Towards a non-trivializing education

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Abstract

Purpose – The purpose of this paper is to propose a model of education that is non-reproductive; that is, productive of non-trivial machines. The reason for this is the postulate that society's main problems are second-order deficiencies, which cannot be fixed by doing what we do better or more intensely, but rather by changing what we do.

Design/methodology/approach – This paper proposes several guidelines for non-reproductive education based on Von Foerster's concept of a non-trivial machine and of legitimate questions, and Ashby's law of requisite variety. The ideas presented are corollaries and the result of a philosophical fleshing-out of said concepts and laws.

Findings – In order to have a non-reproductive education, it is necessary to limit the role of central control and promote self-evaluation in education at every level of recursion: that is, in the relationship between state and educational institutions, educational institutions and teachers, teacher and students and students as evaluators of themselves.

Originality/value – First, the concept of genuine self-evaluation is proposed, to distinguish this from what is currently called self-evaluation; which, it is shown, is not truly so. Second, the concept of authentic research is proposed, as distinguished from original research. This is useful for seeing how legitimate questions work at all levels of education. Third, a number of relationships between cybernetics and philosophical thought are established. Fourth, a model for non-reproductive education is proposed.

Keywords Control systems, Philosophy, Cybernetics, Education, Learning, Social change

Paper type Conceptual paper

1. Introduction

If current societal ills are mainly a product of our social system rather than of its failure, a feature and not a bug, it would be pointless to attempt to fix them by perpetuating the system. What is needed is not to do things better or more, but differently. Our social systems need to be able to adapt to unforeseen changes; that is, to become ultrastable (cf. Beer, 1994).

Educational institutions work toward reproducing themselves, irrespective of social changes (Martínez, 2009, p. 168) whereas they should be geared toward producing change (see Beer, 1994, p. 97). Educational institutions are producers of sameness in two different ways: first, like all bureaucracies, they are self-reproducing systems which tend to seek their own preservation rather than produce the effects they were designed for (Beer, 1994, pp. 75-78); and second,they reinforce certain models of the world – certain epistemologies – which guide the way we act (see Von Foerster, 1996).

In order to work with students, educators must have a model of them (Pask, 1966, p. 290), which can be explicit or tacit (Scott, 2001, p. 347); in the worst cases, students are perhaps seen as "untamed savages" or "sons of paying costumers." But often, educational institutions also operate with an idea of the final product, a certain idea of

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what their graduates should look like (official school documents attempt to make this idea explicit, with statements like "graduates are respectful of the law and of others"). For example, the theory of human capital sees education as education for the jobs marketplace (Ossenbach and Martínez, 2011, pp. 679-680). With a model at each end, the process of schooling can be seen as the transformation of raw material into a specified product (the degree to which actual graduates diverge from product specifications is the degree to which the educational institution has failed). In this way, sameness is produced: this might not be a bad idea if our society was working well; since it is not, difference is a better desideratum. Of course, a viable adaptive system does not aim to be wholly different from what it is: a system is able to persist over time if it can maintain certain essential variables steady (e.g. peace for a society; or blood-sugar levels for a human being) while non-essential variables are changed (Beer, 1994, p. 77).

In his famous essay *On Liberty*, John Stuart Mill (1997) praised individual freedom because divergent lives are experiments in living, which can help us fallible human beings find better ways to live (the argument, of course, works at other levels of recursion: unusual institutions are just as valuable as unusual persons). In times of societal crises, experimentation ought to be encouraged: the variety of a system is a source from which a system can develop new responses (cf. Espejo and Reyes, 2011, p. 46). In what follows I present some ideas for non-reproductive education with regards to both pedagogy and institutional frameworks.

