to publication to a shared web portfolio. The process is also inclusive, where the richness of the review and feedback experience is in the differences in subject matter and the differences in reviewer perspectives. [See newlearingonline.com: When You Take These Walls Down.]

Figure 11.14a: Collaborative knowledge work: the 'new learning' classroom

Figure 11.14b: Collaborative knowledge work: the 'new learning' classroom


Figure 11.14c: Collaborative knowledge work: the 'new learning' classroom

New Learning Affordance: Metacognition

Metacognition is second order thinking. It is thinking about thinking. Research shows that metacognitive awareness improves learner performance.[23] Metacognition can have several meanings. In one it is psychological: 'self-regulation,' or to undertake an educational endeavor with self-conscious intent, to focus and to achieve goals. A broader definition includes thinking that exemplifies disciplinary practice—to think like a historian, writer or physicist. This requires explicit thinking about the methods of the discipline, for instance how claims are supported by evidence in history, or how persuasion works in writing, or to explain mathematical thinking. It also involves theoretical work where the learner not only immerses themselves in content, the facts of a topic, but is able to relate these facts to overall explanatory frameworks, applying facts to frameworks and testing frameworks against facts.

Here we are in *CGScholar* again (Figure 11.15). These students are working on the physics of drag on a cricket ball.

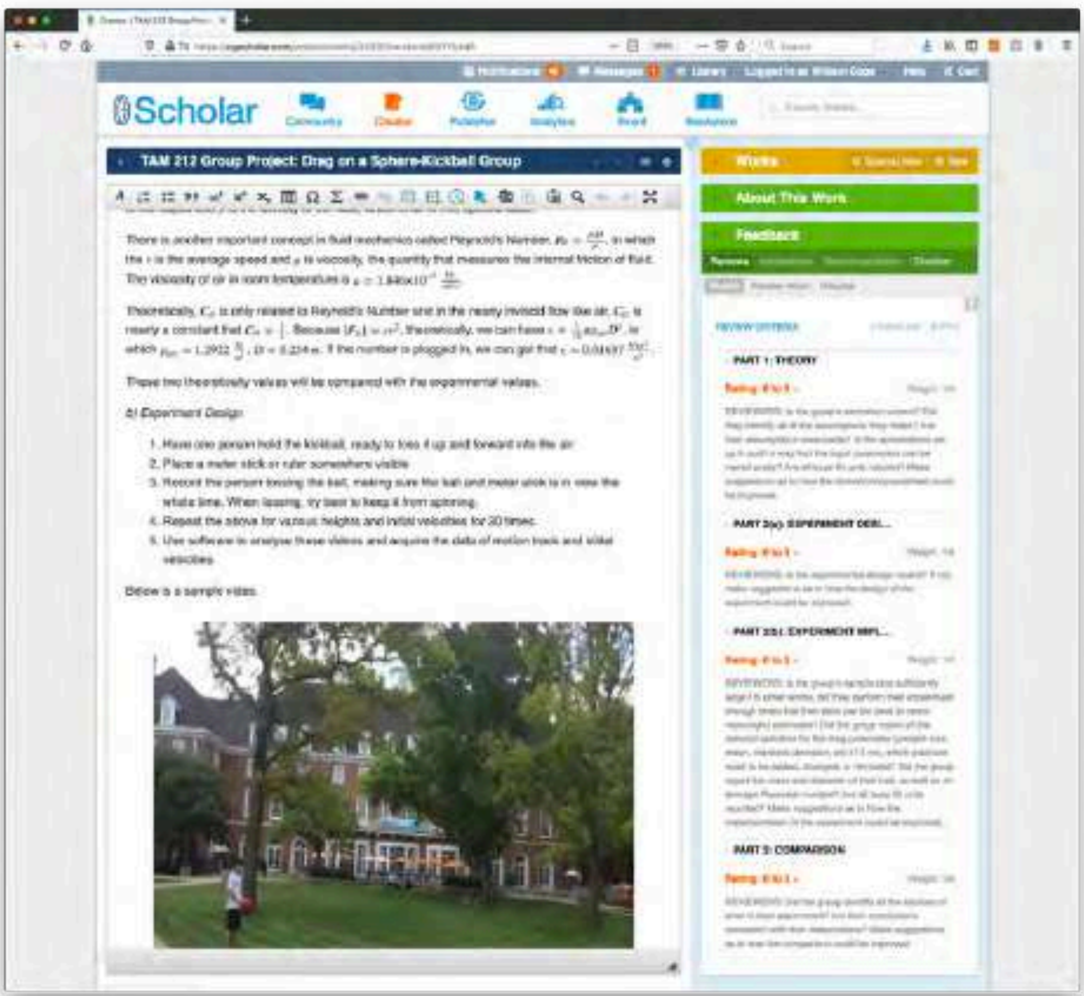


Figure 11.15: Cognition on the left; rubric prompting metacognition on the right

Fig. 11.16: Peer review

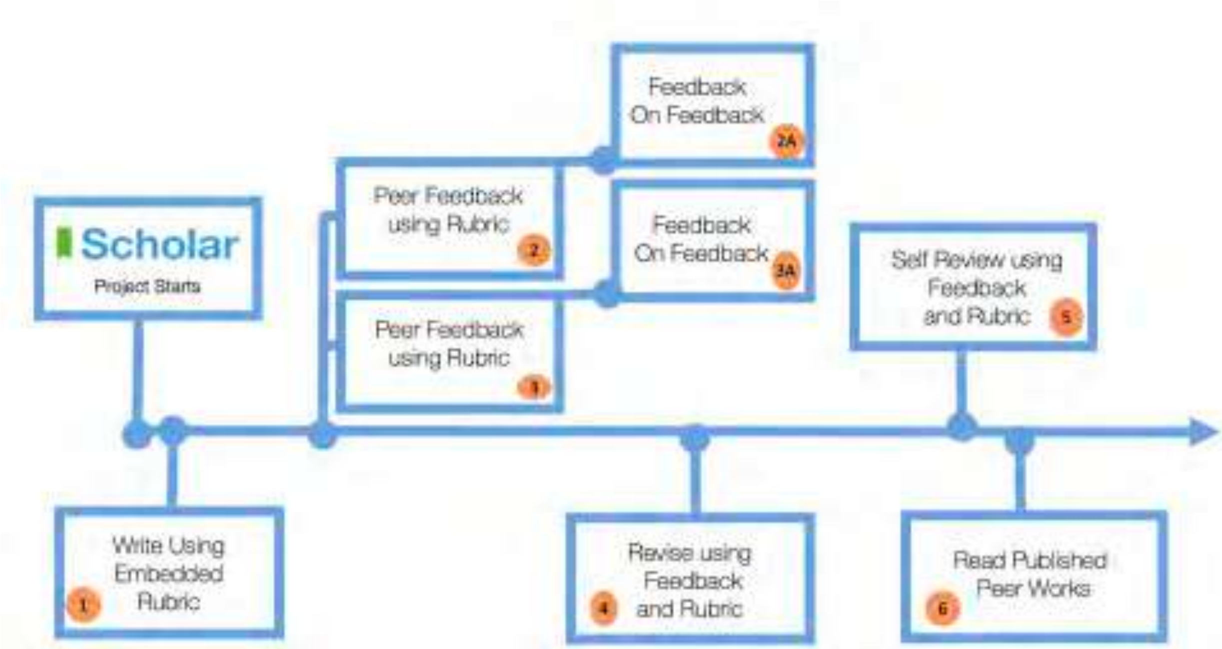


Figure 11.17: The knowledge process, a play between cognition and metacognition

CGScholar's Creator space has a temporal structure, consisting of a number of phases (Figure 11.17). It also has a spatial structure, designed to support metacognition. The student (or students, in the case of jointly created works) does their work in the multimodal editor on the left. Aspects of metacognition are juxtaposed on the right: a rubric, peer reviews, coded annotations, a natural language processor, dialogue with contributors. In every phase there is a dialectic between cognition on the left and metacognition on the right:

1. While the student creates their work on the left, they see the rubric on right, created by the teacher or Learning Module designer, specifying disciplinary expectations at a high level of generality.

2. They read their peers' works and review them on the right—the number of reviews having been determined by the teacher/admin, anonymous or named as determined by settings. They may also annotate these works.

3. Feedback is returned, viewable on the right, and the juxtaposed text on the left is revised based on feedback from multiple perspectives, and against the same rubric that they have already used intensively in phases 1 and 2.

4. In a self-review on the right, criterion by criterion and against the same rubric, students reflect on the influence of peer feedback on their work, and the changes they have made from version to version, viewable on the left.

5. Finally, the revised work is published to an e-portfolio by the teacher/admin, where further dialogue around the work may occur. The teacher/admin may also review the work at this stage, and request revisions before publication.

In every phase of this process, there is a play between the left and right sides of the screen as follows:

<u>Cognition:</u> Left Side of the CGScholar Screen	*<u>Metacognition:</u> Right Side of the CGScholar Screen*
<u>Learning Activity</u>: a focus on representation of specific content knowledge	<u>Self-regulation of Learning</u>: project objectives, phase outline; ongoing dialogue around processes
<u>Disciplinary Practice</u>: thinking about a specific topic, its facts and arguments	<u>Disciplinary Thinking</u>: a focus on the general conditions of insightful work in this discipline; epistemological reflection
<u>Empirical Work</u>: outlining specific content, applying disciplinary reasoning to that content	<u>Theoretical Work</u>: thinking based on the general theoretical precepts of the discipline; a play/dialogue between the particular (thinking about specific details of knowledge), and the general (thinking about conceptual concepts and frameworks that tie this knowledge together).
<u>Individual Intelligence</u>: the activity of representing knowledge (including contribution to jointly created works)	<u>Collaborative Intelligence</u>: structured feedback; productive diversity in learning from varied perspectives
<u>Learning</u>: the knowledge representation made by the student	<u>Assessment:</u> formative assessments by peers, teachers and self; retrospective data analytics

New Learning Affordance: Multimodal Meaning

Contemporary digital media are multimodal—where text, image, sound are all manufactured of the same raw material: binary encoding. In the era of analogue information and communication technologies (letterpress print, lithography, photography, sound recording, cinema, radio, telephone), media for the production, reproduction and distribution of knowledge and culture were relatively separate. In the digital era, they are now made of the same stuff and distributed through the shared infrastructure of the internet. With this transition, we have seen the rise of new, multimodal genres where text, image, sound and data are inseparable: the social media feed, the website, the app, the infographic, the data visualization. Elsewhere, we have called this phenomenon 'Multiliteracies'.[24] As it happens, the web still tends to separate the media into spaces that have a specialist focus on audio, video or text. But this need not be the case, and often it is not the case.

