A new paradigm for evaluating the learning potential of an ed tech activity

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This paper represents an attempt at constructing a language for describing the potential learning value of computers as a learning material. A lack of precision in describing the value computers add to the learning process has paradoxically made it easy for people to elevate the significance of using computers in pedestrian ways while simultaneously marginalising higher-order uses.

Currently, all manner of computer-based activities are granted equivalence by educators lacking a suitable metric for assessing value. When combined with the liberal and often inaccurate use of terms, like constructivist, we are left with a culture of intellectual relativism where the loudest voice sets the agenda. This work attempts to define the continuum that lies between the use of computers to reinforce traditional practice and powerful ideas.

Existing paradigms for evaluating educational technology, including LOTI or 4MAT, confuse teaching and learning while doing little judge the value of an activity. Curriculum and teacher fluency are conflated recklessly with student learning. These schemes may describe teaching practice, but offer little predictive benefit for learners.

I propose the creation of a continuum that spans the gulf between traditional education routines possibly enhanced by the use of a computer and the sort of powerful idea construction only possible with the computer's purposeful use. The subjectivity of the examples are acknowledged, but intended to generate discussion.

Introduction

This paper is not an attempt to advance a personal perspective or agenda, but to inspire an honest discussion about the state of educational computing and the technology's affect, if any, on the culture of schooling. Such discourse depends on a consistent, articulate and descriptive language for describing what learners *do* with technology in an educational setting. Such shared knowledge and terminology are necessary to advance practice.

Readers are not expected to share the same educational values of the author. The examples used in this text were chosen to model a necessary continuum, not to imply that there is one way specific way to teach or learn. It is impossible to investigate a sufficient quantity of activities in any grade level of curricular domain in any one paper, especially one of this length. While even the metrics proposed may be changed, this paper succeeds if it generates dialogue about the nature and value of learning with technology.

Previous attempts at assessing educational computing

Not all educational technology use is equivalent. Lazy rhetoric and ignorance leaves many in the educational community incapable of differentiating the educational value of particular tools or activities.

Efforts to describe differences in education approach or outcome often descend into the creation of an assessment system. It is human nature to then label, rank, sort and assign merit or value to each action

or result. Existing paradigms for describing educational computing are often reduced to simple rubrics or checklists that may be used to 'grade' performance. The assumption is that such external measures will then be used to motivate or shame educators. Neither is my objective.

Even if we were to succumb to such behaviourism, the politics of schooling often values forms of learning devoid of powerful ideas. Memorisation, mechanics and conformity are often prized at the expense of critical thinking, creativity and the free exchange of ideas. Emotional flailing and shallow justification often counter media attacks on the value of educational technology. The solution to weak educational technology implementation is not less technology, but rather more transformational use of computers.

The focus is too often on pedagogy or product

States, school districts and national departments of education have created instruments for assessing the impact of educational technology. It is beyond the scope of this paper to review all but the best known of these schemes. The Levels of Technology Implementation (LoTI) is a popular 'instrument for measuring technology use.' (Moersch, 1996–97) The LoTI framework describes six levels of computer efficiency from non-user to refinement. 'As a school site progresses from one level to the next, a corresponding series of changes to the curriculum is observed. The instructional focus shifts from teacher-centered to a learner-centered orientation.' (Moersch, 1996–97)

The following table describes the LoTI Scale used to evaluate educational technology use. (see http://www.drchrismoersch.com/loti.html for details)

0) Non-use	1) Awareness
2) Exploration	3) Infusion
4a) Integration (mechanical)	4b) Integration (routine)
5) Expansion	6) Refinement

The LoTI Scale represents just one variable in the complex arithmetic calculation required to calculate a classroom's level of computer efficiency. Moersch validates his metric by comparing his findings to those of Becker (1995) who used a survey to determine 'exemplary computer-using educators.' (Moersch, 1996–97) Apparently the results of Moersch's Computer Efficiency formula mirror the results of Becker's survey. This hardly proves the accuracy or educational value of a set of calculations dependent on such variables as the number of computers in a classroom and the amount of time they are used.