2. Perception

An important factor in facing the challenges of the future is the ability to recognize them. Climate change denialism (see Dunlap and McWright, 2011) shows how relevant this factor is. The model that our brains can make of the environment is necessarily less complex than the environment itself: we must therefore filter out parts of the environment that we consider irrelevant. It is crucial that we only filter out what is irrelevant to a situation when we make our models: picture, for example, a parent whose model of how well his son is doing in life is derived exclusively from the child's school reports and not, for instance, the child's mood. In a time in which climate change is affecting the state of Florida's coastline, agriculture and freshwater reserves (NRDC, 2001), governor Rick Scott has forbidden state officials to use the phrase "climate change" in state communications (Goodell, 2013). To ignore crucial features of the environment is a recipe for disaster. However, the overwhelming complexity and sheer awfulness of our world today leads us to do just that (cf. Beer, 1994, p. 94). A few months ago, while the coal mining company Drummond was illegally pouring tons of mining waste into Colombian oceans, one of the leading stories in national news was that a homeless person had mistreated his dog – the Drummond story was mostly ignored. This is compounded by what Diamond (2011, p. 425) calls creeping normalcy, our tendency to see as normal negative changes that occur slowly, so that what would have been scandalous 50 or 20 years ago is now considered ordinary. Finally, inadequate low-variety models can be self-confirming because "they cannot accept the very data that which would modify them" (Beer, 1983, p. 803).

At a deeper level, it could be argued that civilization is chiefly guided by an imperative of objectivity (i.e. that the properties of the observer ought not to enter the description of observations), that helps to make us blind to our epistemological failings; since the epistemology of objectivity ignores the fact that we make models of the world that filter out some of its features, it makes it difficult for us to correct our filtering

processes when they go wrong- this is a second-order deficiency (Von Foerster, 1996, 187 y ss). If societal crises are chiefly crises of perception (Capra, 1996, 3 y ss) the problem of education is not one among many, but rather a strategic determinant of humanity's failure or success.

Adaptation requires change. Education has the potential to change our ways of doing things and our ways of seeing things. But it can only do so if it produces difference, rather than being reproductive. Heinz von Foerster's concepts of trivial and non-trivial machines are useful for conceiving a non-reproductive education.

3. Triviality

Paulo Freire (1977) uses the term banking education for what we call reproductive education. In banking education, pre-existing knowledge is "deposited" in students by a teacher in a one-directional, non-dialogical, non-creative relationship (pp. 72-73). Rather than being taught to transform the world, students are made to adjust to the existing world, as springs and sprockets adjusted to a given machine; therefore banking education reveals a necrophilic hatred for the spontaneity of life (Freire, 1977, pp. 74-82).

Banking education can be seen as the production of trivial machines. A machine is a formal function with an input, a transforming function and an output. In a trivial machine, the transforming function is always the same, therefore the relationship between the input and the output is invariant: the behavior of wholly trivial machines is predictable and independent of their history (Von Foerster, 1996, pp. 148-150). For example: a lamp that invariably turns on when a switch is moved, a well-functioning calculator, a well-trained dog or a well-trained soldier responding to commands. At least in certain contexts, trivial machines are convenient and desirable. Reproductive or banking education is education geared toward producing certain given responses to specific questions: this is well exemplified by standardized tests, which have grown in importance in recent years (see Holmes, 2010).

Non-trivial machines have an input, a transforming function and an output; but the function changes in relation to the machines' internal states which, in turn, change in relation to the input. The first couple of times one plays peek-a-boo with a baby, the baby will be surprised and delighted. If the child were a trivial machine, this would be its response perpetually; however, previous inputs will change the baby's internal state, and it will get bored with the game. A history of inputs has changed her internal state, and therefore the output has changed from joy to boredom. The number of possible outputs for a given input will be a function of the number of possible internal states of the machine, which are determined by the individual machine's history (Von Foerster, 1996, pp. 150-152). A sufficiently complex non-trivial machine, by the sheer amount of possible outputs, will be unpredictable to an outside observer (Von Foerster, 1996, pp. 152-153) and therefore, for practical purposes, can be considered free. Non-triviality can be used as a measure of freedom.

Consider Adolf Eichmann, a rather trivial machine as to obedience to orders. In his famous Jerusalem trial, he stated that he would have been more ashamed of disobeying orders than of sending Jewish captives to their deaths (see Arendt, 2005). Had Eichmann's superiors given him more humane orders, he would not be a reviled historical figure, but perhaps even a beloved hero. Trivial machines work well within a correctly designed system, but are more than worthless when the larger system needs to be changed.

Since trivial machines cannot be agents of change, social systems need components that function as non-trivial machines in order to transform themselves. As Diamond

(2011, pp. 523-524) has pointed out in his study of the collapse of civilizations, societies that can survive crises are the ones that are capable of transforming their values; change presupposes the production of difference (see Bateson, 1993, 107 y ss).