The grounding for this multimodality is practical, material, tangible, a product of industrial design even before reaching the consumer. Then once in the consumer's hands, meaning is a matter of manufacture. These modes are all made of the same material stuff, text and image of pixels, and one layer behind that, sound and manipulable data as well in common binary encodings. This is how we can manufacture all these meanings in the one recording and dissemination device. This device — a phone, a tablet, a laptop — becomes a cognitive prosthesis for the purposes of both representation (lending support to our thinking-for-ourselves) and communication (defying distance by connecting us through telepresent messaging-for-others).

Now that we have at hand the tools for fully multimodal knowledge representation, we can offer these to our learners. Our times require us to move beyond the handwritten work book or the word processor. Instead, our learners should be working in the twenty-first century world of web communications. This is a pedagogical imperative as well as a practical one, so students can represent their meanings independently and simultaneously in different modes — written, oral, visual, audio and dataset. Each mode complements the other — the diagram and the text, the oral and the written explanation, manipulable data and its synthetic summary. Each can say the same kinds of things as the other, and is also an irreducibly different mode of representation.

Much can be learned by moving backwards between modes, representing meaning in one mode then another — a cognitive process we have called 'synesthesia', extending by metaphor the meaning of a word whose origins lie in cognitive psychology. Take the science experiment — the representation of its results can include words, diagrams, tables, dataset, and also a video demonstrating the experiment itself. Learning is deepened as students shift from one mode to another, making their meanings one way, then another complementary way.

Our response in *CGScholar* has been to offer expanded tools for knowledge representation and communication through the multimodal editor, 'Creator' (Figure 11.18). Here, creators can write their text, and insert audio, video, image or any other data type—a manipulable dataset, a 3D animation, or a mathematical formula, for instance. They can also embed inline external media—a YouTube video, SoundCloud audio, or code in Github for instance.

Creator is a 'semantic editor', so the person producing the work is always prompted to be explicit about their meaning. When 'emphasis' is added to a word or a phrase, this text is italicized. When 'block quote' is selected, it is indented, and this tells us unequivocally for the purposes of reading and learning analytics to determine the writer's language levels, that the creator did not write the selected text. The 'structure' tool is for creating sections and headings, and so doing tells us clearly what the creator intends in terms of their architecture of their text. It also prompts the creator to think explicitly about the structure of their text. Having a semantic editor means that the creator's work is more readily analyzable, and also allows for flexible rendering to a web portfolio or a PDF. Rendering to different formats varies based on the medium, but is always based on the creator's 'semantic markup.'

This is a fundamental difference between technologies such as the word processor and desktop publishing software which are based on the typography of the printed page invented in the fifteenth century—fonts, and point sizes, and, and type weights, variable spacing in a million possible combinations, the differences between which don't mean a great deal. There is no directly entered typography in Creator; nor are there in contemporary social media spaces. This is how they are able to render effectively to very different devices. Now we have also educational reasons to move to a semantic editor—

to prompt students to think explicitly about the form of their text, and to make that text more readily analyzable by peers, teachers and natural language processing technologies.

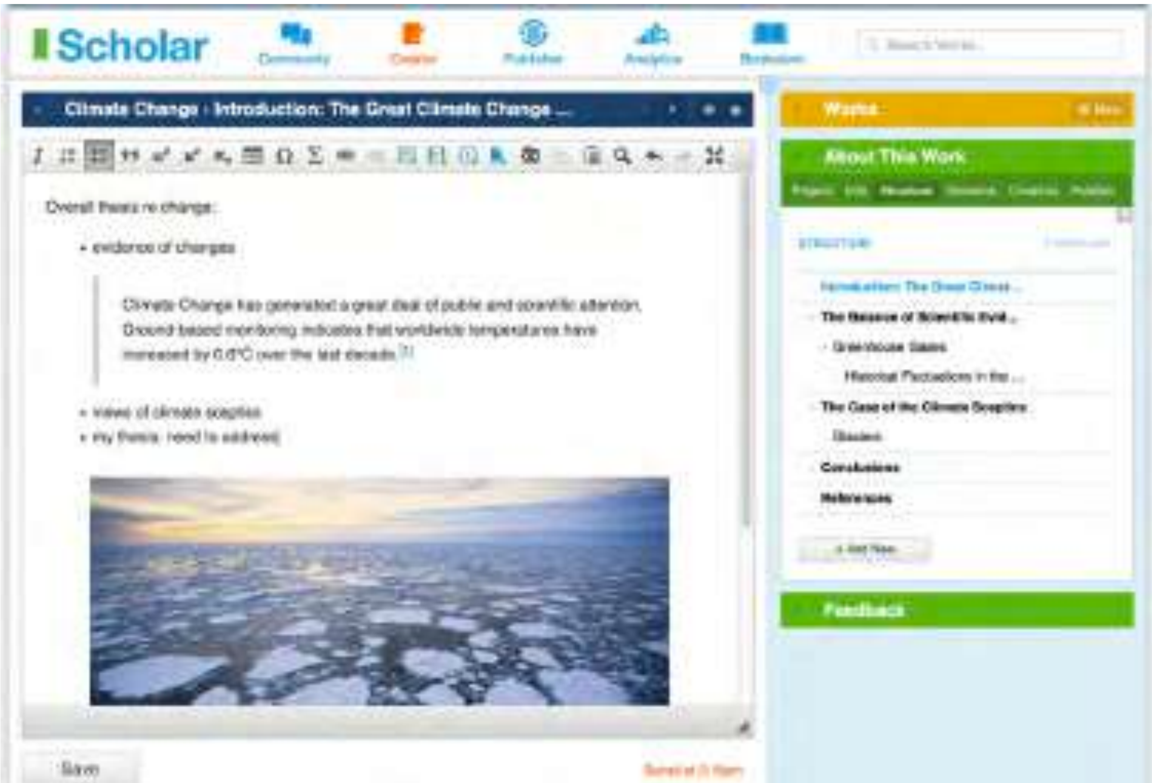


Figure 11.18: Beginning to draft work in the multimodal editor (left); planning and navigating its structure (right).

Dimension 2: Teachers' Working with Technology

New Learning Affordance: Ubiquitous Learning

The classroom of mass-institutionalized education is a communications medium. There is nothing of the knowable world outside of the classroom that cannot be brought into the classroom via media: about volcanoes, or algebra, or dentistry, or poetry, or geometry, or spelling, or geology. The reference is exophoric, to things outside of the classroom. The outside is brought in via media—primarily in the era of didactic pedagogy, teacher lecture and textbook. These are classical one-to-many media, in their general form not unlike the mass media of pre-digital newspapers, radio and television. For younger learners, one-to-twenty or thirty or seems to work. Much of the time, the teacher speaks and the students listen. Each student has a limited opportunity to speak during classroom discussion. This is simply a matter of logistical necessity, given the affordances of the media. For college students, a lecture may be one-to-hundreds, with even less or no opportunity for dialogue.

As a communications system, this classical modern classroom requires two kinds of confinement. One is spatial, or what is hearable within the four walls of the classroom. The other is temporal, framed by the cells of the timetable, determined by the necessity to listen together, and to be on the same page of the textbook at the same time.

Just as media in the wider society have changed, so the media of classrooms are changing. Where the mass media were one-to-many, the social media are many-to-many. Where the mass media configured audiences, viewer and readers as relatively passive recipients, the social media configure ‘users’ simultaneously as readers and writers, viewers and image makers, media creators and media consumers. Where the mass media assumed an audience which was fundamentally the same (because their message had to be mass produced and mass distributed), the social media express and reflect a panoply of identities and interests depending on a user-selected pattern of friends, or likes, or followings. Quietly underlying these transformations are some fundamental technological changes which might variously be named ‘ubiquitous computing’, ‘web 2.0’, ‘cloud computing’, and ‘semantic publishing’. [See newlearingonline.com: Cope and Kalantzis on Ubiquitous Learning.] But the technologies do not produce the change; they only offer affordances, for the same technologies could with equal force be used for control, command, and social homogenization, and sometimes are. To the extent that there is change, it is fundamentally social, in our everyday communicative relationships.

Ubiquitous learning means learning any time, any place. Older versions of the idea of formal learning out-of-school included homework, self-paced textbooks and ‘distance education’. Ubiquitous learning is a riff on the idea of ‘ubiquitous computing’. Once science fiction, with the rise of laptop computers, tablets, smart phones and smart watches, ubiquitous computing is an idea that arrived a long time ago in a very ordinary and pervasive way — in every store, every workplace, and almost every home, handbag, pocket or wrist. But only recently in schools, if yet. And when they do arrive there, it is often in ways that hardly do justice to the dynamic knowledge potentials of new media.

The significantly new things that can be offered by ubiquitous learning environments range from student discovery of multimodal content originating from a variety of authentic sources, to intensive simultaneous interactions in which everyone in the learning community can be actively engaged, and far more responsive feedback and assessment systems.

Perhaps most significant, however, is that the traditional educational distinctions of time and space no longer matter. Ubiquitous learning means you can do all the stuff of traditional classrooms, and more, and anywhere, and anytime. Learners using ubiquitous computing technology are able to perform the same acts of knowledge making and knowledge interaction — and new ones as well — inside the classroom as they can outside of the classroom.