Moersch defines computer efficiency as 'the degree to which computers are being used to support concept-based or process-based instruction, consequential learning, and higher order thinking skills (e.g. interpreting data, reasoning, solving real-world problems).' (Moersch, 1996–97) Moersch reinforced his stance when he wrote, 'The level of computer efficiency is influenced directly by how teachers are using computers to develop students' higher-order thinking skills.' (Moersch, 1996–97)

If one could set aside the Dickensian goal of measuring computer efficiency and peculiar formula for deriving it, LoTI is consumed by larger intellectual inconsistencies. U.S. States offer 'LoTI training' and require teachers to take 20-minute LoTI surveys which in turn make recommendations for 'increasing their current levels.' (http://www.nheon.org/oet/loti/) Other agencies overlay LoTI on top of Bloom's Taxonomy (http://www.fisd.us/LoTi/lotisnifftest.htm) when one system is about learning and the other teaching. Several examples of LoTI Teacher Self-Assessments published on the Web don't even include the use of technology despite that being an integral part of LoTI. While it would be unfair to dismiss a theory based on its application by laypeople, LoTI itself is replete with inconsistencies, not the least of which is its constant use of the term, instruction, despite a commitment to constructivism. The fact that LoTI describes the 'school site' shifts the locus away from the learner. Such anomalies undermine Moersch's assertion that LoTI is empirical (Moersch, 2001)

Although Moersch writes extensively about a desire to shift the focus from teacher to learner his practice and the examples he offers remain firmly focused on teaching rather than on learning. One need not read more than the LoTI Framework to determine that nearly every example of technology use described by Moersch (Moersch, 1995, 1996–97, 1998a, 1998b, 1998c, 2001) is teacher-centred despite rhetoric to the contrary. Despite protests to the contrary the number of computers in a classroom, seat-time and externally imposed curricular goals are critical elements in Moersch's calculus. His expressed commitment to constructivism and a 'learner-centred orientation' is at best confused and at worst serves to camouflage the very practices he seeks to reform. Since this paper seeks a precise language for describing the learning potential of computing activities, LoTI is of limited value.

4MAT is another taxonomic system purporting to support and respect individual learning styles, except the theory's application is focused explicitly on the creation of lesson plans for teaching specific content. Again, the distinction between learning and teaching is blurred in a way favouring pedagogy. (anonymous, 2007; McCarthy, 2007)

Porter's work in evaluating student digital products is more consistent in its approach and language, but suffers from a focus on curriculum related products. Some of these products are more personal than the result of imposed curriculum, but the focus on the quality of the artefact does little to assist my quest for a language for describing learning activities. (Porter, 2001) Since the 1980s attempts have been made to develop evaluation criteria for technology use in the classroom, but most models apply a treatment model of measuring teacher actions, not the learner.

Curriculum integration, verbal inflation and technocentrism

Computer integration into the existing curriculum regardless of its rigor, creativity or level of student engagement holds limited potential as a catalyst for powerful ideas. Efforts at integration assume the relevance and value of the existing curriculum while curriculum by its very nature is a map used to steer teaching practice. Efforts to improve curriculum integration support instructionism, the belief that education results from transmission and is informed by forces outside of the learner. On the other hand, Papert's theory of constructionism builds upon the Piagetian notion of constructivism in which knowledge is constructed by the learner and suggests that the best way to ensure such learning is through the act of making something sharable. (Ackerman, 2001; Papert, 1993, 1991; Papert et al., 1991; Stager, 2002; Stager, 2007; Turkle & Papert, 1991) The computer expands the range of things one can construct and provides a means for sharing ones invention; whether it's a poem, a computer program, a robot or a film.

