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Towards a Model for Assessment in an Information and Technology-rich 21st Century Learning Environment

Johannes Cronjé

In a world where *Google* knows what you are asking even before you have finished typing, the question becomes, “What is left to learn?” or, for that matter, what should we assess if learners carry all the answers around in their pockets?

There are many definitions of learning, but the one that I like best is the one that says *Learning is being able to do something afterwards that you could not do before*. The main problem with this definition is that, thanks to technology, there are numerous things we are now able to do, which we were not able to do before—such as navigate through traffic taking the optimal route in real-time by using GPS, or recognize a piece of music never heard before using *Shazam*, or tell the distance to the flag on a golf course by pointing a cell phone at it. Even converting from one currency to another, taking into account the rate of exchange at any given date, or determining how much paint is needed to cover a wall can be done from an internet-enabled cell phone without any calculations. So, now the definition breaks down. With every new app downloaded to a smartphone a learner can do something new, without having engaged in any mental effort. So from “what is left to learn?” we move to “what should we assess?”

In response to this problem there has been a shift in assessing for learner attributes, rather than for actual learning outcomes. Most notably Tony Wagner, as early as 2008 called on schools to help learners achieve seven “survival skills”, such as *Critical Thinking and Problem Solving, Collaboration and Leadership, Agility, and Adaptability, Initiative and Entrepreneurialism, Effective Oral and Written Communication, Accessing and Analyzing Information, and Curiosity and Imagination* (Wagner, 2008).

Even with these skills in place, though, the problem still lies in the fact that the actual learning is still hard to define. The person with the best technology is the one who can do the most—provided of course that person knows how to use the technology. There’s the rub. It is not the person with the best technology, it is the person with the best technology who knows how (and when) to use it that is most likely to be able to do all these things.

Dave Cormier and Bonnie Stewart move closer when they argue that we live in a *rhizomatic* age (Cormier & Stewart, 2010). In this paper I argue that rhizomatic learning is not so much a matter of learners having to adjust to a hyper connected world, but rather it is that the locus of learning has shifted from the learner to the rhizome. Before the ubiquity of the Internet, the knowledge

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bottleneck was at the duplicating room. Learners could only be expected to learn as much as teachers could duplicate. Now the bottleneck sits between the ears of the learners. Learners can only learn as much as they can take in. However, in the connected rhizomatic world, the whole system is learning and thus what we have to do is connect and ride along. The shift in the bottleneck thus calls for a re-evaluation of what we currently assess. There needs to be a shift in emphasis from evaluating the learner's *collection* of knowledge, skills and attitudes to evaluating the learner's *connection* to the system in which they survive using Wagner's skills.

Rhizome Theory

Where knowledge is traditionally represented as a branching tree, Rhizome theory (Deleuze & Guattari, 1987) argues that knowledge can be entered and exited from multiple directions. Knowledge is thus better represented by a web structure than by a tree structure. In an environment where most of our information comes from the World Wide Web, a web makes a strong metaphor for knowledge and learning. Where a tree structure implies a hierarchy with something at the top, and some root structure, the rhizome implies a non-hierarchical, flat structure that favours organic growth above one of causality and chronology. Rhizonomic learning, therefore, would allow for learning at the time of need, rather than learning at the time specified by the curriculum. In fact, the rhizome *becomes* the curriculum (Cormier, 2011).

Learning in the 21st century has also been called *Learning 3.0*, hinting at learning in a Web 3.0 environment (Rubens et al., 2014). In a Web 1.0 environment, information is presented by the provider to the user on a static web page. Web 2.0 is the social web, where users provide information and interact with information of other users through social media such as blogs, and social sites such as *LinkedIn*, *Facebook* and *Twitter*. Web 3.0 brings the inclusion of the *device* and the *system* as partners in the production of information. When a Web 3.0 user uses an Internet-enabled device to search information on *Google* for instance, then the user's current and previous behaviour, as well as the location of the device, is factored into the search and in that way the user, the device, and *Google* have obtained more information. The more users use their devices, the more *Google* learns about them, and the more able they become to do things that they were not able to do before.

The link between Learning 3.0 and the rhizome is clear. There are no hierarchies. The learner, the system and the device are equal partners. The movement is multi-directional and occurs at the time of need, rather than at a time specified by a curriculum.

There needs to be a shift in emphasis from evaluating the learner's collection of knowledge, skills and attitudes to evaluating the learner's connection to the system in which they survive.

Rhizomatic Implications for Assessment

Six principles govern the rhizome: Connection, heterogeneity, multiplicity, asignifying rupture, cartography and decalcomania (Deleuze & Guattari, 1987). It stands to reason that the survival skills of 21st century learners need to be measured against the extent to which they accommodate, or even exploit the rhizome, since we are effectively assessing how they adapt to their complex environment.

