Without Miracles

12 Education: The Provision and Transmission of Truth, or the Selectionist Growth of Fallible Knowledge?

Providence

But referring now to all things which we understand, we consult, not the speaker who utters words, but the guardian of truth within the mind itself, because we have perhaps been reminded by words to do so. Moreover, He who is consulted teaches; for He who is said to reside in the interior man is Christ, that is, the unchangeable excellence of God and His everlasting wisdom, which every rational soul does indeed consult.

--St. Augustine[1]

Instruction

Instead of paper, we have pupils, pupils whose minds have to be impressed with the symbols of knowledge. Instead of type, we have classbooks and the rest of the apparatus devised to facilitate the operation of teaching. The ink is replaced by the voice of the masters, since it is this that conveys information to the minds of the listener, while the press is school discipline, which keeps the pupils up to their work and compels them to learn.

--John Comenius[2]

Selection

Let me first briefly summarize the critical approach [to education]. It is based on evolutionary epistemology, which claims that we never receive knowledge, but rather create it; we create it by modifying the knowledge we already have; and we modify our existing knowledge only when we uncover inadequacies in it that we had not recognized heretofore. Accepting this as an explanation of how knowledge grows, I have suggested that teachers construe their roles as facilitators of the growth of their students' knowledge.

--Henry Perkinson[3]

The important roles that tradition, technology, and science play in the survival and proliferation of our species and the quality of our life make it imperative that new generations both acquire this cultural knowledge and be able to revise and improve it in response to changing physical and social environments. As the scope and complexity of human knowledge have increased, just about every human society has instituted formal methods of education to facilitate the acquisition of knowledge by its children.

Some isolated communities still do not make formal education a requirement for children, relying still on more informal means of cultural continuation such as apprenticeships. Universal formal education is the stated goal, however, of all countries. In the developing world the goal of universal primary education is to provide formal schooling for at least five or six years to allow all children to become literate in either their native language or the official nonnative language of the country (for example, English or French in most of sub-Saharan Africa). In the more industrialized countries children are usually required by law to attend school until age 15 or 16, and to become a doctor, lawyer, or university professor in any country may require formal education until age 25 to 30.

Considerable financial resources are devoted to formal education, especially in the industrialized countries, which have great need for skilled workers, technicians, and professionals, including, of course, teachers. Since citizens contribute a significant portion of their paycheck in the form of taxes to public education, it should not be surprising to find considerable controversy over the schools' effectiveness, methods, and curricula. Nonetheless, it is clear that despite its problems, education does increase the fit of students' knowledge and skills to the physical and social environments in which they will live as adults. Students learn to read and write. They learn how to use mathematics to solve problems ranging from the mundane (balancing checkbooks and filing tax returns) to the creative (designing new automobiles, sending space probes to the planets and beyond). They gain knowledge of other times and places in geography and social studies classes. They learn additional languages to facilitate travel and to participate in our new world economy, which requires knowledge of English but also often Spanish, French, Russian, Arabic, Japanese, or Chinese. And they develop expressive abilities in dance, music, and art classes (often in special schools and programs), and sports and recreational skills in physical education classes.

The purpose of this chapter is to explain the puzzles of fit that are the consequences of education. Some of the discussion may overlap and draw on previous ones, but its focus will be on formal education and past and present views of how education results in new and improved knowledge and skills.

Education as Providence

Perhaps the most well-known geometry lesson of all time is the one presented by Socrates to Meno's slave boy. Although we addressed the Meno dilemma in chapter 6, it will be useful to start our discussion of education by taking a closer look at that interaction between teacher and student.

The problem Socrates describes concerns the area of a square. After establishing that the boy understands that a two-by-two square contains an area of four square units, he asks the boy how long each side would have to be for the square to contain eight square units. Since eight square units is twice as much as four, the boy quickly (and erroneously) concludes that a four-by-four square would contain the desired area.

But when Socrates sketches this four-by-four square, it becomes apparent that such a square contains not eight but rather sixteen square units. The boy, then realizing that the desired eight-square-unit figure must be larger than two by two but smaller than four by four, guesses that the answer is three. But when asked to reconsider this

answer, the boy realizes that it is also in error, since such a square would have an area of nine square units, not eight.

At this point the boy admits that he does not know the answer, and Socrates points out to Meno, who is observing the interaction with keen interest, that in his admitted ignorance and confusion the boy is actually better off than he was before when he believed he knew the answer but in fact did not. With further careful questioning by Socrates, the boy finally discovers the correct answer, that is, that a square made of sides equal in length to the diagonal of a two-by-two square (equal to the square root of eight) has an area equal to the desired eight square units.