Scale also disappears as a factor in learning — a class of three and a class of three thousand can be configured to work the same way, be that the video lecture, textbook and test routine of didactic pedagogy, or highly reflexive social relations of knowledge, including giving and receiving peer feedback, collaborative writing, and threaded discussions.

Does this spell the end of the traditional school? Not necessarily, because school is as good a place as anywhere to work in these technology-mediated ways. One thing will remain constant: society has devolved to schools the responsibility of keeping children in a relationship of duty-of-care during specific times in order to free parents up for work. However, its classrooms—more broadly conceived as learning ecologies—may alternatively have larger numbers of students than the historical norm, or fewer.

So what might happen in education that parallels these changes in the wider world of our communications media? To provide an example from the microdynamics of pedagogy, we will examine the subtle but profound changes in classroom discussion that occur when it moves from oral, in-class discussion, to online discussion.

In her pathbreaking book, *Classroom Discourse,* Courtney Cazden characterizes the classical pattern of classroom discussion as Initiate-Respond-Evaluate (I-R-E) (Cazden 2001). Teacher Initiates: 'What's the furthest planet from the sun in the Solar System?' Students shoot up their hands, and one responds, a proxy for all the others: 'Pluto.' Teacher Evaluates: 'Yes, that's correct!' (Or an alternative ending: 'No, that's wrong, does someone else know the answer?')

Figure 11.19: 'Hands Up!' in classical classroom discourse

To compare this to the dialogue that occurs in discussion boards, they're the same in this respect—a class discussion space which enacts the classic discursive Initiate-Respond-Evaluate pattern. And they are utterly different. And they are better in the following ways. We will use examples from the 'Community' space in *CGScholar,* illustrated in Figure 11.20:

- *Everyone responds.* In classical I-R-E, one person is proxy, answering for all. Instead, in *CGScholar* everyone can respond. In fact, there may be an expectation that everyone must respond. The result: a silent classroom that in classical classroom discourse would have been chaotically noisy as everyone speaks at once, or where the class would have to wait an interminably long time for more or all to give their response.

- *Lowered barriers to response.* Here's a rough rule of thumb—in classical I-R-E, it's usually the wrong person who responds with the proxy answer—the student who has the confidence to shoot up their hand first or early, or the person who the teacher can rely upon to have the anticipated answer. In *CGScholar,* the initiation happens in an 'update', and the response in a 'comment' on that update. Students often tell us that simply having a few extra moments to look over their response before they press the ‘submit comment,’ button reduces their anxiety to participate.

- When everyone responds, *differences become visible*. In the classical I-R-E scenario, it is not practicable to get answers from everyone. The expectation is that there is one answer because the person answering for the rest of the class must act as proxy for the others. This becomes an exercise in guessing the answer that the teacher expects. In asking the question, they must have had something particular in mind. If only one person is going to answer, it must mean there is only one answer. But is Pluto really a planet? Perhaps not, though if it is, might there be other small planets? The definition of planet is not so simple. Most things are interesting enough for there to be more than one answer, or differently nuanced answers, or different examples that students might give to illustrate a point based on personal interest and experience. In the *CGScholar* Update <=> Comment dialogue, the univocal response of the proxy in classical I-R-E, becomes polyvalent. Distinctive identities and voices come through. Students soon start discussing these differences, addressing each other @Name. If classical I-R-E erases the differences, now they become visible and valued as a resource for intellectual dialogue. This phenomenon we term ‘productive diversity’. Also, anxieties to participate and voice one’s own view are reduced as others’ responses start to come through.

- *This is highly engaging.* Classical I-R-E is boring—listening to the teacher ask a question and another student give an answer. The cognitive load is suboptimal. Reading lots of answers is much more engaging. Instead of one answer, there may be as many as there are members of the community, and more. In the era of social media feeds, the cognitive load when everyone answers in the discussion thread is about right. And there is a social stickiness in the visibility of the discussion—you stay engaged because others will be reading and responding to your updates and comments.

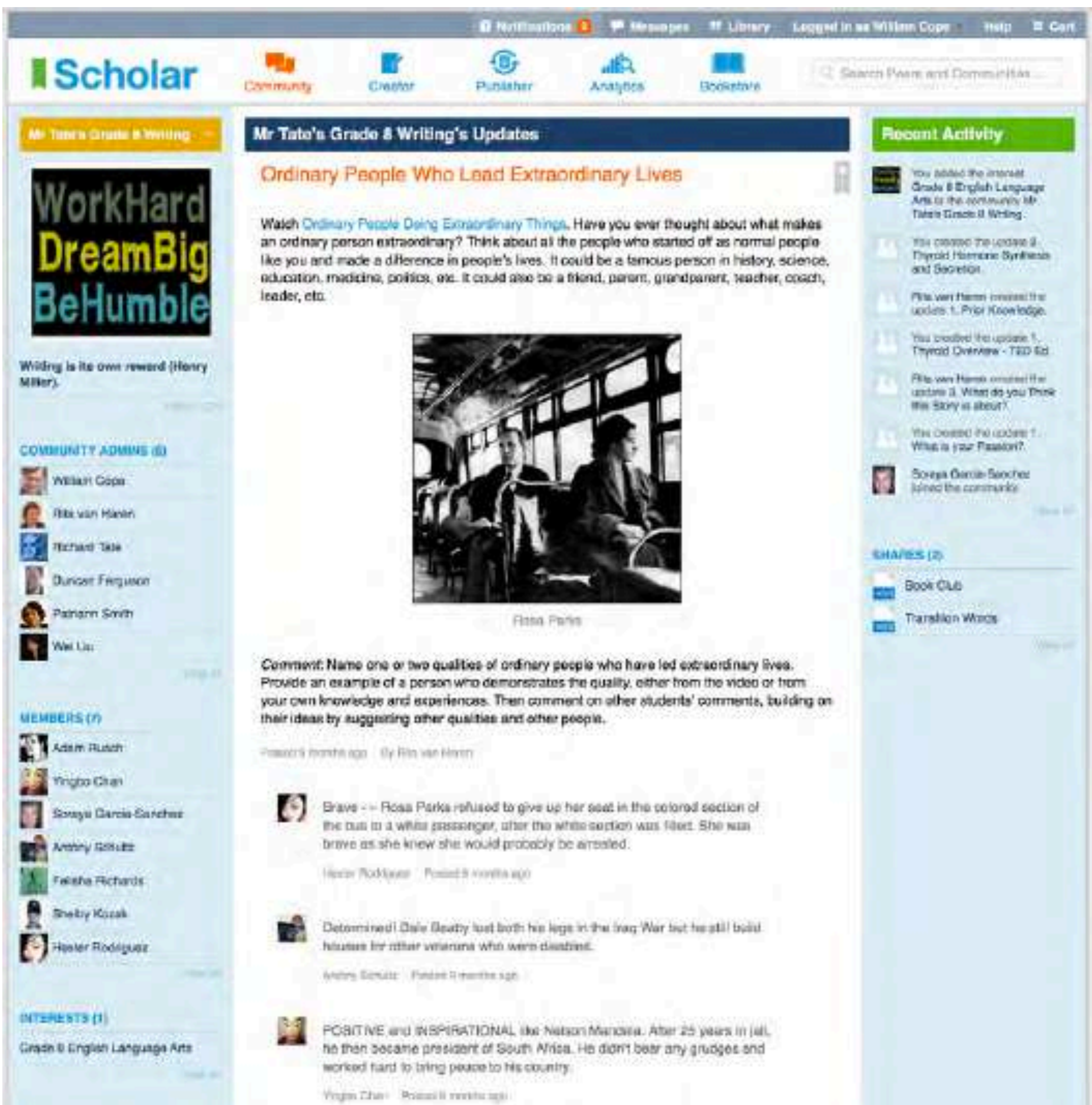
- *The read/write mix and the participation mix is right.* Heritage classrooms had students listening more than speaking, reading more than writing. Like the participatory social media, e-learning environments such as *CGScholar* offer a balance of read/write, and an expectation of active participation that resonates with the spirit of our times. Also, the text of the discussion is deceptively different from oral language. Looking back over a comment and editing it before submitting, moves part way from the grammar of speaking to the grammar of writing—and towards ‘academic literacy.’

- *We can break out of the four walls of the classroom and the cells of the timetable.* In an environment like *CGScholar,* there is no difference between in-person, synchronous classroom discussion and at-a-distance, asynchronous discussion. And there are useful intermediate permutations—‘Finish the discussion tonight,’ or ‘Not at school today? No problem, participate anyway.’

- *Anyone can be an initiator.* It's not only the teacher who can make updates in *CGScholar* or start a classroom discussion. If the teacher choses to open this setting in the Community area, students can make updates too—and this can include any number of media objects, including image, sound, video and dataset.

- *A new transparency, learning analytics and assessment.* Whereas discussions in the traditional classroom were ephemeral, online discussions are for-the-record. In the new I-R-E where everyone responds, every response can be seen, and the responses can be parsed using learning analytics (frequency of engagement, extent of engagement, language level, discussion network visualizations, and a myriad of other measures). If you are not participating, it will be visible to others and your teachers. It will show up in your results.

Such are the renewed dynamics of classroom discourse in the era of social media.