Few examples of computers being used as incubators for powerful ideas exist in the educational technology literature or in common practice. Either lack of imagination or a desire to preserve the status quo leads to the creation of formal documents, such as the National Educational Technology Standards in the USA produced by august sounding bodies like The Partnership for 21st Century Skills or the International Society for Technology in Education (ISTE, 2000, 2007; Partnership for 21st Century Skills', 2000). In fact, the new NETs fail to mention either computer science or programming despite an expressed commitment to technical fluency, creativity and invention. Such documents and their creators suffer from what Papert called verbal inflation at the 2005 K-12 Conference on School Networking in Washington D.C. (Papert, 2005)

Verbal inflation, Papert explained, was the use of exaggerated language to describe very little actual transformation or change in practice. Verbal inflation is often accompanied by technocentrism when an educational activity is overvalued due to the presence of a computer. 'Technocentrism is the fallacy of referring all questions to the technology.' (Papert Technocentrism) Examples of the intersection of verbal inflation and technocentrism include the use of 'office' software to 'prepare children for the real world;' word processing your book report rather than writing it with a pen; using PowerPoint to present five facts about invertebrates or using the web for 'research' instead of an encyclopaedia when the goal is paraphrasing a couple of paragraphs. Paradoxically, it is the technocentric focus on

mechanical skills or specific software applications that denies children any deep understanding of computing or agency over the device central to their lives.

Disruptive semantic trends

In the early 1980s Seymour Papert was dissatisfied with Robert Taylor's metaphors for describing school computer use. Taylor wrote about the computer as a tool, tutor or tutee (Taylor, 1980) while Papert described the computer as 'mudpie' (Papert, 1980a; Papert, 1984) and then later more generally as 'material.' (Papert & Franz, 1987) The tool metaphor dominates most discourse regarding the use of computers in education. Educators and policy-makers alike use it to describe nearly every application of 'technology.' It would be impossible to list all of the examples of 'computer as tool' in common usage or even scholarship.

Over two decades I have witnessed a semantic shift transforming the words used to describe our field from educational computing to technology to information technology or ICT. Computing is a verb, something one does. Technology is a noun made even more passive when modified by information. The implication is that the dominant metaphor for computer use in school is information retrieval, not the personal construction of knowledge.

Information retrieval represents a small part of learning. Somebody stands in front of the classroom and preaches, and information is somehow flowing into people's heads, or so it is said. But that's only one part of education. The other part, which Dewey would have emphasised, is about doing things, making things, constructing things. However, in our school systems, as in the popular image of education, the informational side dominates.

There is a parallel between an unrecognised dichotomy in digital technology and a generally unrecognised dichotomy in the education system. In both cases the informational side is best known to the general public. So the image of computers in school supports the traditional role of the teachers in their part of education-providing information.' (Papert, 1998)

The use of the word technology is almost exclusively synonymous with computer. However, the generic term implies less potential for revolutionising learning than computing which requires the purposeful actions of a user expressing new fluencies. This rhetorical trend mirrors the recent political shift in schooling away from individuality towards conformity and homogeneity. National standards and curricula move frequently the locus of control from the learner to the system; from construction to delivery.

Content

Most efforts at educational reform are concerned with changes in pedagogy or the materials used. Rarely is the content reviewed, removed or changed. Educational leadership must be concerned with subtraction as well as addition. The desire for students to master new content and develop modern skills cannot always result in the addition of new requirements to a brimming list of requirements. Some content must go.

Content dictates what children do. Since knowledge is the consequence of experience (Smith, 1995), content influences the learner's actions and determines the relationship to the knowledge they construct. The seemingly simple question, 'What do you do with computers?' provides more information about the learning experience than any complicated rubric.

A failure to make new content accessible not only reduces a learner's opportunity to construct modern knowledge, but also runs the risk of making education less relevant and students more passive. New content may not only inspire learners, but also provide a context in which additional concepts gain power. For example, a student 'messing about' with a number theory problem will internalise arithmetic. A student writing a program in French will learn a lot of computer science, mathematics and problem solving, plus become more fluent in French and perhaps learn about the system being

simulated as well. Building a robot designed to pull a great deal of mass requires an understanding of friction, force, gearing, ratio and a host of other concepts. Most importantly, prior knowledge is used to construct new understanding. New compelling models of learning with computers are essential if others are to follow our example.