Since Meno states that the boy had never been instructed in geometry, Socrates concludes that the knowledge the boy finally demonstrated in solving the problem could not have been learned earlier in his life. And since Socrates did not instruct him, but only questioned him, he did not give the boy his new knowledge. Socrates therefore argues that the knowledge the boy used to solve the problem must have been possessed by the boy all along and was therefore simply *recollected* during their encounter from knowledge provided by an immortal soul. That is, inquiry is the recollection of knowledge that we already have--a providential view of knowledge that leads to a providential view of education as well.

Such a view of education did not die with Socrates and Plato. St. Augustine (354-430), the intellectual father of Christianity, fashioned a philosophy in which God is the answer to all questions. God made the universe, was responsible for everything that happened in it, and was the source of all the knowledge that humankind was able to acquire about it. In his *De Magistro* ("concerning the teacher"), Augustine adopted the same basic conclusion as Socrates concerning teaching, but instead of attributing all knowledge to immortal personal souls, he acknowledged God as the source of all knowledge, "the unchangeable excellence of God and His everlasting wisdom, which every rational soul does indeed consult."[4]

Therefore according to Augustine, teachers cannot transmit knowledge to their students by instruction, since teachers can only utter words. If the words are already familiar, students can learn nothing from them. And if the words are unfamiliar, the students can still learn nothing from them:

> For it is the truest reasoning and most correctly said that when words are uttered we either know already what they signify or we do not know; if we know, then we remember rather than learn, but if we do not know, then we do not even remember, though perhaps we are prompted to ask.[5]

The noninstructionist argument concerning words that Augustine makes is remarkably similar to the one at the end of the previous chapter that language use does not involve the transmission of meaning or concepts or information from one person to another. To make Augustine's point clear and relevant to education today, imagine that you are a physics teacher attempting to teach a student the concept of acceleration. If the student already has a good idea of what velocity is and understands what it means for a quantity to change over time, you may explain acceleration as the change in velocity over time, and the student may now have a basic idea of what acceleration is. This is because she already knew what velocity and change over time mean, so putting these two familiar concepts together yielded a new one. But if the student has no idea of what velocity is or doesn't understand what is meant by a changing quantity, a teacher cannot do much to teach the concept. Nonetheless, by demonstrating acceleration and allowing both teacher and student to ask and answer questions, the concept can be acquired. Since it is not clear how such new knowledge is acquired, Augustine can only imagine that it is provided by God. For him, therefore, teachers can only hope to guide students to knowledge that is provided by God as divine illumination.

Education as Instruction

But a quite different view of education was to accompany the new philosophy brought about by the beginning of modern science in sixteenth-century Europe. Exemplified in the writings of Sir Francis Bacon, it rejected God, religious dogma, and the classic philosophical texts as the sole sources of knowledge. Instead of looking within oneself for God's revealed truth, or studying books and listening to the words of the teacher, Bacon insisted that nature be studied directly, for it was only in understanding nature and thereby advancing science that the human condition could be improved. According to Bacon, if you want to know how many teeth your horse has, you must look into its mouth and count them, not waste time reading what scholars and philosophers have to say about the matter. This new philosophy also stressed the importance of practical knowledge--knowledge that could be put to use for growing crops, building factories, and conquering the seas and the unknown lands that lay beyond the horizon.

This change in perspective concerning knowledge and science was to have a significant impact on education. Whereas before education had been considered a sort of initiation into the culture of the society or a process of discovering the truth within provided by God, it now began to be regarded as a process of instruction. Direct and careful observation of the world would allow knowledge to grow by the transmission of information through the senses to the mind. Where direct experience could not be easily had, the knowledge already gained by teachers (who now became instructors) would be transmitted into the minds of students through their spoken and written words. To facilitate the latter, textbooks came to replace classic texts. These textbooks were designed to present knowledge to students in the most effective manner. Subject matter was broken down into small, easily digested components and then carefully organized and sequenced to facilitate learning. Teachers and textbooks thus became transmission relay stations whose job was to reflect knowledge of the world into the minds of students.

This instructionist view of education had, and still has, important consequences for all aspects of education. First of all, if education is the transmission of knowledge from the teacher (or textbook) to the student, then the knowledge possessed by the teacher (or textbook) must be accurate. Instruction makes no sense if what is to be taught is not true. Teachers and textbook authors must therefore be (or at least pretend to be) unquestioned authorities on the subjects being taught and written about.