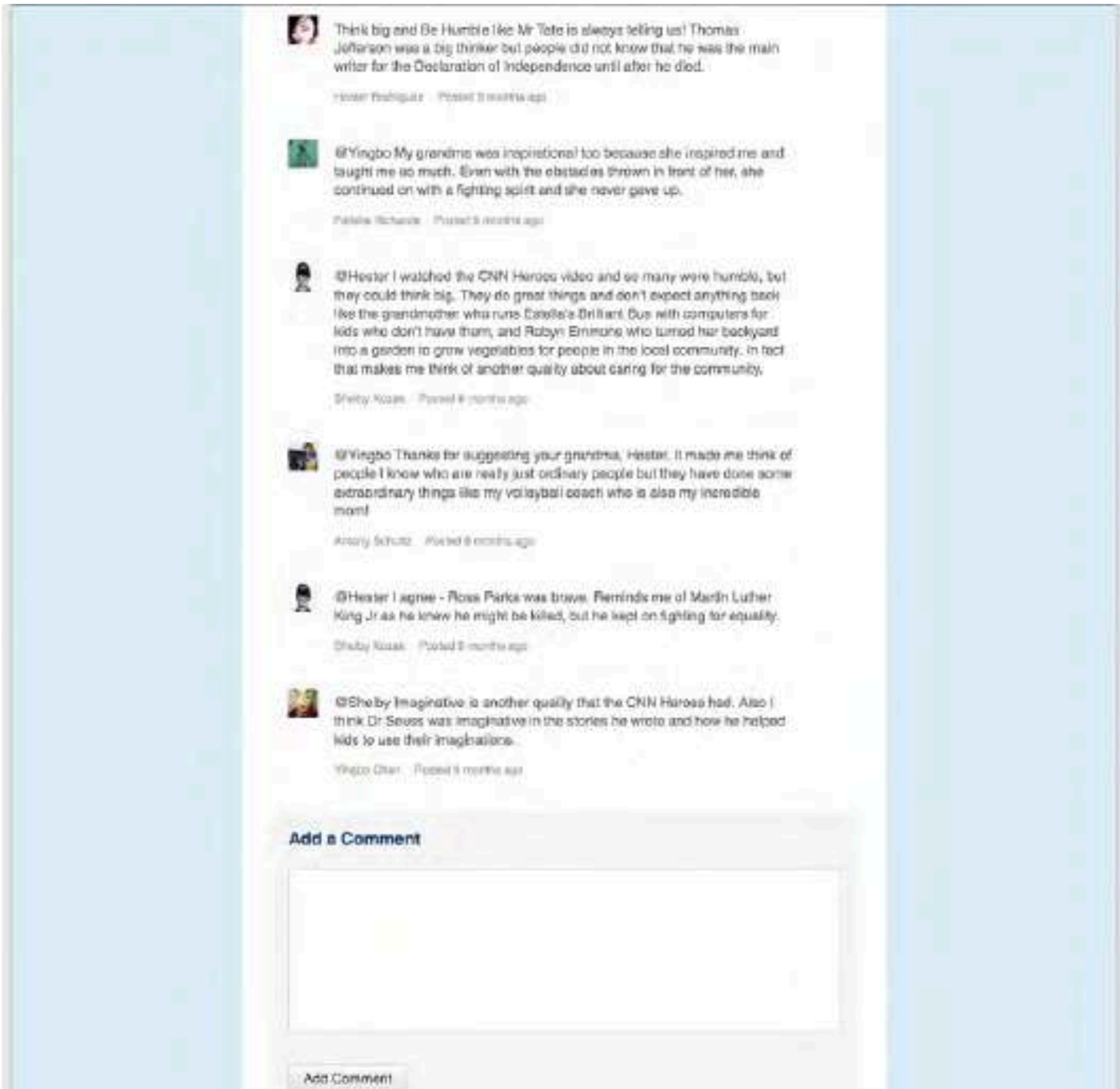


Figure 11.20: Discussion in CGScholar's 'Community' space

In these ways, classroom discussion in social media spaces is deceptively the same and totally different from traditional classrooms. In this medium, there is no difference between in-class and out-of-class discussion. Ubiquitous learning means that we have transcended the old pedagogical separations of space (the walls of the classroom) and time (the cells of the timetable). Not that classrooms go away, just that a certain kind of convergence occurs, where there are no discursive differences between in-person and at-a-distance learning. The platforms can be the same. The learner-teacher and learner-learner dynamics can be the same.

Gone too is teacher surveillance requiring that students be in the teacher's direct and embodied line of sight. Student work and activity in the cloud is always accessible, and always recorded for the purposes of learning analytics and behavior management. A new transparency plus insistence on responsible digital citizenship, is accompanied on the flip side of new forms of digital surveillance. In the case of cyberbullying and other forms of antisocial behavior, new duties of care must be exercised by teachers. Finally, there is a question of scale. For children, traditional classrooms had an optimal scale of twenty or thirty students. In the era of ubiquitous learning, scale is variable—from a teacher working one-to-one with a student while others work autonomously, small groups working together based on activity scaffolds created by teachers, or larger numbers of students across multiple grade levels working in open online spaces. Ubiquitous learning makes possible all of these profound changes in the institutional forms and pedagogical modes of education.

New Learning Affordance: Differentiated Learning

Defying the seemingly neat demographic classifiers that we critically examined in Chapter 5, in classrooms of today we encounter learners whose affinities are complex, belonging to fluid and overlapping affinity groups, whose encounters may be in-person or in online hangouts. We negotiate the chosen or circumstantial associations that come with strangely juxtaposed circles of friends and social media followings. We encounter personae that are increasingly self-created and with intense affect—from fashions, to gendered demeanors, to sculpted bodies, to web or game avatars. We find learners whose identities can only be accounted for in the unique conjunctions that are the narratives of visceral experience and life history.

However, didactic pedagogies and traditional educational media were grounded in an architecture of sameness: the whole class listening to the teacher lecture in real time, all the students on the same page of the textbook, and tests that were standardized. Digital educational media facilitate the management of the complexities of differentiated instruction, where students can be working on different things at the same time.

Connectivism speaks to diversity as a valuable component of collective learning, though it is not clear how productive learning outcomes might be arranged. Constructivism does not speak to diversity. If didactic-mimetic pedagogy was a learning architecture of sameness (learners listening to the same lecture, on the same page at the same time, measured against standardized tests), constructivism anticipates sameness albeit by different means. In Piagetian terms, learners accommodate and assimilate what has been expected of them. Instead of being told to think the same way as the instructor (learner volition is irrelevant in didactic-mimetic pedagogy), they are expected to internalize to think the way the instructor wants, and by their own volition. In constructivism, sameness is self-imposed.

So too, when we hear mention of personalization in constructivist e-learning environments, does it just mean covering the same stuff at a different pace? Does just it mean—eventually at least—getting the answers right?

Our response is 'productive diversity,' to make the differences work for us, in our civic, working and community lives—and in our schools. Productive diversity is an orientation to learner differences where those differences are explicitly validated and leveraged as a resource. These are its principles:

1. *The Differentiation Principle:* Architectures of pedagogical sameness are no longer logistically necessary, as perhaps they were in the era of didactic pedagogy. It is not necessary that learners do the same tasks at the same time and in the same way. It is not necessary that they work through and complete a task at the same pace. With today's dashboards, on-the-fly learning analytics, alternative

navigation paths, recalibrating systems, and adaptive learning mechanisms, new educational media make the organizational intricacies of productive diversity ever more manageable. In fact, managing learner differences becomes easier than one-size-fits-all teaching because there is not the dissonance of bored or disaffected students for whom the pace of learning may be wrong.

2. *The Design Principle:* In reflexive pedagogy, learners are positioned as designers of their own knowledge. Students are scaffolded by their teachers and digital learning environments to encounters with available knowledge resources in the world, in all their multivocal and multimodal diversity. They remake that world according to the disciplinary scaffolds that are the studies of science, or art, or language. They are positioned as disciplinary practitioners—as scientists, as art critics or artists, as critical readers or writers. Now knowledge producers more than knowledge consumers, every artifact of their knowledge (re)making is uniquely voiced—a notion that we call 'design'. Learning is no longer a matter of replicating received knowledge from memory. The evidence of learner activity is to be found in designed knowledge artifacts—for instance, students' projects, solutions with workings explained, online discussions, models, or the navigation paths they have taken though games, simulations or intelligent tutors. As active designers, the world of knowledge is redesigned by learners, revoiced according to the tenor of each learner's interest, identity, and experience.

3. *The Collaboration Principle:* One unfortunate consequence of personalization with educational technologies can be to individualize the experience of learning, reducing the learning relationship to a lone student with their computer. However, in technology-mediated learning environments designed on social media principles, complex structured social interactions can also be managed. And as soon as the social comes into play, differences become visible and may be deployed as a productive resource. Different perspectives prompt deeper discussion. Providing structured peer feedback exposes learners to different perspectives and ways of thinking. Sharing work-in-progress and finished work highlights different points of focus and different angles on knowledge. In these ways, learner diversity can be harnessed as a resource for learning.

4. *The Comparability Principle:* Under the principle of comparability, where assessment rubrics are pitched at a high level of generality, students can be doing different things but of comparable cognitive or practical difficulty. Learners no longer have to be the same to be equal.

Digital media make make these pedagogical design principles more feasible. Learners can be doing the same thing at their own pace, or they can be doing different things according to their needs or interests. Such is the objective of adaptive, personalized or differentiated instruction which calibrates learning to individual needs and interests.

This becomes all the more feasible once the teacher has an immediate view of where they are up to in a project status screen. Indeed they can click right into the student's work and see their most recent keystroke. Moreover, positioning the student as a knowledge producer affords more space for student voice, interest, experience and localized relevance. In general terms, the intellectual project might be the same, but the topics may vary. Or, where the aim is collaborative knowledge creation, every student might be working on one distinctive piece in a jigsaw puzzle of class knowledge that is later shared when it is published and shared with the class community. Instead of forcing homogeneity, such a classroom operationalizes the principle of productive diversity or the complementarity of differential knowledge and experiences. Students might go on to cite each others' works as knowledge sources, as distributed expertise. Such a learning ecology is one that harnesses learner identities, deepens their sense of engagement, and increases their motivation to devote time to task and engage with others in their knowledge community.

Then assessment becomes a somewhat different process than in the past, not measuring capacities to remember identical things or correctly deduce the same answers, but measuring higher order comparabilities and equivalences between knowledge artifacts which may in substance be different. At this point, managing learner differences may become easier than one- size-fits-all teaching.