It is important to point out that there are two independent arguments in favor of a non-trivializing education: the argument being made here is that society as a whole is in need of transforming agents. But a second and important argument is that non-trivial machines have a richer life experience. Indeed, human ideas and perceptions are internal states; the more complex a human system is, the more varied its internal states, the more varied are its perceptions and ideas. A non-trivial machine is, by definition, capable of more states than a non-trivial machine. Therefore there is a relationship between non-triviality and richness of experience. This does not mean that non-trivial humans are necessarily happier but it does mean that their lives are more interesting: "it is better to be a human being dissatisfied than a pig satisfied; better to be Socrates dissatisfied than a fool satisfied" (Mill, 1972, p. 9). Therefore, a non-trivializing education is called for not only for the sake of society but for the sake of the students themselves.

4. Control

I will argue that producing non-trivial machines is not merely a "letting be" of human spontaneity. Heinz Von Foerster (1996) calls for leaving the door open for agents of change (p. 199), for not burning heretics, but this is not enough: freedom ought to be a product of our social system, rather than a side-effect of its inaction.

Against certain libertarian positions that stress negative liberty[1] (freedom from State action) Martha Nussbaum (2012) argues that since freedom is always freedom to do or to be something, liberties are always positive; rights exist merely on paper if they cannot be effectively exercised, independently of whether the barrier to effective exercise is state action or some other cause; therefore it is the job of the state to positively guarantee rights (pp. 86-87; of course this includes, but is not limited to, curtailing state actions which harm people's rights).

The key distinction to be made is whether freedom is conceived as the output of a system or as the amount of operational constraint in it. How free is a neglected child whose parents let him do whatever he wants? How much actual freedom is there in stateless, tax-free, Somalia (which has been praised by libertarians, see Doherty, 2006)? A social system that produced liberty would not be an entity "characterized by more or less constraint, but a dynamic viable system that has liberty as its output" (Beer, 1994, p. 35). For example, traffic lights impose constraints on drivers, but the net output is that drivers have more freedom moving around than they would if there were no traffic lights.

In order to regulate a system, its variety must be absorbed. Variety is the number of possible states of a system; the mode of organization of a system is the way in which it absorbs variety. How? "Variety absorbs variety" (Beer, 1994, p. 24); regulatory variety must be equal to the systemic variety being regulated. Picture an adult taking a small child out to the city park; now picture him taking three children. The situation is quite different; in the first case, in soccer terms, we have man-to-man marking; in the second, we have zone marking. The adult may have to ask the children to hold hands while they cross the street, or to play in the same area of the park. Whereas regulatory variety remains the same (there is still only one adult), systemic variety has increased dramatically. In order to cope with this extra variety, it must be attenuated by rules and regulations. The other way in which variety can be balanced is by amplifying

regulatory variety, which could mean an extra adult in the park, or a more creative one who organizes a structured game for the kids[2]; or, and this is the essence of autonomy, teaching the children to look after themselves. In any case, variety must be absorbed by a regulatory system, some way or another.

If we manage to increase regulatory variety rather than attenuate systemic variety, we have preserved some measure of freedom (Beer, 1994, p. 25); this can be achieved by transferring regulatory functions to the periphery of the system. What is needed is to figure out what ought to be controlled by the central function of the system and what by peripheral functions.

For any system of appreciable complexity (like an educational system, a school or a family), it is quite impossible for a centralized agent to regulate all of the systemic variety (see Beer, 1994, pp. 71-75). The truth is that persons and organizations have a finite amount of regulatory variety that is generally quite less than the systemic variety they need to handle. Attempts to assume complete control end up in overload and failure. Colciencias (the chief educational and research institution in Colombia) demands huge amounts of information from researchers and institutions in order to evaluate and rank them; so much, in fact, that its web site is usually overloaded and there is no real control on whether the information being uploaded is true or false.

If peripheral elements in a system are given regulatory function, their variety can be turned into regulatory variety. An example is the old teacher's trick of giving restless students the role of hall monitors, or other responsibilities. In this case, disruptive systemic variety is not only neutralized but transformed into regulatory variety.