Connection

The principle of connection holds that “...any point of a rhizome can be connected to any other, and must be” (Deleuze & Guattari, 1987, p. 7). In the context of 21st century learning this means that learners, teachers, information and technological devices are all connected. Moreover, there is no such thing as discrete knowledge areas. All knowledge is connected to all other knowledge. The principle of connection resonates with the educational theory of connectivism, which argues that:

- Learning and knowledge rests in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning.
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision (Siemens, 2005).

Bringing non-human agents into the conversation opens the door to actor-network theory (Latour, 2005). Actors in a network can be human or non-human. Thus, the technological device that assists in the learning process becomes an actor too, and enters into the learning conversation. However “as soon as an actor engages with an actor-network it too is caught up in the web of relations, and becomes part of the ‘entelechy’” (Latour, 2005, p. 27) . *Entelechy* meaning both working and remaining the same, thus dynamic and static at the same time, is a good summary of the nature of networks. If there is no tension in the network it will stagnate. If there is too much it will tear apart. The

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network, furthermore, is both material and semiotic. It is a network of things and a network of meanings. The actors in the network (both human and non-human) are therefore both physical objects as well as units of meaning.

The principle of connection and its associated theories have a number of implications for assessment. The bulleted list below responds to the eight principles of connectivism discussed above, as well as the principles of activity theory.

- Assessment should recognise diversity in opinion—a learner should be assessed on the quality of the argument rather than the ability to reproduce the opinions of others.
- The ability to recognise the quality of information sources is more important than being able to obtain the information.
- The ability to interact with non-human actors in obtaining information and making meaning is a skill that should be taught and assessed.
- Assessment should focus on the ability to learn, rather than on what has been learnt.
- The quality and sustainability of learners' networks should be assessed.
- There should be a very clear focus on learners' ability to recognise connections between fields, but also to spot false connections.
- There is no point in assessing learners' knowledge of information that is not current.
- Learners should be involved in deciding what should be assessed.
- Assessment is both a material and a semiotic process—both things and meanings need to be assessed.

In a world where people's attention is constantly distracted by the multiple stimuli that confront them it makes no sense that we still try and assess learners for how well and how long they are able to concentrate on a single task. Instead, we need to assess how well they cope with the multi-sensory connected world.

Heterogeneity

Where the industrial age brought with it the idea of batch processing and a desire for homogeneity, the information age has given us the ability to deal with diversity. This section will consider diversity in demographics, interest, and learner characteristics.

The Organisation for Economic Co-operation and Development (OECD) shows a major shift in student demographics since 1995. Student numbers in OECD countries have grown from 39% to 60%. The average age of students varies from lower than 19 (Belgium, Japan and Indonesia) years, to over 25 (Iceland,

Assessment should recognise diversity in opinion, should focus on the ability to learn (rather than on what has been learnt), and learners should be involved in deciding what should be assessed.

New Zealand and Sweden). There is a strong growth in women entering higher education and generally the percentage of students who study outside their own countries has doubled to 4%. Social Sciences, Business and Law are the most popular fields and Science Technology Engineering and Mathematics are the least popular fields (OECD, 2013).

In recent years, much research has been done on learner characteristics, such as learning style (Kolb & Kolb, 2013), cognitive style (Kozhevnikov, Evans, & Kosslyn, 2014), multiple intelligences (Gardner, 2011), emotional intelligence (Goleman, Boyatzis, & McKee, 2013), learning preferences (Fleming, 1995; Vark Learn Limited, 2015), and brain profile (Lumsdaine & Lumsdaine, 1995). Nevertheless, there seems to be very little evidence supporting the hypothesis that matching a learner's style will lead to improved performance (Klein, 2003; Pashler, McDaniel, Rohrer, & Bjork, 2008). Recently it was shown that individual differences do not lead to differences in decision making (Galotti, Tandler, & Wiener, 2014). Nevertheless, although accommodating individual differences may not significantly improve results, it may well add to learners' enjoyment or motivation to learn and in that way lead to attitudinal, rather than scholastic improvement (Dunn & Dunn, 1993; Schick, 1979).