Engagement

The desire to achieve a different learning outcome without changing the content is evident in educators who speak of student engagement with computers. I often hear, 'The children are so engaged.' Hardware and software companies use engagement as a marketing tool. This is a wonderful result if authentic engagement is possible. However, it may not be. Papert argues that some 'school math' is so noxious that is impossible to make it engaging without trivialising the experience. The result is a lack of rigor and powerful ideas that leaves progressive educators exposed to unpleasant criticism from instructionists.

'When ideas go to school they lose their power, thus creating a challenge for those who would improve learning to find ways to re-empower them.' (Papert, 2000) Papert describes how even big ideas, such as probabilistic thinking, are disempowered by traditional curriculum and the pencil and paper technology of school. 'It's been disempowered because you couldn't give kids any way of using it.' (GLEF, 2001)

'In a pencil and paper environment, it is very hard to be creative with mathematics. The great contribution of computers is that, it is now possible to use mathematical ideas to make things that kids care about. Making their own game. Making artwork. Turning mathematics through these activities into a useful tool for something that kids really care about. This is the secret to mathematics education. NCTM is just blind because it assumes that mathematics will always be done with pencil and paper.' (Professor Papert discusses one laptop per child project, 2006)

Probability is a powerful idea fundamental to modern mathematics, science, economics, social science and even the arts. Yet, this powerful idea is often sacrificed by directed activities in which children ask classmates their favourite flavour of ice cream and then 'predict' a new student's preference. (Papert, 2000) This school version of probability is predicated on primitive technology.

Papert suggests that rather than find yet another way to teach math that kids hate, we should invent a mathematics they can love. Such a mathematics is likely to more closely resemble the real work of actual mathematicians and have more authentic application in the 21st Century than what is taught in math class. Building a robotic 'bee' trying to find pollen or programming a StarLogo simulation situates students in a context for using the powerful idea of probability.

'We've got the technology to be able to have kids solve for themselves the kind of problem that nature solved using randomness. But of course, that doesn't fit into the second-grade curriculum, so we don't do it. Or we reduce probability to some little spinner and see how often (the number) six comes up. Who cares how often six comes up? You can't do anything with it.' (GLEF, 2001)

Frankly, very few educational practices are borne of student desire. 'They are so engaged' is often used as justification for questionable practice. The belief that learning should be hard and unpleasant often accompanies cries of engagement. However, engagement need not be superficial or technocentric. It may accompany rigor, purpose and creativity. Engagement is the result of powerful ideas, not a substitute.

'Kids like computers … I think it corresponds to children wanting to control an important part of the world … They can feel the flexibility of the computer and its power. They can find a rich intellectual activity with which to fall in love. It's through these intellectual love affairs that people acquire a taste for rigor and creativity.' (Brand, 1988)

Some content leaves learners hostile or reluctant to learn. If the old content or skills are so invaluable, they will be learned in the context of learning something else. Repetitive demands to learn what may be, at least temporarily, unlearnable may diminish a student's motivation, result in learning pathologies and reduce the chances of learning that content at a later date.

Abandoning content, after careful reflection, is not an admission of failure. It may be an act of liberation—opening the door to new learning adventures.

When faced with declining enrolment in university computer science and substantial attrition rates following the introductory course, Guzdial and Soloway did not search for a new way to teach better. They examined the course content and decided to replace curricular staples, such as sorting algorithms, with the creation of web spiders and graphic manipulation programs. This content was more current, relevant and challenging. The content shift allowed students to not only do more sophisticated work, but it also improved student attitudes towards the study of computer science; leading to further matriculation. (Guzdial & Soloway, 2003)

'We should change the way we talk about schools by talking less about learning and teaching, and more about doing. When we focus on teaching specific skills, students frequently fail to learn them and rarely become enthusiastic about engaging in them voluntarily. When we concern ourselves with engaging students in interesting and comprehensible activities, then they learn.' (Smith, 1995)

A reluctance to review traditional content may be based on heuristics, but it may also be based on the reluctance of some teachers to develop new skills and subject matter knowledge. Digital learning communities extending beyond the four walls of the physical classroom may offer students access to expertise unavailable in school.