Since the transforming function of trivial machines is unchanging, they have far less possible states than non-trivial machines. From the point of view of variety management, it would therefore be desirable, in a centrally controlled system, that peripheral elements be trivial, reducing systemic variety to match regulatory variety. However, in as much as peripheral elements in the system are given control responsibilities, this desideratum is reversed: it is desirable that the peripheral elements be non-trivial because this will add to regulatory, rather than systemic, variety. In the case of our restless student, in as much as she is a nuisance in the classroom, it seems desirable that she be less active, creative and spontaneous; but, in those cases where making such a student into a hall monitor gives her a sense of self-worth and a well-defined role, then her spontaneity becomes a regulatory asset. Picture a bus driver instructed to follow a given route with specific stops who must decide what to do when a passenger suddenly goes into premature labor. Will he make a small detour to a nearby hospital or continue his route? Whereas trivial machines can only handle pre-specified problems, non-triviality is a condition for handling the unexpected (here, it must be stressed that a non-trivial machine is not a random machine, but rather one capable of modifying its own behavior).

Giving control responsibilities to the periphery can help the emergence of non-trivial machines. If it is understood that our bus driver is to make judgment calls in certain situations, he will exercise his judgment. Trust can aid in making people non-trivial.

What is the proper role of centralized management? If a system is to remain viable, it must preserve its identity: guaranteeing cohesion between its components. The function of centralized agents is the preservation of the system's essence. Everything else may be handled autonomously by the periphery.

The problem of centralized and decentralized control in education, at every level of recursion, is about finding what is essential in a system and what can and ought to be

left to peripheral control. I will give examples of how not to go about things, at different levels of recursion:

- Colciencias (the governing body of education in Colombia) measures and ranks research groups according to an online system that records the academic production of the groups. Among the metrics used is one called "group cohesion," groups score higher in Colciencias if their members are often co-authors of academic papers, rather than publishing as single authors. If what is essential is to evaluate the quality of academic production, is it necessary that good research papers be written collectively by members of a research group? Of course not. "But – it may be replied – academic work is improved by collaboration." Perhaps, but that should be up to the researchers to decide (e.g. this may be a good idea for biology but not for philosophy). What this metric is causing is that many people in academia are starting to cheat and trade favors, by including each other as co-authors in singly authored research papers, which was surely not the intended effect.
- Let us agree that the essential purpose of a given school lesson is to gain mastery of a certain mathematical operation (say, long division). Usually, the teacher recommends a single method for reaching this mastery: rote repetition, say 50 exercises of increasing difficulty. But maybe some students can gain mastery with just a couple of exercises, or by skipping to the hardest exercise and taking it on as a challenge, or by inventing new exercises for themselves. Why should students who understand the operation but fail to complete the 50 exercises be penalized? (see Von Foerster, 1996, p. 130) Again, a response to this sort of imposition is widespread cheating[3].

If the central function were to enable autonomy and responsibility to the periphery, it would relieve itself of systemic variety and make its own job easier by turning systemic variety into regulatory variety (cf. Espejo and Reyes, 2011, p. 47). Sugata Mitra's (2010) experiments with "hole in the wall" computers (i.e. computers accesible to children mounted on public spaces for free use) have shown that a rich environment can cause self-organizing learning systems to form (in which, e.g. some children unpromptedly take on the role of teachers) that can produce results comparable to those of formal schooling. This is a perfect example of putting a systems' self-organizing capabilities to work.

It must be noted that self-organizing parts of a system only work to balance the variety equation when they are aligned with the purposes of the larger system; otherwise it is a source of disturbance (cf. Espejo and Reyes, 2011, p. 59). Universities should promote independent initiatives from students and teachers that further the broad goals of the institution; whereas initiatives that are orthogonal or at odds with those goals will add to the systemic variety that is to be regulated. Central command should enforce these broad guidelines, but it should also abstain from backseat driving[4].

A non-reproductive educational system should, at a minimum, limit central control to the bare essentials. But this is not enough. In the next section I will explore Heinz von Foerster's idea that non-trivial machines could be produced by an education that asked legitimate questions.

5. Questions

An important problem with education is that it is generally understood as the transmission of knowledge, where knowledge is a thing that is possessed by the

teacher and not the student. It can be argued that education is better understood as a dynamic relationship, in which teacher and student construct understanding through mutual structural coupling (see Pask, 1975; Scott, 2001). Thus understood, teaching is not to be seen as a process of communication (where knowledge is transmitted) but as a conversation (Pask, 1966, p. 289); it is an operation upon a dynamic person.

A reified understanding of knowledge leads to an education guided by illegitimate questions. These are questions to which there already exists an answer (Von Foerster, 1996, p. 198). In this framework, the teacher must get the student to give specific answers to specific questions. A legitimate question, on the other hand, is a question to which the answer is unknown: to allow the asking of legitimate questions in the classroom is to activate autonomous research.