In *CGScholar,* we offer a number of ways in which the diverse perspectives, understandings and voices of students can be leveraged as a productive resource. Where the print or e-textbook summarizes a subject domain in a singular voice, *CGScholar* Learning Modules curate varied authentic web resources. Where a lecture tells, whether live or recorded in video, learners research and contribute course content according to a scaffold of conceptual prompts suggested by the instructor. Where classroom discourse has only one speaker talking at a time, and then to guess the correct answer expected by the teacher, when everyone responds, diverse interpretations become visible and relevant for their nuanced differences. When learners chose their topics for peer reviewed projects and these are subsequently published to their portfolios and a class knowledge bank, the diversity of empirical realizations of a particular subject domain becomes valuable. When a learner receives two or more criterion-referenced peer reviews, the diversity of interpretations becomes more valuable than a teacher's single, often cursory judgment. In these and other ways, diversity becomes a core resource for learning.

In this context, the work of the teacher changes. Highly structured learning management systems impose content on learners. You watch the video, then in the manner of didactic-mimetic pedagogy, you answer the questions so the system can be sure you have watched the video and have interpreted its contents in the way that was expected. In constructivist versions e-learning, the processes of learning may involve somewhat more agency on the part of the learner than this. For instance, a learner might be able to keep working at a problem until they get the right answer. This is how second-chance questions work in online quizzes, and hints work in intelligent tutors. The technology of learning might be a little gentler, but the effects of the same.

Connectivism in theory renounces any such structures. Learning is a process of co-design, a self-governing community or practice. Here we are likely to encounter the same critiques as we saw for constructivism. How efficient is this? When is this just a pooling of shared ignorance? Does this mean we can displace the domain expert and the professional pedagogue?

In a reflexive pedagogy, learning is recursively co-designed. Learners interact with learning designers. Learners contribute content. Learning data inform iterative changes to instruction.

Dimension 3: Assessing Learning with Technology

New Learning Affordance: Recursive Feedback
Old analogue media were linear — the one-way flows of information and culture from television studio to viewer, from newspaper office to reader, from radio studio to listener, from movie lot to audience. Digital media are by comparison recursive. At the beginning of the computer age, Norbert Weiner attempted to capture the logic of self-adjusting systems, both mechanical and biological, with the concept of 'cybernetics'.[25] The Greek *kybernetis,* or oarsman, adjusts his rudder one way then another, in order to maintain the course of the vessel.

Whereas the communicative logic of the old media was linear (knowledge creator to passive knowledge consumer), new media is dialogical and recursive, to the point even where it is hard to distinguish creator and consumer. Feedback is pervasive. Web reputation and moderation systems add social filters to the feedback. The 'quantified self' of ubiquitous devices provides continuous feedback on self in space and society, from walking directions, to exercise routines, to the social reach of a post.

Feedback systems in traditional schools were, like old media, linear starting with the curriculum and ending with the test. In this regime, the summative test is separated from learning — an at-the-end managerial thing, a retrospective judgment which can do little in an immediate sense to further learning. It also conceives knowledge in a peculiar way, using as it does quite different devices from the ordinary processes of engaging with knowledge and learning themselves. Assessment becomes a strangely school-ish game in which students do things like discriminating atomized right responses from trick 'distractors', designed to look right but which are deceptively, deliberately not right. In recent decades, the obsession with testing for the purposes of institutional accountability has magnified everything that was problematic about these linear processes. Digital media technologies, however, mean that assessment does not have to be this way anymore.

Instinctively, learners know what is wrong with tests. But generation after generation, we have resigned ourselves to their inevitability. Here are the main problems, first in summary and in contrast with AI-supported, embedded assessments, followed by a more detailed analysis:

1. *The measure of what we learn is long term memory*.[26] The traditional test checks what you can remember until the moment it is administered, and that you are free to forget the day after. This may have been appropriate to industrial-era society where information and tools of analysis were not readily at hand. But now these are readily available, in the cognitive prostheses that are ubiquitous, networked, digital devices.

2. *The cognitive range measured in traditional tests is narrow.* Remembering a fact or calculating a correct answer by correct application of a procedure are not only anachronistic cognitive skills. They are too narrow in fact for today's world where

the most valuable kinds of thinking have qualities that might be described as holistic, imaginative, emotionally sensitive, and a host of other such epistemic and productive virtues.

3. Traditional select response tests (e.g. multiple choice) in their nature throw up false positives and negatives. A false positive in such tests occurs in the case of an answer you accidentally get right, even though you don't understand the underlying principles, and a false negative when you get an answer wrong for a trivial reason. These data distortions are systematically built into select response assessments, because distractor items are designed to be nearly right. They are trick answers, right-looking answers to tempt you to give the wrong answer, and possibly for the right reasons, or reasons that make sense in terms of fuzzy logic. Conversely, if select response assessments are a game of trickery, you can play the game to get the right answer just by learning the tricks, such as the process of elimination where you successfully guess the right answer. In other words, false positives and negatives are endemic to the design of select response assessments. As knowledge artifacts, these are strange things, unparalleled elsewhere in learning and life.

4. *Traditional tests are based on limited sampling and highly mediated inferences.* How could a few hours at the end of a course be enough to sample what a learner has learned? Then there is a leap of inference, characterized by Pellegrino et al. as the assessment triangle: observation (the test that prompts student answers) <> interpretation (the test score) <> cognition (an inference about thinking based on the score).[27] This is a large leap from such a small sample, and as if something as complex, varied and multifaceted as cognition could be reduced to a number. This applies equally to the other canonical from of assessment, supply response assessments, or traditional essays.

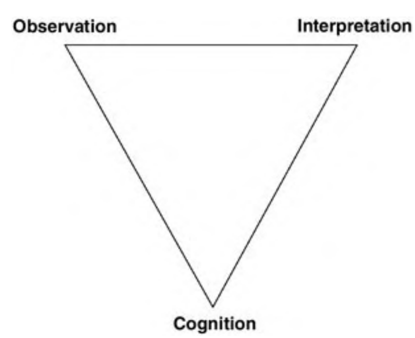


Figure 11.21: Pellegrino et al. assessment triangle

5. *Existentially, tests are disturbing experiences.* Students mostly dread tests. What if there are unexpected questions, or if I have studied the wrong things? What if on the day, I can't remember something? The dread arises not just when the stakes are high, but because they mostly are running blind, not knowing for sure what will be in the test. Then, you don't know how well you have been doing until it is too late to do anything about it. And you can't learn from the test in a measurable way because it

comes at the end. Tests are mostly summative (of learning: retrospective and judgmental in their orientation), and rarely formative (for learning: prospective and constructive in their focus). They are for the managers of educational systems more than they are for learners and their teachers.

6. *Test logic is linear.* Students learn the work then do the test, and after that if they pass, they can move on in a linear way to the next step in their learning or their life. There are no feedback loops—unless you have to repeat a course, and that is hardly a positive experience.

7. *Test logic is isolating and individualized.* Tests measure the memory and procedural capacities of individual brains. The social is excluded. No looking things up! No cheating! Knowledge, however is in its nature social, in workplaces for instance, and community life where we rely on readily accessible knowledge resources and the power of collaborations. This focus in tests on an individual's thinking is unlike any other parts of knowledge and the intrinsically social environments in which knowledge is put to work.

8. *Tests insist on inequality.* Lastly, and perhaps the most egregious of the flaws of traditional tests, is that they insist on inequality. Children are placed into a Grade 3 literacy class because it is assumed they will all be able to learn to read and write at about that level. Then we want to insist on unequal outcomes and a defined point of measurement. Aspiring doctors have to get incredibly high scores to get into medical school. Then we insist on tests that differentiate them across a distribution curve. We insist that there must always be inequality, and in classical testing theory we adjust our tests and their statistical calibrations in order to differentiate degrees of knowing. So here is a huge contradiction: to start by assuming everyone in a class is capable, then at the end to insist that only a few can be really smart, defined against the rest who are mediocre or dull. This culture of enforced inequality begins in Education 1.0 with intelligence testing, where Henry Goddard was by the 1920s able to differentiate across a statistical distribution people who were idiots, imbeciles, morons, average, above average, gifted, and genius (figure 11.22).[28]

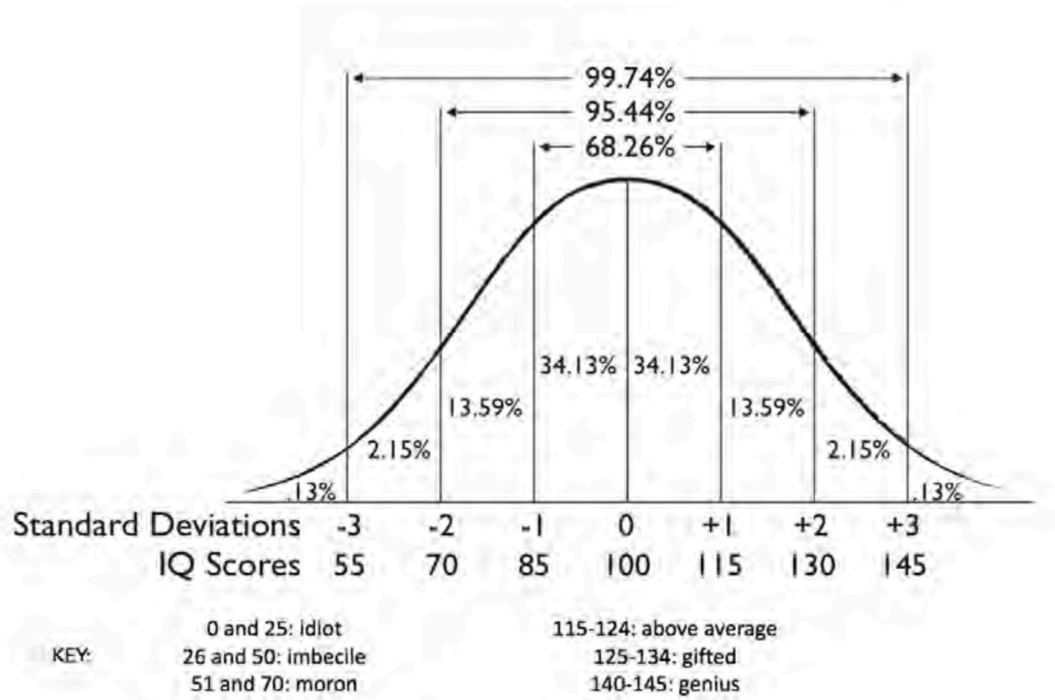


Figure 11.22: Norm-referenced assessment in standardized tests, Henry Goddard's 1920 distribution and classification of intelligence

Digital media enable a renewed focus on formative assessment — assessment that is on-the-fly, and that makes in a detailed and constructive way a direct contribution to student learning.[29] In the era of social knowledge technologies, no learning environment should be without always-available feedback mechanisms — machine feedback and machine-mediated social feedback. Then, when it comes to summative assessment, all we need to do is present a retrospective view of student progress, using no more and no less than all the data collected in the formative assessment process. In fact, we might in the not-too-distant future be able to abandon summative assessment, and its perverse peculiarity as an artifact and its baleful institutional effects. And this because there is so much assessment going on, all the time — recursive feedback from so many perspectives, of everything the learner does in digitally mediated learning environments.