Second, an instruction-oriented view of education tends to put the blame on the student for failure to learn, since if the information to be transmitted is presented clearly and accurately, such failure must be due to problems on the receiving end. Inattentivenss, laziness, and lack of motivation are therefore often met with punishment and ridicule in an effort to make students pay attention and do their work.

Third, if education is the transmission of knowledge from instructor and textbook to student, then the usual test of its success is whether students can reproduce the transmitted information in spoken or written form. This encourages the memorization of what is "known" to be "true" and the use of standardized, objective tests as indicators of academic success.

In a word, a transmission-based, instructionist perspective on education is authoritarian. As New York University educational historian Henry Perkinson observed:

> . . . the transmission metaphor [for education] persisted through the eighteenth, nineteenth, and into the twentieth century. It persists down to the present, where many educators still remain caught in its spell. Believing that we inductively learn from experience, they strive valiantly to *transmit*

> knowledge to their pupils. Inevitably, this leads teachers to authoritarianism; the attempt to secure greater control over the educational process. Take for example the subject matter: teachers who seek to transmit knowledge attempt to control the subject matter by packaging it into a transmittable curriculum. . . . Take as another example of authoritarianism, the treatment of pupils: teachers who seek to transmit knowledge to students attempt to control them; they "prepare" them, "stimulate" them, "motivate" them, "get them to pay attention," "get them moving." All these tactics are attempts to control pupils so that teachers can more expeditiously and efficaciously transmit knowledge.[6]

Whereas the consequences of an instructionist view of education may be problematic, its greatest problem is belief in the transmission of knowledge itself. David Hume identified this problem in the eighteenth century with his critique of induction. Recall from chapter 6 that he concluded that we can never justify knowledge by observation, since to be useful, our knowledge (for example, objects fall to the earth) must go beyond what we have personally experienced (*some* objects fall to the earth at *certain* times and places). But although Hume admitted the logical impossibility of the environment being able to instruct the mind by way of the senses, he did not reject a psychological theory of induction. That is, he concluded that learning from observation was logically unjustifiable; however, this is what we actually do, since we believe that repeated observations of a phenomenon indicate a general law of nature. So it is logically invalid to assert that the sun will rise tomorrow since it has risen every morning up to and including today, but we still believe that we know that the sun will rise tomorrow based on our prior repeated observations of mornings and sunrises.[7]

If Hume is correct in asserting that no amount or type of experience can provide us with certain knowledge, yet we believe that experience leads to knowledge, this puts education in a very curious situation. For it means that although the knowledge possessed by teachers and contained in textbooks is almost certain to be mistaken, students will tend to believe (and will be encouraged to believe) that it is unquestionably accurate. From this perspective, education is not a process by which students acquire and improve their knowledge, but is a type of indoctrination in which students are encouraged and compelled to accept as true the inevitable errors of their teachers and textbooks.

But is it actually the case that we acquire what must be uncertain knowledge from our sensory experiences of the world? That is, does induction work psychologically even though it is a logically invalid process? To answer this question, we must consider again the work of Karl Popper who was also discussed in chapter 6. The belief in the transmission of knowledge from sense experience to mind is part of what Popper referred to as both the common-sense theory of knowledge and the bucket theory of mind; he convincingly argued that this view of learning is inaccurate from both logical and psychological perspectives. Hume believed that we are conditioned by habit to believe that repeated observations lead to useful generalizations. Popper noted that learning cannot proceed in this manner *since to recognize that an observation is in some sense a repetition of a previous one requires knowledge that cannot be obtained by observation alone*. This is surely a difficult idea to understand, but it is essential to grasp if we are to appreciate how knowledge cannot be a product of instruction either from environment to person or from one person to another.

In an attempt to make this important point clear, let us consider one of philosophy's favorite animals, the swan. According to Hume and the common sense or bucket theory of knowledge, repeated observations of white swans will lead to the idea that all swans are white regardless of the fact that such a conclusion is logically indefensible; there may be many nonwhite swans that simply have not yet been observed. But a problem immediately surfaces if we carefully consider such repeated observations, for it turns out that no observation is

ever likely to be an exact repetition of a previous one. The swan we see today is not exactly the same as the one we saw yesterday. Even if we encounter the same swan, it will be not adopt exactly the same posture or movements it had yesterday, its feathers will likely be either cleaner or dirtier, and the light reflecting off the bird will not be of exactly the same hue and intensity. Thus to observe similarity one must have some prior idea concerning the way in which similarity will be observed. As Perkinson paraphrases Popper's argument:

> A repeated observation, say, of a white swan, presupposes that the observer perceives the second observed swan as similar to the first, and to do this, the observer must have an expectation, a theory, about the two observations that make the first observation similar to the second. In other words, the theory "all swans are white" could not have been the result of conditioning, the outcome of repeated observations of white swans, since in order to experience a repetition, one must already have a theory that all swans are white.[8]

Turning to Popper's own words:

> It is therefore impossible to explain anticipations, or expectations, as resulting from many repetitions as suggested by Hume. For even the first repetition-for-us must be based upon similarity-for-us, and, therefore, upon expectations--precisely the kind of thing we wished to explain.[9]

In other words, if the observation of similarity depends on an *expectation* of similarity, we obviously cannot use repeated observations to explain the origin of these initial expectations. And since much if not all knowledge can be considered a type of expectation (knowledge that unsupported objects fall to the earth will lead a mountain climber to expect to fall if he loses his grip on the rock face), repeated observations without prior expectations cannot in themselves lead to new and better knowledge. This analysis suggests that the knowledge acquired in educational settings is not acquired by transmission from teacher and textbook to student, and in this sense the teacher cannot literally instruct the student.

Hume's arguments against the logic of induction and Popper's argument against the psychology of induction would probably be considered irrelevant philosophical nonsense by most educators, particularly since our everyday experiences suggest that such transmission of knowledge from teacher to student takes place routinely. So although these ideas have had a considerable impact on philosophy, particularly the philosophy of science, we should not expect educators to be much influenced by them, especially since they are usually more concerned with the practical difficulties of education than with the philosophical ones.

So an instructionist conception of education remains very much alive and influential today. Nonetheless, the twentieth century has seen the emergence of educational theories that have rejected the instructionist view of education. This has come about as more and more psychologists and educators dismiss the conception of students as passive buckets into which knowledge is poured by teachers and textbooks, and replace it with a view of students as active creators of their own knowledge.

Education as Darwinian Selection

Piaget and Montessori

Jean Piaget's theory of cognitive development (touched on in chapter 9) has had perhaps the most impact on this change of perspective. Piaget showed that children see and understand important aspects of the world in ways

very different from those of adults despite the fact that both are exposed to the same world. If knowledge results from taking in information, how is it that children perceive things so differently? Why does a two-year-old call a butterfly a bird? Why does a four-year-old insist that spreading out eight coins on a table results in more coins than when the same coins were grouped closer together? And why does a five-year-old "explain" that the sun does not fall down because it is yellow, or that the sun pushes the clouds across the sky? The fact that children have had fewer and less varied experiences than adults might explain why they may lack certain types of knowledge or have less knowledge. But it cannot explain why their understandings are *qualitatively* different from those of adults, and how they come up with such extraordinary and creative explanations that cannot be traced to actual experiences.

According to Piaget, these differences arise because children do not passively receive knowledge from their environment but rather make it themselves. From this perspective, knowledge resulting from the transmission of information from environment (or teacher) to student is replaced by the concept of *growth*. Children grow in knowledge because they construct it, often by recombining what they already know in new ways and testing it, and the environment, whether it be the physical environment of hard knocks or mommy's verbal response, provides feedback concerning the adequacy of their constructed knowledge. Thus the role of the environment for Piaget is not that of a provider or transmitter or instructor of knowledge, but rather as the selector of the knowledge created by the child.

Piaget's own words (translated from French) indicate the degree to which he rejected a transmission view of education and advocated a constructive one:

> I'm not an educator; I have no advice to give. Education is an arena of its own and educators must find the appropriate methods, but what I've found in my research seems to speak in favor of an active methodology in teaching. Children should be able to do their own experimenting and their own research. Teachers, of course, can guide them by providing appropriate materials, but the essential thing is that in order for a child to understand something, he must construct it for himself; he must reinvent it.[10]

Renowned Italian educator Maria Montessori (1870-1952), unlike Piaget, had little time or inclination for psychological theory or experimental research. Instead she developed

> the most successful method of education in the twentieth century, perhaps the most successful method in the history of education. In Montessori schools, children of three years of age learn to dust, to dry, to set the table, to serve at table, to wash dishes. At the same time, they learn to take care of themselves: they wash, bathe, dress and undress themselves, they arrange their clothes in their locker or in a drawer, tie their shoes, comb their hair, and so on. By four and a half years of age, they learn how to write and how to read and can do basic arithmetic calculations.[11]

Montessori did not see the role of the teacher as an instructor or transmitter of knowledge. Instead, in a Montessori classroom the teacher tends to stay in the background, acting as a kind of valet who creates an interesting and challenging environment. The child's own natural curiosity and desire to master the environment results in learning, learning that depends on attempting new skills, making errors, and learning from mistakes. As for Piaget, the learning environment, including the teacher, acts not as a source of knowledge but rather as a selector of the knowledge constructed by the child.