Describing the potential of an activity

A more precise language is needed to describe the potential for encountering powerful ideas during a computing activity. The primacy of the activity must be the focus if we are to articulate the ways in which computers may enrich the learning process.

I have grappled with the creation of a matrix suitable for explaining complex learning theories and have yet to determine a formula for predicting the probability of encountering powerful ideas. Deriving such an algorithm is likely impossible.

There are numerous overlapping ways of describing any educational activity. A series of continua might represent agency, the novelty of an activity, the learning theory expressed, the contribution of the computer and the degree of creativity involved. These descriptions fall along continua, including:

Traditional Activity	*To*	*Novel Activity*
No Computer Use	To	The Computer is Integral
Teacher Agency	To	Learner Agency
Instructionism	To	Constructionism
Replication	To	Invention
Routine Activity	To	Transformational Activity

When these continua are condensed, activities may be described by points along the span between extremes described as *Routine Activity* and *Transformational Activity.* At one end of the continuum traditional content is presented in a teacher-centred fashion with little or no use of the computer. At the other extreme a person learns in a personally meaningful fashion resulting from the critical role the

computer plays in maintaining a conversation with the human user. The activity is impossible without computational power.

The learner might experience 'flow' (Csikszentmihalyi, 1991) while the answer to a good question leads to an even better question or a more complex hypothesis. 'Bugs' are an opportunity for the learner to rethink their strategy or try an alternative approach. A successful action by the learner may lead to a serendipitous discovery or motivation to attempt a more challenging feat. Activities falling in the right-hand column are demonstrably richer due to computer access and open-ended software or programming languages, such as Logo. Transformational activities offer the greatest potential for encountering powerful ideas.

> My goal in life … has been to find ways children can use this technology as a constructive medium to do things that no child could do before, to do things at a level of complexity that was not previously accessible to children. (Papert, 1998)

Vignettes along the activity continuum

The examples provided in this paper are mathematical in nature. Other domains may be explored in subsequent work. However, it seems obvious that an activity like digital movie making would progress along the continuum based on well-established aesthetic values. Evaluating how well the movie entertains, communicates, inspires, surprises, enrages or engages the audience are of greater value than how many transitions were in the movie, if special effects were included or if there were more than three people interviewed. The isolated technical skills assessed by teachers armed with rubrics are of less importance than the learning experience of the learner and her audience or collaborators.

Although far from empirical, it may be possible to divide the continuum into five pairs or ten units.

Routine Activity—Teacher-centred   **Little impact of Computers**

Level 1   *Level 2*

A student solves dozens of similar arithmetic problems on a worksheet in an attempt to memorise his multiplication tables.

A student uses a piece of computer-assisted software to play a game in which the frequency of problems presented increases after a correct answer. This is thought to increase recall of math facts.

Explanation of Levels 1 & 2: Level 1 describes an activity that is teacher-directed, routine and does not require or benefit from the use of a computer. In Level 2, the computer may make the activity a bit more fun or even lead to slightly greater efficiency. It hardly improves the learning of arithmetic or situates it in a meaningful context.

Level 3   *Level 4*

A student uses tactile manipulatives to make patterns on her desk. Tangrams or pattern blocks may be used. The teacher may expect that terms like symmetry or tessellation will be remembered as a result of the activity.

Computer software provides virtual manipulatives on the computer screen that allow a child to produce an infinite number of a piece, change their colour, save and print the designs created.