Heterogeneity in education has a number of advantages. It gives access to more students, teaches tolerance and respect for the 'other', encourages cooperation and mutual help, allows for the development of richer personal resources, and challenges teacher development (Class & Class, n.d.) It has been found that dealing with heterogeneous groups by ability grouping has a significant effect when high achievers are grouped together and given enriched learning, but no improvement has been shown for low-achieving groups (Good, 1997; Kulik & Kulik, 1982). Another way of dealing with such diversity has been to adjust for individual needs, which seems impractical. A solution lies in creating a context in which a class is seen as a group of individuals who make their own meaning (Millrood, 2002). Such a context is created by keeping students motivated through variation and interest, reaching individuals by collaboration, individualisation and personalisation, and providing for different levels by open-ended assignments and a variety of compulsory and optional work (Class & Class, n.d.).

The implications for assessment for heterogeneity, is a move in thinking from *university* to *diversity*. One needs to ask questions such as:

- Is the performance adequate for the age of the learner?
- Has the assessment accounted for language barriers?
- Have learners added personal value to the content based on their particular style or preference?

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- Has the learner taken care to value the significance of the ‘other’ in the assignment?
- Do the learners show collaborative skills?

Multiplicity

In terms of Rhizome theory multiplicity holds that the multiple is the unit (Deleuze & Guattari, 1987). In other words, everything has a multiple. Bergson (2001) identifies two types of multiplicity: continuous and discrete multiplicities. Table 1 shows a comparison between the two types.

Table 1. Continuous and discrete multiplicities (Adapted from Bergson)

Continuous Multiplicities	Discrete Multiplicities
Differences in Kind	Differences in Degree
Divides Only by Changing in Kind	Divides Without Changing in Kind
Non-numerical-qualitative	Numerical-quantitative
Virtual Differences	Actual Differences
Continuous	Discontinuous
Succession	Simultaneity
Fusion	Juxtaposition
Duration	Space

Adjust for individual needs by keeping students motivated through variation and interest, reaching individuals by collaboration, individualisation and personalisation, and providing for different levels by open-ended assignments and a variety of compulsory and optional work.

The types of multiplicity can be identified across various multiples. This paper will consider three multiples: Multiple lives, multiple devices, and multiple truths.

In a world of ubiquitous connectedness and with the flat, rather than hierarchical structure of the rhizome, the number of roles played by teachers and learners have both increased and blurred. Teachers have become learners—learning not only about the subject, but also about the learners. Galloway and Lesaux (2014) identify five roles of a 21st century teacher: Leader, teacher, diagnostician, colleague, and change agent. It is therefore necessary to recognise the tensions that arise as teachers re-adjust to their changed position (Taylor,

Klein, & Abrams, 2014). Learners, on the other hand have as much access to Internet-based information as the teachers have, and thus have become teachers of themselves, their peers, and their teachers. As their portfolios become digital rather than paper-based, so they become focused more on an online portfolio as an identity, rather than an archive; at the same time they become more future-focused, recognising the value of the portfolio as a way of getting a job (Bennett, Rowley, & Dunbar-Hall, 2014). In such a context, assessment actually means learning about the learner.

Multiplicity in devices is both continuous and discrete. There are numerous devices that can perform the same functions, and one device can perform numerous functions. Thus, for instance one can use a smartphone, a tablet, an e-reader, a computer or a printer to read a document. Then again one can use a smartphone to make and receive voice calls, read emails, send text messages, communicate on social networks, perform calculations, listen to voice and music and watch videos. The divergence of technology has enabled the multiple to be the one, and the one to be the multiple. Multiplicity brings with it complication as well as simplicity. Life is simplified since at any given time one can perform any given function with whatever device is handy. Life is complicated since one has to navigate the complexity of various devices and platforms with which a task can be done. The rhizomatic nature of knowledge has meant that there are numerous ways to arrive at information. Nevertheless there are also multiple truths, and it may be difficult to distinguish between options. On the other hand two different truths may hold for the same situation under different circumstances, as is shown by the two explanations of the shape of the Fish River in Namibia in Figure 1.

Figure 1. Why does the Fish River loop like a Snake?

The mythological explanation for the shape of the river is placed first—that it was shaped by a snake trying to escape from San hunters. The scientific explanation, that it flows on a low-gradient plane without direction is second. Although this is a humorous dichotomy, there are some that are more serious—particularly those that are subject to scientific debate while having life-changing implications for the rest of us: Is the Banting diet good or bad? Is there a relationship between high-cholesterol foods and heart disease?

In the Learning 3.0 context, assessment actually means learning about the learner's multiple identities and their ability to manipulate various devices across various platforms to reach specific objectives or achieve particular outcomes.