The difference between the two types of questions can be illustrated by the role played by language and by the teacher in each case. In answering illegitimate questions, students learn pre-existing categories that guide their thinking (see Von Foerster, 1996, p. 190); whereas in answering a legitimate question, students must create their own categories (see Von Foerster, 1996, p. 167). The teacher that asks illegitimate questions is the possessor of the answers and is therefore in a position of power over the students; whereas in answering a legitimate question the teacher (as well as the library, the internet or other people in the community) becomes a resource for the student, an aid in solving a problem, that can be called upon if necessary (cf. Beer, 1994, p. 61).

Can school students do original research? Yes: a recent example is the development of an artificial intelligence program for detecting breast cancer by a 17-year-old school student (see Kuchment, 2012). But more importantly, there needs to be a distinction between original and authentic research. Original research comes up with theories or innovations that are new for the academic community as a whole; authentic research is research that tackles autonomously formulated questions that are significant to the person or group that formulates them. A rural community might take on the task of solving some of its problems regarding drinking water and come up with solutions that are quite similar to others already known elsewhere in the world: their research will not be original, but it will be authentic. Picture a 16-year-old who is having doubts about which career to pursue: she might look for information about the nature of certain professions on the internet; interact with people in her community, etc. What she finds out will not be new for humanity, but it will be new and important for her, and she will be empowered by the experience. Authentic research can be stimulated by increasing the role of self-evaluation in education, thereby permitting institutions, teachers and students to formulate research projects autonomously.

6. Measurement

Reproductive education has an easy time measuring the success of students, teachers and institutions. Given a pre-specified model of expected results, the task of measuring success is simply that of comparing actual results to required ones. But what if success in education means producing the unexpected? How should we rank a school where the students have created a club for designing videogames as compared to one where the kids have decided to use some of their school time to build houses for the underprivileged?

I tackle the problem of measurement in the context of what has elsewhere been called Gorgia's disease (Bula, 2012). In Plato's (1983) Gorgias, Socrates states that philosophy is to sophistry like gymnastics is to cosmetics. Gymnastics produces true beauty while

cosmetics produces its superficial appearance; in the same way, philosophy produces truth, whereas sophistry produces the appearance of truth; in both cases, the search for the superficial and apparent is harmful for the search of the true. The term Gorgia's disease refers to the current ubiquitous tendency on the part of institutions to seek to do well on official measurements while disregarding the goods these measurements are designed to measure: schools focus on doing well on standardized tests rather than on providing a good education (e.g. Ross, 1997); researchers focus more on publishing plenty of articles than on quality research (e.g. Casati *et al.*, 2006); countries focus on increasing GDP rather than improving the lives of their citizens (e.g. Leonard, 2010, 310 y ss); remember what I mentioned about cheating on silly policies emanating from central command, like Colciencias' group-cohesion metric.

This disease has to do with a disproportionate focus on quantitative measures; for instance, universities are evaluated more on bibliographical production than they are on extension work toward the community simply because the first is more easily quantified (De Sousa Santos, 2011, p. 68). Part of the problem is that we tend to trust the bureaucracy of formal models and procedures more than we trust people. But people are capable of morality, intelligence and flexibility; while bureaucratic models and procedures are not (see Beer, 1994, p. 81).

A common answer to these problems is to propose new instruments for measuring success (e.g. alternatives to the GDP for measuring the success of countries, see Nussbaum 2012; Leonard, 2010). This is a good idea, but a question that should be asked is who should be measuring what. Remember our limited role for central management: whatever is essential to the system should be guaranteed by central management, whatever is not should be left to the autonomy of the periphery. In education, this is how self-evaluation and other-evaluation should be assigned.

It should be noted that what is usually called self-evaluation is really other-evaluation that is outsourced to the people being evaluated: the evaluator chooses the criteria for evaluation, and gives the "evaluees" the task of performing the evaluation, according to criteria that they did not select. This has nothing to do with educational autonomy, but rather with creating the superficial appearance of it, and maybe saving evaluators a little work. Self-evaluation is only genuine when the self-evaluator gets to choose the criteria with which he is to be evaluated. At my university, as part of my "self-evaluation," I am asked whether I try to use new technologies in the classroom: I actually think that this is quite irrelevant to the quality of my classes (and I should know, I teach them).