Digital media also facilitate a broader range of assessment modes. The machine itself can provide some feedback using natural language processing algorithms, and this feedback is computable. There is also the possibility of constant, machine-mediated human feedback, 'crowdsourced' from multiple perspectives — teacher, peers, and self. Revealingly, we have shown in our research that the mean of two or more peers' assessments is remarkably close to the score of an expert rater.[30] Teachers and learners are all assessing learning, and every one of their perspectives has distinctive value. In fact, as perspectives vary, the feedback may be more extensive, more thought-provoking, more rapidly provided and thus more valuable, than the most assiduous of lone teacher-markers. We can also moderate the various ratings and calibrate results via processes of inter-rater reliability, and the result may also be a more reliable assessment. One effect of distributing assessment responsibilities in this way is to make explicit assessment processes and remove the trickery.

Digital learning platforms also lend themselves to a phenomenon that has been termed ‘big data’ in education, accompanied by the emerging educational subfield of ‘learning analytics’. Leaders in this emerging area speak clearly to what they consider to be a paradigm change. [See newlearingonline.com: Behrens and DiCerbo on Big Data in Education.]

Learning analytics is also expected to do a better job of determining evidence of deep learning than standardized assessments — where the extent of knowing has principally been measured in terms of long-term memory, or the capacity to determine correct answers.

As well as being able to measure individual work, we can measure social interactions and peers’ contributions to others in the form of the feedback they have provided. In other words, we can assess learning interactions as well as learning artifacts. We can also build recursive feedback — feedback whose value is weighted by feedback on feedback, and ratings that are moderated by inter-rater reliability calculations. We can, in other words, calibrate crowdsourced assessment so it is increasingly reliable, and perhaps even more so than the expert marker assessment in isolation.

So what might we achieve with these modes of assessment that extensive use new media? One effect may be to reframe the assessment question from ‘how did we do?’ to ‘how are we doing?’ — ‘we’ being the learner, the class, the teacher. Assessment’s primary reference point would not then be a managerial focus on results (framing our assessment question in the past perfect tense), but a formative focus on progress and improvement (framing our assessment question in the present continuous tense).

We could even take a more audacious step, in the direction of a ‘no failure’ educational paradigm, where you can keep taking on feedback until you are as good as good is supposed to be. This is by way of contrast with distribution of students across a bell curve, where the few can succeed only because most are destined to be mediocre or fail. A culture of mutually supportive constructive feedback not only models the ideals of a knowledge economy where teamwork and networked collaborations are more valuable than ever. Assistance helps the stronger as well as the weaker. It sets community standards, where the weaker see models in the works they review that are stronger and the completed works of peers, published to a web portfolio. And, in feedback-on-feedback and the measurement of constructive interactions, peers are offered help credits rather than being rewarded with the beating-the-other-person credits of the normal distribution curve.

A new generation of embedded assessments enabled by computer-mediated learning may be a key to these changes. Indeed, it is conceivable that summative assessments could be abandoned, and even the distinction between formative and summative assessment. In a situation where data collection has been embedded within the learner’s workspace, it is possible to track back over every contributory learning-action, to trace the microdynamics of the learning process, and analyze the shape and provenance of learning artifacts.

This can be achieved with a mix of machine assessment and crowdsourced human assessment, as well as linking technology and persons by applying machine learning and artificial intelligence methods so the system becomes smarter as more data are collected—smarter in the sense that, based on past patterns that have been analyzed, the system can learn to provide progressively better feedback.

As assessment can now be readily embedded into learning, the traditional instruction/assessment distinction is blurred. Learning and assessment take place in the same time and space. Every moment of learning can be a moment of computer-mediated feedback. The grain size of these datapoints may be so small and so numerous that without learning-analytic systems, they would have almost entirely been lost to the teacher. For instruction and assessment to become one, however, every datapoint needs to be semantically legible datapoint, or learner-actionable feedback. In this way, every such datapoint offers an opportunity that presents to the learner as a teachable moment.

When semantically legible datapoints are 'designed in', these can serve traditional formative purposes. They can also provide evidence aggregated over time that has traditionally been supplied by summative assessments. This is because, when structured or self-describing data is collected at these datapoints, each point is a waypoint in a student's progress map that can be analyzed in retrospective progress visualizations. Why, then, would we need summative assessments if we can analyze everything a student has done to learn, the evidence of learning they have left at every datapoint? Perhaps, also, we need new language for this distinction? Instead of formative and summative assessment as different collection modes, designed differently for different purposes, we need a language of 'prospective learning analytics', and 'retrospective learning analytics', which are not different kinds of data but different perspectives and different uses for a new species of data framed to support both prospective and retrospective views.

Students of today will not want to wait until the end of the course or the unit of work to be told 'B-', which is simply to say something like, 'you're a bad person, try harder next time.' They want and need continuous feedback. Not to be merely retrospective and judgmental, they require feedback that is prospective, constructive and constitutive of their learning. This may be a machine response in a game or an intelligent tutor, a peer comment against the criterion of a rubric, a select response question where the answer can immediately be checked, a reply in a discussion board, or a review of a work in a e-portfolio.

Moreover, instead of norm-referenced assessment, with rich, on-the-fly feedback from multiple sources and perspectives (machine, peers, teacher, self-reflection), it may be more possible for all students to achieve what Benjamin Bloom called 'mastery'.[31] In this context, moreover, it is not so relevant whether students reach performance outcomes at a different pace, as long as they do. The measure then is self-referenced, or progress assessment. Could we create a no-failure educational paradigm where you can keep taking feedback until you are as good as you are supposed to be? Perhaps this is for the first time possible where the teacher's grade and the test are not the principal forms of feedback. Instead of the 'B-' on the test at the end of the term in the course of that term a student may receive tens of thousands of small, incremental pieces of feedback that were responsive to their needs, and which they could respond to in turn, realizing the dialogic promise of reflexive pedagogy.

In *CGScholar,* over the course of a single project (a piece of writing, documentation of a science experiment, a worked mathematical example), students may receive many hundreds or even thousands of pieces of feedback in a process that is carefully designed by the teacher or the creator of the Learning Module: a comment from a peer against a criterion in a peer review rubric, a coded annotation, machine feedback from the natural language processor, an answer to a question in a survey, a comment in a class discussion (Figure 11.23). It's not just the teacher who is offering feedback, nor is the feedback just coming at the end. The sources are multiple, incremental and just-in-time—in fact there are many more items of peer and teacher feedback than a teacher alone could realistically offer. In the context of Web 2.0, this involves the crowdsourcing of assessment. The result is an enormous amount of data, in different forms and from multiple sources.

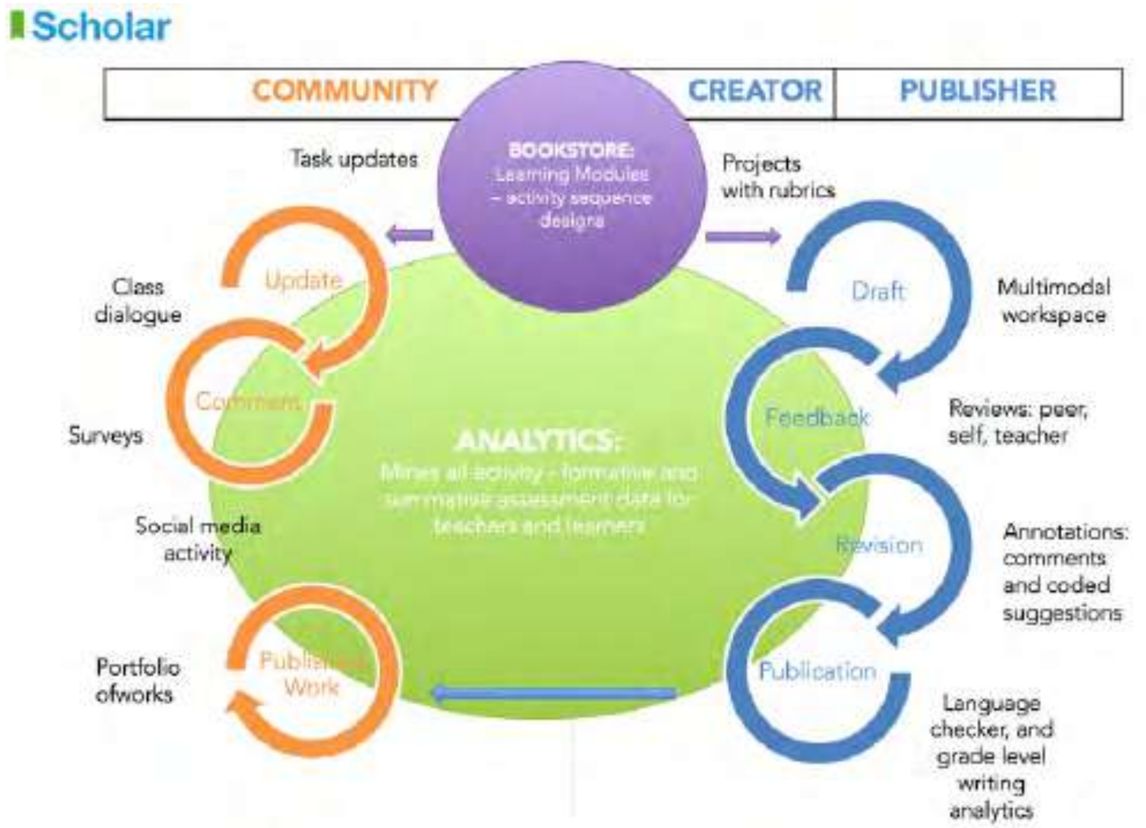


Figure 11.23: The CGScholar learning and recursive feedback ecology

Here is a series of propositions towards an agenda for the future of assessment:

1. Assessment can increasingly be *embedded in instruction*, allowing us to realize long-held ambitions to offer richer formative assessment.