The implication of multiplicity is that the teacher needs to understand that assessment is not a binary function to determine if the learner is good enough or not. The purpose of assessment is to obtain as accurate a picture as possible of the multiple identities of the learner. The focus of assessment should not be on what has been produced, but on what might be produced in the future. What should be assessed is the learner's ability to manipulate various devices across various platforms to reach specific objectives or achieve particular outcomes, such as:

1. To what extent is the learner able to balance efficiency and effectiveness by selecting the optimal tool for a given task?
2. How does the learner create a safety net by using the redundancy inherent in multiplicity?

The assessment should consider the extent to which a learner is able to distinguish the truth in a given context, and the assessor needs to realize that the result of an assessment is but one truth out of many others that exist simultaneously.

Asignifying Rupture

Whenever a piece of the rhizome breaks off it begins to grow afresh. Every piece of knowledge has the potential of growing into a new set of insights. The principle of transfer is not new in education, but in a rhizomatic environment it is central. "The transfer of learning is universally accepted as the ultimate aim of teaching" (McKeough, Lupart, & Marini, 2013, p. vii). Transfer, however, is always difficult to measure (Cormier & Hagman, 2014). Aspects to consider in the measurement of transfer include the direction and the extent of transfer, as well as the nature of transfer, be it motor, cognitive, or metacognitive (Cormier & Hagman, 2014). Gagné (1985) distinguishes between vertical transfer, where the subsequent skill depends directly on the acquired one, and lateral transfer, when the learner realizes that a skill acquired in one field can be used in another—such as fractions in a classroom translating to dividing slices of pie. Motor transfer relates to physical skills—whether weight lifting might lead to increased performance on the sports field, while cognitive transfer relates to knowledge, and metacognitive transfer concerns attitudes.

The main problem in assessing transfer is that the skills being assessed need to be measured outside of the environment in which they were achieved. It is not possible to measure transfer in the classroom—it needs to be assessed in the workplace. Here is where portfolios, peer assessment and workplace assessment become important. More importantly, however, one should be assessing the extent to which learners have the ability and attitude of seeing how whatever knowledge, skills and attitudes acquired can be transferred onto other situations.

The assessment should consider the extent to which a learner is able to distinguish the truth in a given context, and the assessor needs to realize that the result of an assessment is but one truth out of many others that exist simultaneously.

- How appropriate is the size of the “chunks” of knowledge that the learner has “broken off”?
- To what extent has the learner shown that this knowledge can be applied in other areas?
- How well does the learner apply this knowledge outside the classroom?

Cartography

The concept of cartography holds that the rhizome represents a map, rather than a tracing. This means that each learner has an individual map, and that one learner cannot trace another’s map. Recently the mapping of understanding as a form of learning has become very popular. It makes sense to use a map that shows connections when one deals with a connected environment. Davies (2011) distinguishes between mind maps, concept maps, and argument maps, pointing out that each type may have a different application. Nevertheless for the sake of this essay the concept of getting a learner to draw a map linking various pieces of information is good enough.

What is important though, is that learners should be encouraged to generate their own maps, rather than simply to trace those that the teacher draws. Traditionally, a teacher would set learners a task of taking a piece of material and converting it into a map. Invariably such a map ends up having the headings and sub-headings of the chapter as branching structures. The result is then a tree of knowledge, rather than a web of knowledge. Instead, learners should be encouraged to have three foci in the map. They put themselves in the middle, the learning material to one side, and the environment, both physical and intellectual on the other side. The map then shows the relationship between the learner, the material being learnt, other connected material, and the environment in which the learner is. In this way, no two maps can be the same, since no two learners are the same.

- How complex is the map that the learner has drawn?
- How accurately does the learner’s map reflect the field?
- How well does the learner establish him/herself in the field? (i.e. maps himself/herself onto the knowledge area)

Decalomania

Decalomania refers to the production of an endless series of repeating patterns that are usually fractal by nature. All learning, grammar, history, poetry, mathematics involves recognizing the underlying patterns and how they repeat themselves, as well as the exceptions. For instance, memorizing multiplication tables does not involve simple, mechanical rote learning. It involves learning the pattern. The five times table, for instance, contains all the numbers that end

Learners should be encouraged to generate their own maps towards an outcome, rather than to simply trace those that the teacher draws.

in 0 and 5. The nine times table contains all the numbers that together add up to nine ($9 \times 9 = 81$, $8+1 = 9$).

In assessing learners, therefore, it is of significant importance to judge the extent to which they recognise patterns—and also distinguish between similar and dissimilar patterns. They also need to understand how those patterns develop over time, and what governs their formation. The patterns that learners need to recognise are not just subject-related. There are the cultural patterns in the community and the patterns of behaviour expected from them in their place of learning. A good example of such pattern recognition beyond the textbook would be the school pupil who starts off looking exactly the same as all the others, but soon realizes what it takes to become a part of the leadership group in the school. When that learner moves to another school or moves up to university, it does not take long before he or she again fits into the leader group. It is a matter of recognising the pattern and emulating it.