So what should be measured by central management, what should be left to (genuine) self-evaluation? Central management should guarantee minimal, essential standards and leave whatever goes beyond that to self-evaluation. For example, the government should figure out what are the minimal qualifications for someone to be a licensed doctor and test the different Schools of Medicine on that; and teachers should think what is minimally required from each assignment and make sure that students reach it. The idea would not be to rank schools or students, but just to certify that they comply with minimal standards; you either pass (with, say, a 95 percent grade or higher) or you do not. Ranking would not be a function of evaluators; this would greatly help to alleviate Gorgia's disease: educational institutions would not be compared by ranking but rather (as they were for many centuries) in the court of public opinion, so there would be no stimulus to cook the books or beef up the numbers.

What about what goes beyond the bare minimum, everything that is creative, transformative, interesting? This should be the province of self-evaluation: each

institution, as well as each student, should be able to select the criteria for evaluation. Since each institution or student will select different criteria, ranking is out of the question, as it would be akin to comparing apples and oranges.

Often, debates on education lead to discussions about essences: "What is a school? What is the true nature of a University?" If educational policy matters are decided in this way, individual institutions are robbed of the proper flexibility to experiment with different ways of understanding education in our changing social landscape; that is, society is robbed of the variety it needs to transform itself. Should we do away with essences entirely? This seems unwise as well; viable systems need to preserve their identity, for which they need an idea of what that is. Spinoza's (1999a) framework seems useful: he speaks of individual essences[5]; there is no such thing as the essence of Man or Dog, but there is the essence of Keith or Pluto. This individual essence is the autopoietic network that produces a given system (see Bula, 2008). On an epistemological level, this means understanding each educational institution in its own terms; on a policy level, this means that it is the members of each institution, not some distant entity, who are tasked with figuring out what the essence of their institution is.

Spinoza (1988, pp. 166-172), in a letter to critic Willen van Blijenbergh on the problem of evil, lays out the idea of what can be called an immanent ethics. For Spinoza, there is no such thing as evil; "evil" being, rather, the name we give to a things' imperfection in comparison to what we think they should be. We compare Peter or Paul to a certain idea we have of what a Man should be, instead of looking at Peter or Paul in their own terms. This, in a nutshell, is transcendent morality: judgment using a pre-existing criterion external to the object. In contrast to this morality, Spinoza posits that God's ethical laws ought not to be understood as the commands of a judge or a king but rather as corollaries of natural laws, as simply the best way to behave given the way the world works: it is not that coveting thy neighbor's wife displeases an angry God, but rather that, given the natural laws that govern human interactions and emotions, this tends to lead, causally, naturalistically, to bad consequences (see Spinoza, 1999b; Deleuze, 2009). Ethics is therefore immanent to a thing's causal operation and connection to its environment. As a corollary, ethics can change with a situation: in a specific set of circumstances, it can be a good idea to covet thy neighbor's wife; this is something you have to figure out thyself.

Beer's (2008, p. 99) aphorism "the purpose of a system is what a system does" is an invitation to examine a system in its immanent operation: look at the way a school works, not at its mission statement. Educational systems are not images or representations, but rather causally interrelated elements (cf. Martínez, 2009, p. 168).

An increased role for genuine self-evaluation would make for more autonomous institutions and persons that would have to make genuine decisions. This means that institutions and persons would have to take more responsibility for their actions: the Eichmann excuse goes out the window. The call for greater autonomy at every level of recursion of the educational system has to do with actually being able to absorb the systemic variety that needs to be regulated. But it also has to do with personal autonomy; which is something that ought to be pursued for its own sake.

7. Autonomy

I recommend minimal hetero-evaluation and genuine self-evaluation at every level of recursion in the educational system: Institutions in relation to the government, teachers in relation to the institutions, students in relations to teachers. There is one final,

crucial, level of recursion: the evaluation of students by themselves. Students should be their own variety attenuators. This is personal autonomy.

Since human beings are finite and live in a finite environment, they must necessarily operate within variety constraints (Beer, 1994, p. 82). Freedom cannot mean freedom from constraints: rather it means freedom of control over one's own variety attenuators (Beer, 1994, p. 83). Would the main news item in a free Colombian society be the mistreatment of a dog while Drummond pollutes Santa Marta's oceans?