2. We may now have so much *interim learning or progress data,* why do we even need these strange artifacts, summative assessments? With the help of data mashups and visualizations, the datapoints need only be those located within the learning process. The test is dead; long live assessment!

3. Now that we can assess everything, and there is no learning without reflexive, recursive, machine feedback, peer and teacher feedback, and structured self-reflection, do we even need a distinction between instruction and assessment? There should be no instruction without embedded recursive feedback, and no feedback that does not directly and incrementally contribute to learning. Reflexive

pedagogy *ends the assessment/instruction distinction.*

4. The focus of what is assessable now shifts from individual cognition, to the *artifacts of knowledge representation and their social provenance*. It's not what you can remember, but the knowledge artifact you can create, recognizing its sources in collective memory via links and citations, and tracing the collaborative construction process via the feedback offered by peers and teachers, and the revisions made in response.

5. The focus of what is assessable moves from the repetition of facts and the correct application of theorems to what we call *complex epistemic performance*, or the kinds of analytical thinking that characterize disciplinary practices—being scientist, or a writer, or to apply mathematics to a problem.

Our aim here is to liberate learning from shackles of traditional testing and to end the distinction between instruction and assessment—where no worthwhile instruction occurs without embedded feedback processes, and where there is no assessment that is not meaningful to learning.

1. *The measure of learning is higher order thinking.* This is an era in which we have wondrous cognitive prostheses. In our purses and in our pockets we have a massive encyclopedia elaborating on every significant fact, a map of the world with its every street, a calculator, and a myriad of other look-up and calculation apps. Instead of factual memory and correct application of procedures—we have ubiquitous computing machines to do that for us now—what we should be measuring is how well we use these memory-supporting and analysis-enhancing technologies. Today, the capacities we should be measuring are knowledge navigation and critical discernment that what distinguishes the true from the 'fake' in available knowledge resources. The answers that are often matters of careful judgment and well informed perspective, and not simply, unequivocally 'correct.' <u>Some AI-supported assessment processes</u>:
    a. Rubric-based peer-, self-, teacher- assessment of knowledge syntheses and objects (for instance projects, reports, designs), where the computer manages a complex peer-to-peer social interactions.
    b. Machine feedback on the quality of feedback, comparing rubric criterion to response, and training data where previous reviewees have rated review quality.

2. *The cognitive range that we want to measuring today is broad and deep: complex epistemic performance.* We might want to measure critical, creative and design thinking. We might want to measure the complex epistemic performance that underlies disciplinary practice: computational, scientific, clinical, or historical and other knowledge tradition or methodology. Or we might want to assess deep epistemological repertoires: thinking that is evidentiary/empirical, conceptual/theoretical, analytical/critical, and applied/creative. <u>Some AI-supported assessment processes:</u>

    a. Crowdsourcing of criterion-referenced peer assessment of that pushes learners in the direction of disciplinary reflection and metacognition.
    b. Coded annotations, supported by machine learning where users train the system to recognize higher order thinking.
    c. Ontology-referenced maps that prompt knowledge creators and reviewers to add a second layer of meaning to text, image and data; this is direct support to learners, as well as machine learning training data.

3. *We need to broaden the range of data types and data points for assessment.* The dominance of select response assessments is based on the ease of their mechanization. It has for some time been easy and cheap to mark item based tests with a computer, starting with the notorious 'bubble tests.' Today, supply response tests (e.g. essays, short textual answers) can also be graded by computers easily and cheaply, but the purpose is the same, to judge students with grades. However, these two assessment technologies could be pushed in a more helpful direction for teachers and learners. <u>Some AI-supported assessment processes:</u>
    a. Select response assessments and quizzes that give students a second chance to answer, with an explanation.
    b. Computer adaptive and diagnostic select response tests that recalibrate to learner knowledge and offer specific, actionable feedback on areas of strength and weakness.

4. *Changing the focus of sampling to big data: n=all.* When students are working in computer mediated environments—reading text, watching videos, engaging in classroom discussions, writing and offering peer reviews on projects, and reviewing the reviews, we are able to assess everything they do. Here is the paradox: assessment is now everywhere, so by comparison the limited sampling of tests becomes quite inadequate. Moreover, all assessment is formative (constructive, actionable feedback), and summative assessment is no more than a retrospective view of the learning territory that has been covered as evidenced in formative assessment data. <u>Some AI-supported assessment processes:</u>
    a. 'Big data' analytics, where the size of the data is related to the scope of data collection and the granularity of datapoints.

5. *Embedded assessment is the learner's friend.* Machine, peer and teacher formative assessments come at a time when they can be helpful to learners. Progress data can tell students what they have achieved in a course or unit of work, and what they still need to do to meet curriculum and teacher objectives. <u>Some AI-supported assessment processes:</u>
    a. Developing a culture of mutual help with peer and machine offering feedback at semantically legible datapoints—i.e. every assessment datapoint can make manifest sense to the student.
    b. Overall progress visualizations: clear learning objectives, transparent progress data.

6. *Assessment logic is recursive.* This means that learning is characterized by feedback loops where a learner can act on feedback, seek further feedback, and act on it again, to the extent that is necessary for their learning. <u>Some AI-supported assessment processes:</u>
    a. Incremental feedback and data transparency allow a student to keep working until they meet a detailed learning objective and overall course objectives.

7. *Intelligence is collaborative.* Cheating only happens when learning is measured as isolated memory recall and correct answers using procedures. When knowledge is acknowledged to be collaborative, the collaborations can be recorded and included in the assessment process. Students learn by giving feedback as much as by receiving it. In fact giving feedback against the criteria of a rubric prompts students to think in disciplinary and metacognitive terms. These social source of feedback, moreover, are multifaceted (different kinds of datapoint), and mulitiperspectival (peer, teacher, self, machine). <u>Some AI-supported assessment processes:</u>
    a. Measuring individual contributions to collaborative work in shared digital spaces.
    b. Rating the helpfulness of feedback, using reputation measurement methods now ubiquitous on the web.
    c. Machine moderation of peer ratings, recalibration for inter-rater reliability.

8. *Every student can succeed!* Half a century ago, Benjamin Bloom conceived the notion of mastery learning, or the notion that every student in a given class can achieve mastery, perhaps with additional time and support. Today's computer-mediated learning environments can achieve this, albeit by mechanisms that Bloom could never have imagined. These processes are personalized to the extent that assessment is not at a fixed moment in time, but a record of progress towards mastery which may take some students longer than others. The key is data transparency for learners and teachers. For the teacher: here is a data visualization showing that a particular student needs additional support. For the learner: here is a data visualization that shows what you have done so far in your journey to achieve mastery as defined by the teacher or the curriculum, and this precisely, is what you still need to do to achieve mastery. <u>Some AI-supported assessment processes:</u>
    a. Data transparency for students: clear learning objectives and incremental progress visualizations showing towards those objectives.
    b. Data transparency for teachers: class progress visualizations, showing effectiveness of instruction, just-in-time data identifying students who need additional support

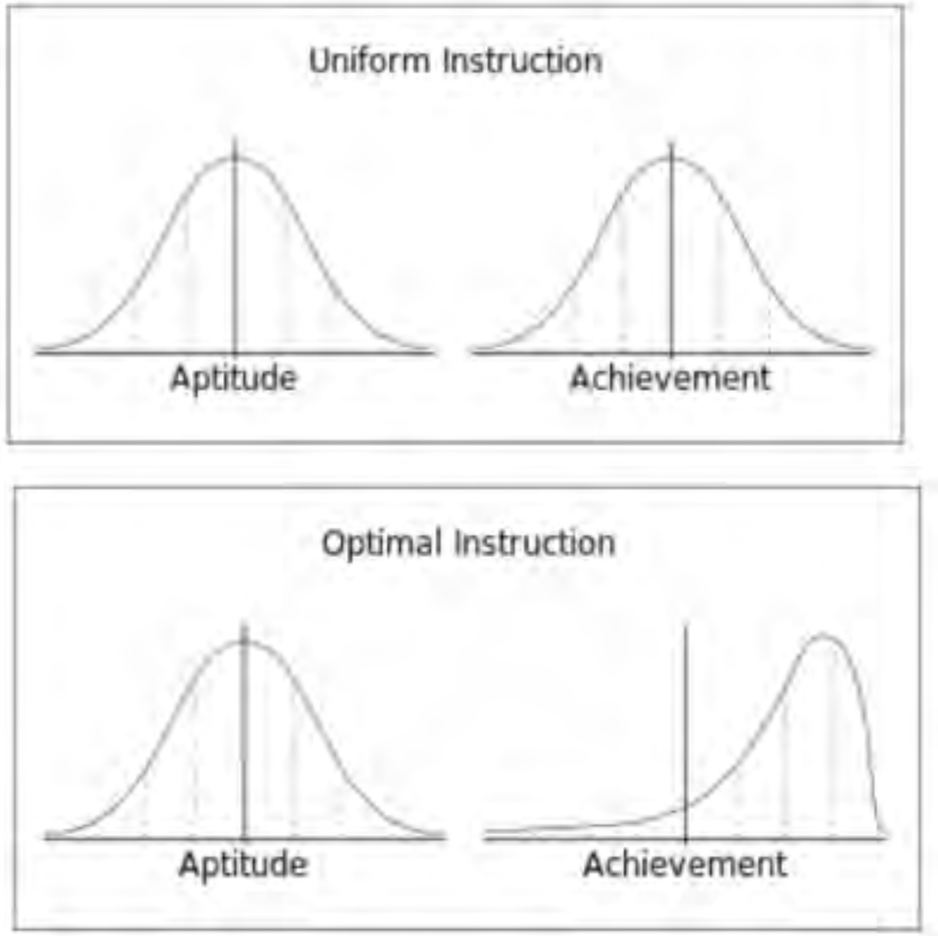


Figure 11.24: Benjamin Bloom's optimal instruction, with regular, formative assessment that directs teachers to intervene in the case of students who are falling behind, allowing students to work at their own pace, group work, and intensive tutoring.