Explanation of Levels 3 & 4: Level 3 uses tactile objects to make geometric concepts more concrete, but those concepts remain decontextualised and the activity only exists because of a teacher's insistence. Many advocates of educational computing would view this level 4 activity as innovative even though a purpose for using manipulatives remains inauthentic and a mystery to the user (perhaps the teacher as well). The features of the software may lead to an impression of 'false complexity,' even when the activity itself may be of little merit.

Level 5

A child uses Logo to write procedures replicating the shapes found in the assortment of physical manipulatives. The teacher may explain the 'total turtle trip theorem' at the board.

or

The teacher uses Geometer's Sketchpad and a projector to present a new concept to the class.

Level 6

A child develops a strategy for writing Logo procedures that allow the virtual manipulatives she created to be moved, oriented and tessellated.

or

A student uses Geometer's Sketchpad to explore forms of symmetry or to draw a line through the perpendicular bisector of a figure.

or

The teacher challenges students to use LEGO robotics materials and Logo to build a vehicle that goes down an incline very slowly. This requires the use of gears and exploration of physical science principles.

or

The teacher instructs each student to create an Excel spreadsheet to find the average of five numbers.

Explanation of Levels 5 & 6: In both level 5 activities, the computer is used to teach geometric concepts that the teacher or set curriculum requires. Student motivation is not a concern. The turtle geometry activity does offer the possibility that students will learn the shapes with greater understanding and comprehension since they are 'teaching' the turtle to draw them; therefore describing the relationships that form the shapes.

Although the level 6 activities are anchored in the curriculum, the computer is essential and the students may express a bit more autonomy, ownership and divergent thinking. However, it is possible to have Geometer's Sketchpad draw the perpendicular bisect without the student having any greater understanding of the concept than had it been presented without a computer.

Level 6 represents the point at which students are first engaged in projects where they are actively engaged in making something as a way of constructing knowledge.

Level 7

A child designs an interface for her virtual manipulatives that allow the pieces to be stretched, shrunk, collared differently and overlapped. The interface is designed for her friends to use in making their own original designs.

or

A student uses Geometer's Sketchpad to understand a concept that would otherwise taught three years later.

or

Level 8

A student uses Geometer's Sketchpad to help perfect a skateboarding move.

or

The girls decide they would like their robot teddy bear to sing. They locate a piece of sheet music, convert all of the notes, rests and durations to numerical values Logo will understand and once they complete their program they ask it to play. The music plays too quickly, but the intervals appear to be correct. The girls brainstorm and determine that multiplying each duration by a constant will slow the music down.

The class is engaged in a thematic unit about carnivals. A group of eight year-old girls decide to use LEGO and Logo to make a stuffed teddy bear dance. A skeletal system must be built that can transfer the rotational motion of the motors into the up and down motion of arms and legs.

or

Tim is able to use Excel to create a catalogue of his baseball cards, complete with each card's current value and is able to find out how much he might earn if he sold the entire collection.

or

Each student in Miss Crabtree's class is asked to create a database containing the address and phone numbers of at least four friends.

or

Tim manipulates Excel so he may explore how much money he might earn if he just sold the cards of Yankees players. He can also project how much his collection might be worth by the time he goes to university based on information he found on the Web.

or

Michael invents a LEGO robot, programmed in Logo that graphs fluctuations in temperature over multiple days using one roll of adding machine tape and a mechanism with a complex gear ratio.

or

A five year-old girl wants to make a dancing ballerina out of LEGO and programs it to spin via Logo. The ballerina has two touch sensors that allow the girl to spin it left or right. She changes the rate of spinning by using different combinations of gears, by changing the voltage being sent from the computer to the LEGO brick and by inserting wait commands to her Logo program.

Explanation of Levels 7 & 8: The level 7 activities are much more dependent on the computational power of the computer, although the projects themselves remain consistent with the artificial nature of the curriculum in which teachers are told to teach specific concepts or tools at a specific time. Using Geometer's Sketchpad to learn something previously taught at a later time demonstrates the value of the computer in making sophisticated concepts accessible at an earlier age by concretising them.