I have called for self-evaluation at all levels of recursion in education. Self-evaluation is a way of gaining control of variety attenuation. To decide what to evaluate is to decide what matters. It has been shown that high-stakes standardized testing is a form of curricular control (Au, 2007); control of the test implies at least partial control of the curriculum. Therefore, in as much as an educational model includes genuine self-evaluation, it also includes control of the curriculum on the part of students. This is how self-evaluation relates to authentic research and legitimate questions: if curricular control is ceded to peripheral elements in the educational system, they will formulate research projects according to their particular interests and needs. This is how the emergence of non-trivial machines can be stimulated: genuine self-evaluation is an invitation to use one's own judgment, to set one's own goals. Educational policy, however, is moving in the opposite direction: Guy Neave (2012) has described the rise of the evaluative state: the rise in power, frequency and scope of an evaluative state instrumentality that robs students, teachers and educational institutions of autonomy.

The world we perceive is necessarily the product of variety attenuation: it is necessary to understand this if we are to regain control of the attenuation process (Beer, 1994; Von Foerster, 1996). Heidegger (2001) has conceptualized freedom in a very similar manner. For Heidegger, the essence of technology is ontological; it is a way of disclosing the world, of revealing reality. The essence of techonology is its way of disclosing the world in a technological manner, where things appear as resources to be put to work. The danger of technology is that this particular way of uncovering the world (as opposed, e.g. to ancient Greek or medieval ways of disclosing) may become dominant and exclude all other possibilities of uncovering, thereby robbing man of his essence as capable of disclosing worlds. But man regains his freedom if he realizes that he is a discloser (Heidegger, 2001, p. 29; see also Spinosa *et al.*, 1997).

The freedom that comes from taking charge of the construction of one's own reality comes with a corresponding responsibility. To say "my hands are tied, such is the nature of reality" is no longer an excuse, because such a reality was a product of construction (see Von Foerster, 1996, p. 92). Against the drift that makes certain choices and positions seem inevitable (see Martinez, 2009, p. 175), to disclose that we are disclosers, to gain control of our variety attenuation, is to be able to ask, like Socrates, "how are we to live"?

Notes

1. Isaiah Berlin (1969) distinguished between negative liberty (the absence of coercion) and positive liberty (self-mastery and the exercise of political rights). While he denounced the rhetorical abuses of positive freedom (where people are oppressed "for their own good"), he recognized that both types of liberty are desirable in society. The idea that, for Berlin, negative liberty is the only kind that matters is a crude caricature of his liberalism.

2. For the sake of brevity, I have omitted Espejo and Reyes' (2011) distinction between variety (the number of possible states of a system) and complexity (the number of behavioral

distinctions of an observer in relation to a system). However, the example of a creative adult is a good illustration of how increasing individual complexity(the repertoire of behaviors an observer can have toward a system) can balance the variety equation by increasing regulatory variety.

3. These mistakes can be related to certain discourses on development that originated in the middle of the twentieth century which had a profound effect on educational planning (Ossenbach and Martínez, 2011). In Latin America, between 1950 and 1970, "[…] the new bureaucratic structures created […] to undertake planning for education were set up for the production and circulation of discourses […] that were generalized on a worldwide scale. In large part, they displaced the traditional places where expert knowledge regarding education was legitimized (the academic culture)" (Ossenbach and Martinez, 2011, pp. 699-700). The philosophy of planning circulated by these discourses included the idea that development implies detailed planning, that "[…] improvisation and governmental spontaneity had to be eliminated at any cost" (Ossenbach and Martínez, 2011, p. 686). In systemic terms, this means an imperative to eliminate peripheral control in favor of central planning.
4. Christoph Wulf (2013) has called for peace, cultural diversity and sustainable development to be goals of education. In the same article, he calls for curricula to include peace studies, heterological thinking and studies on sustainability. It is important to distinguish between the two calls: one is about where we should go, the other is about how we should get there. The where should be decided by central management, the how is a matter for self-organizing peripheral systems.
5. This does not mean that, for example, the idea of a class identity of all autopoietic systems (see, e.g. Brocklesby and Mingers, 2005, p. 4), or, in general, of a class of things with certain invariant properties, is not useful. But, in the context of finding a normative horizon for educational institutions, the idea of an individual essence identical with the autopoietic network that constitutes a given system seems to provide an adequate guide without robbing an individual system of flexibility to define itself.

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