- What patterns did the learner recognise in the field?
- To what extent are these patterns valid?
- How do these patterns compare with patterns in other fields?

Conclusion

Assessing rhizomatic learning may be possible along a matrix where the principles of the rhizome are plotted against the desired outcomes and the resultant cells get populated with a substantiation of the learner's performance in a particular field. So, the principles of the rhizome would form the headings at the top of the table, and the subject outcomes would label each row, as will be seen in the worked example lower down. In this way the assessment is not binary—pass or fail, or even linear somewhere between zero and 100%. Instead there will be a flat plane describing the points where the best connections for a particular learner occur.

As an example, Tony Wagner's (2008, 2012) survival skills could form the outcomes against which the rhizomatic learning is measured. Table 2 shows how such a matrix could be assembled. Say, for instance a learner had been given an assignment. An assessor could then check the extent to which the principles of the rhizome were matched with the survival skills. In the hypothetical situation contained in Table 2 the assessor found that the principle heterogeneity had contributed to critical thinking and problem solving, since the learner had to take a variety of different perspectives into account. The principle of connection was useful in developing leadership, since the learner had to deal with a group of associates in doing the assignment. The principle of multiplicity meant that the learner had to be agile and adaptive. Since the learner had to develop an individual assignment that was unlike any other, the work was a map, and not

In assessing learners, it is important to judge the extent to which they recognise patterns, distinguish between them, how those patterns develop over time, and what governs their formation. The patterns that learners need to recognise are not just subject-related. There are cultural patterns in the community and patterns of behaviour, as well.

a tracing—following the principle of cartography. The learner had to develop patterns of communication and write the assignment according to a specific format. The endless transformation of assignments into the same format relates to the principle of decalcomania. Assignifying rupture meant that the information had to be accessed and analyzed for its usefulness and transfer, as did obtaining the information through curiosity and imagination.

The resultant matrix (Table 2) is a simple suggestion that would give a more refined insight into the performance of the learner than a simple grade out of 100. The table could be refined ever further if each cell were filled with a narrative explaining how those aims were achieved. Moreover, those cells where there were no overlaps could contain narrative explaining why such overlaps did not occur. Finally, of course the various intersections could be linked up, and in that way could produce an actual rhizomatic sketch of the learning event.

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Table 2. Proposed Assessment Matrix

	Connection	Multiplicity	Heterogeneity	Assignifying Rupture	Cartography	Decalcomania
Critical Thinking and Problem Solving		X	X			
Collaboration and Leadership	X			X		
Agility and Adaptability		X				
Initiative and Entrepreneurialism					X	
Effective Oral and Written Communication	X					X
Accessing and Analyzing Information		X		X	X	
Curiosity and Imagination		X		X		X

Recommendations

Traditional assessment is mainly nomothetic. The assessment first concentrates on the whole population, and then plots the individual learner somewhere inside the bell curve. Such an assessment, however, does very little in explaining the extent to which an individual learner has been able to cope with a particular context and tells us nothing about how a learner's performance might change if the context changes. In essence, what this paper calls for is an ideographic assessment of the Rhizomatic nature of learners' personal learning situation, rather than a nomothetic rating of their performance in a standardized test. The integrative matrix suggested in this paper is but one possible application of Rhizome theory to the assessment of learning. Of course, it could well be possible to put any other set of outcomes on the vertical axis and assess the extent to which they were realized rhizomatically. Furthermore, the patterns which form when multiple learners work together and create their own maps could lead to even more complex descriptions. The assessment shifts from the *collection* of the learner's knowledge, to the *connection* of the various knowledges in the system.

This paper calls for an ideographic assessment of the Rhizomatic nature of learners' personal learning situation, rather than a nomothetic rating of their performance in a standardized test. This shifts assessment from a collection of learner's knowledge, to the connection of the various knowledges in the system.

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About NILOA

- The National Institute for Learning Outcomes Assessment (NILOA) was established in December 2008.
- NILOA is co-located at the University of Illinois and Indiana University.
- The NILOA website contains free assessment resources and can be found at <http://www.learningoutcomesassessment.org>.
- The NILOA research team has scanned institutional websites, surveyed chief academic officers, and commissioned a series of occasional papers.
- NILOA's Founding Director, George Kuh, founded the National Survey for Student Engagement (NSSE).
- The other co-principal investigator for NILOA, Stanley Ikenberry, was president of the University of Illinois from 1979 to 1995 and of the American Council of Education from 1996 to 2001.

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