Level 8 activities mark a significant shift in agency between the desires of the teacher and those of the learner. Learners engage in personally meaningful projects requiring the use of the computer as material. Invention, ingenuity and intrinsic motivation are critical aspects of levels 8–10.

Level 9

Rather than use Geometer's Sketchpad to draw geometric figures and observe corresponding tables of values. Students use Microworlds EX to design their own geometry toolkit. The addition of each successful feature leads to the addition of new functionality. Defining midpoint becomes a tool for finding the area of a triangle. Using sliders representing length and exterior angle allows the students to design a tool for drawing regular polygons. A more sophisticated understanding of geometric terms results from teaching those concepts to the computer in the form of a program.

or

Level 10

Students present what they learned from their careful data analysis to the government in order to advocate for a new swimming pool, cleaner rivers or after school programs for children of single parents.

or

Susan 'Googles' 'the Hailstone Problem,' learns that there is an annual conference for mathematicians dedicated to the problem, emails the organiser of the conference and develops an ongoing dialogue about number theory.

or

The graph produced by Michael's scientific

Each student locates census, economic, health, agriculture or political data for an entire state or nation. Thousands of records are involved. Importing that tab delimited data into a spreadsheet or database program allows each student to interrogate the data and perhaps answer a question nobody has ever asked before. Graphs and charts of trends may be presented to their peers.

or

An unsolved number theory problem, the Hailstone Problem, becomes a source of good natured rivalry between students looking for interesting patterns while simultaneously using a Logo-based toolkit to discredit the hypotheses of their peers.

or

Michael uses calibrates and validates the accuracy of his LEGO instrument and uses it to monitor an experiment in the science lab.

instrument leads to further investigations in the lab.

Explanation of Levels 9 & 10: The sophisticated activities described in level 9 are learner-centred, yet consistent with curricular objectives. The activities are completely dependent on computers and open-ended software. The projects allow for a significant amount of student creativity, problem solving and critical thinking. Correct and incorrect answers are no longer the goal or perhaps even possible. New forms of modern knowledge are accessible to the learners because of the nature of the activities and the power of computer. Learners construct powerful ideas related to a variety of disciplines.

Learners in level 10 are able to use communication and computational technologies to engage in an intellectual (or creative) community of practice outside of their classroom. They may not only share their newly constructed artefacts and the resulting knowledge with peers, but with the community and other experts. It is at this level that learners are doing the real work of mathematicians, engineers, scientists, composers, poets etc. It is quite possible for level 10 students to make genuine contributions to knowledge.

Conclusion

Activities at Levels 1–5 do not require the use of the computer. Its use tends to be gratuitous in such activities and contributes little value to the learning experience. Activities at Levels 6–10 are dependent on the computer. The computer not only enhances the learning experience, but is the material at the centre of the knowledge construction. The value added by the computer increases as the nature of the activity becomes more modern, learner-centred, constructionist, complex and inventive. It is at the nexus of these factors that powerful ideas become accessible.

> One can take two approaches to renovating School—or indeed anything else. The problem-solving approach identifies the many problems that afflict individual schools and tries to solve them. A systemic approach requires one to step back from the immediate problems and develop an understanding of how the whole thing works. Educators faced with day-to-day operation of schools are forced by circumstances to rely on problem solving for local fixes. They do not have time for big ideas. (Papert, 2000)

Transformational computing activities remain viable as long as educators are able to articulate compelling descriptions of the activities in which the learner participates. The telling of these 'learning stories' (Papert, 1993) is dependent on more precise language capable of differentiating between the potential value of an activity.

Too many paradigms for assessing educational technology efficacy focus on teachers, not the actions of students. Analysts and critics who confuse teaching and learning exacerbate this situation. Greater clarity is imperative. This paper discusses one attempt to construct a language for discussing practice and urges practitioners to place greater focus on the nature of the activity—what learners do with computers. This not only contributes to more reflective practice on the part of educators, but also ensures greater equity in learning experiences for students and a greater return on technology investments for the community.

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