Here, in summary, are the ways in which assessment may change in the era of new learning:

Traditional Tests	*AI-supported, Embedded Assessments*
1. Measure long-term memory	Assess higher-order thinking
2. Address a narrow cognitive range: facts and procedures	Address complex epistemic performance
3. A peculiar test logic, unlike other places of knowledge activity	Offer a broad range of data types and data points, authentic to knowledge work
4. Limited sampling	Big Data: n=all
5. Disturbing experiences	Embedded assessment is the learner's friend
6. A linear process: backward looking and judgmental by nature	Recursive processes: prospective and constructive by nature
7. Individualized, isolating	Assess collaborative as well as individual intelligence
8. Insist on inequality	Mastery learning, where every learner can succeed

Summary

TECHNOLOGY IN LEARNING	*REPLICATING THE CLASSROOM OF THE MODERN PAST*	*CONSTRUCTIVISM AND CONNECTIVISM: MORE RECENT TIMES*	*REFLEXIVE PEDAGOGY: NEW LEARNING*
Dimension 1: Students Learning with Technology	• Passive knowledge acquisition • Individual learning • Memorizing factual content and mastering procedures that produce correct answer • Traditional academic literacies	• Learners as active knowledge makers, but replicating what is expected. • Learning may be "personalized" but remains individual	• Active knowledge making • Collaborative learning • Metacognitive reflection • Multimodal knowledge representations
Dimension 2: Teachers' Working with Technology	• Formal teaching confined to the times and spaces of classrooms • One-size-fits all learning	• Minimal recognition of diversity and its value in learning	• Ubiquitous learning • Productive diversity in learning
Dimension 3: Assessing Learning with Technology	• Summative tests: strange artifacts and often fearful experiences.	• Old testing mechanisms often remain	• Recursive feedback, reflexive pedagogy

Educational technologies, as we have argued in this chapter, can reproduce didactic pedagogies, even to give them an aura of newness that affords them a new life. Meanwhile, the principles of reflexive pedagogy are by no means new. Many of these things we have aspired to do in education for a long time. But now, with educational technologies, they become feasible. The result, we contend, will be learning that is more engaging, more effective, more resource efficient, and more equitable in the face of learner diversity. If anything has decisively changed with the emergence of new educational media, it is to offer a new economy of effort that makes long-held pedagogical ambitions more practicable. Because now we can, we should.

From Didactic Pedagogy:	*To Reflexive Pedagogy:*
1. Learning that is institutionally confined in time and space	1. Ubiquitous learning—anytime, any place
2. Transmission pedagogy	2. Active knowledge making, where learners are knowledge producers
3. Traditional academic literacies	3. Multimodal meaning and knowledge representations
4. Standardized, summative assessment	4. Recursive feedback

5. Individual memory	5. Collaborative intelligence
6. Single-level content focus	6. Metacognition, double level thinking
7. One-size-fit-all curriculum	7. Differentiated learning

Even though we now find computers in classrooms, and learners accessing their knowledge and doing their work on digital devices, the social relationships of learning have often remained much the same. How might things be different? How might computer mediated learning, big data and artificial intelligence be part of the change? If didactic pedagogy of what we might call Education 1.0 is to be replaced, what might be the shape of Education 2.0? The answer, we have suggested, as a new learning characterized by reflexive pedagogy.

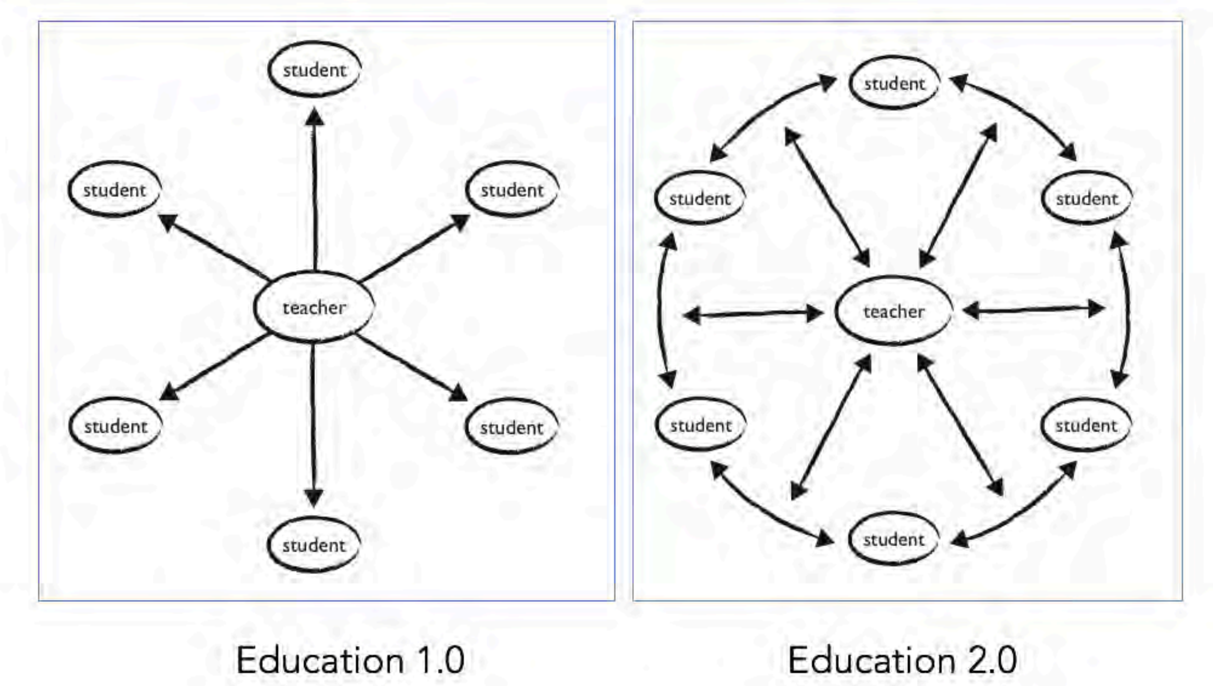


Figure 11.25: From hub-and-spoke knowledge transmission to collaborative knowledge ecologies

Education 1.0:	*Education 2.0*
Teacher-centered	Learner as agent, participant
Learner as knowledge consumer	Learner as knowledge producer
Knowledge transmission and replication	Knowledge as discoverable, navigation, critical discernment
Long term memory	Devices as ‘cognitive prostheses’—social memory and immediate calculation
Knowledge as fact, correctly executable theorem, definition	Knowledge as judgment, argumentation, reasoning

Cognitive focus	Focus on knowledge representations, ‘works’ (ergative)
Individual minds	Social, dialogical minds
Long cycle feedback, retrospective and judgmental (summative assessment)	Short cycle feedback, prospective and constructive (reflexivity, recursive feedback, formative assessment)

Keywords

Artificial intelligence – in a broader definition, more calculation than would be feasible for humans; in a narrower definition, the processes and technologies of machine learning, neural nets/deep learning, and quantum computing.

Big data – the purposeful or incidental recording of activity and interactions in digitally-mediated, network-interconnected learning environments; the varied types of data that are recordable and analyzable; the accessibility and durability of these data, and visual presentations of data analytics.

Cloud computing – moves storage and data processing off personal computing devices and into networked server farms where the social relations of information and communication can be systematically and consistently ordered.

Educational data mining – searching for and analyzing patterns in large and noisy datasets, such as incidentally recorded data (e.g. log files, keystrokes), unstructured data (e.g., text files, discussion threads), and across complex and varied, but complementary data sources.

Learning analytics – interpreting data in environments where analytics have been ‘designed-in’, such as intelligent tutors, adaptive quizzes/assessments, peer review and other data collection points that explicitly measure learning.

Peer-to-peer learning – learning arrangements scaffolded by teachers, in which peers offer each other feedback, themselves moving backwards and forwards between the roles of learner and teacher.

Knowledge Processes

experiencing the known

- What has been your experience of technology mediated-learning. Use the seven affordances framework to analyse the dimensions of that learning as you have experienced it? Would you call the experience more at the didactic end of the pedagogical scale, or more reflexive.

experiencing the new

- Identify a digital learning environment that you have not used. Look into how it works, by looking at promotional information, demo videos, or even try it out! Analyze it using the seven affordances framework. Which aspects of the environment would you consider to reflect didactic or reflexive approaches.

conceptualising by naming

- Create a glossary of terms for technology-mediated learning.

conceptualising with theory

- Create a flow diagram illustrating the dynamics of an e-learning ecology.

analysing functionally

- Analyze the technical features of a computer-mediated learning tool, and explain the pedagogical consequences or affordances of each.

analysing critically

- What do learners and teachers fear about technology? Which fears might be justified or unjustified? What can be done to allay these fears?

applying appropriately

- Create a design for a lesson or a sequence of lessons that attempts to put into practice as many of the seven digital affordances as possible given the tools and resources you may reasonably expect to have at hand.

applying creatively

- Create an imaginary design for an ideal lesson, classroom or school of the future.

Notes

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