Learning from Mistakes

In his book that reviews twentieth-century educational theory, Perkinson contends that the general approach of Piaget and Montessori to education (as well as aspects of those of B. F. Skinner, A. S. Neill, and Carl Rogers) is essentially Darwinian, and he contrasts this selectionist approach to a transmission-instructionist conception with respect to the process of education, and the roles of the teacher, the subject matter, and the student. In contrast to a view of education as a process of transmission, selection sees education as "a procedure of (Darwinian) growth; trial-and-error elimination; the continuous modification of existing knowledge."

From a transmission perspective "the teacher prepares the student, prepares the subject matter, and transmits (instructs, matches) the subject to the student in the form of lessons that the student learns," whereas from a selectionist perspective "the teacher creates an educative environment--an environment that is free, responsive, and supportive--wherein the student can improve (modify) his present knowledge through trial-and-error elimination."

A transmission view sees subject matter as "what is transmitted" but a selectionist perspective considers it "an agenda that specifies what aspects of the students' present knowledge are to be improved" and as that which "evokes the students' present knowledge and tests it (reveals the inadequacies in that present knowledge)."

Finally, transmission conceives of the student as "a learner, a more or less passive receptor who needs to be controlled and motivated" while selection sees the student as "a fallible, active creator of knowledge who seeks order" so that "when he discerns contradictions (errors, mistakes, inadequacies) in his present knowledge, he will modify that present knowledge."[12]

Perkinson does not pretend that Piaget, Montessori, Skinner, Neill, or Rogers would agree with his Darwinian, selectionist reinterpretation of their work. Indeed, we saw in chapter 9 how Piaget explicitly rejected Darwinian theory and in chapter 7 how Skinner believed cultural evolution (which includes education) to depend on Lamarckian transmission. Nonetheless, all of these individuals (with the possible exception of Skinner) considered education to be a process of creative growth that results in the individual becoming better adapted to the environment and therefore better able to control aspects of the environment. Since they rejected both providential and instructionist explanations of education, their views lead quite naturally to a selectionist conception, even if they did not (again with the exception of Skinner) explicitly make Darwinian or selectionist arguments.

The selectionist orientation can perhaps be best appreciated by assessing the role of error. If this perspective views education as involving the fallible creation of knowledge, then educational theories and practices must consider error to be an essential part of educational growth. That is because the process creates fit not by the clairvoyant, advance fashioning of adapted thoughts or skills, but rather by the blind production of variations and the subsequent hindsighted selection of the thoughts and skills that better fit the needs and purposes of the learner. It is therefore not surprising that educational theories that reject transmission emphasize the positive role of error, since a selectionist process inevitably results in more errors (unfit variations to be eliminated) than successes (fit variations).

In Piaget's theory, the child experiences cognitive growth by realizing the mistakes inherent in his view of the world. It is a mistake to believe that there are now more coins on the table simply because they have been spread out to take up more space, and the child will develop more advanced modes of perception and thinking

when he realizes these mistakes. For Piaget, cognitive development proceeds as the child creates new and better ways of interacting with his environment. But since these new ways of interacting are not determined or instructed by the environment, it is inevitable that the child will make many mistakes along the way. Thus, error and its elimination can be considered to be the basis of cognitive growth and education.

Montessori also stresses the central role of errors in education:

> Supposing we study the phenomenon of error in itself; it becomes apparent that everyone makes mistakes. This is one of life's realities, and to admit it is already to have taken a great step forward. If we are to tread the narrow path of truth and keep our hold on reality, we have to agree that all of us can err; otherwise, we should all be perfect. So, it is well to cultivate a friendly feeling toward error, to treat it as a companion inseparable from our lives, as something having a purpose, which it truly has. . . . Whichever way we look, a certain "Mr. Error" is always present! If we seek perfection, we must pay attention to our own defects, for it is only by correcting these that we can improve ourselves.[13]

The essential role of error (that is, unfit variations) in a selectionist view provides the most striking contrast to a transmission or instructionist view with respect to the role of the environment. Since from an instructionist perspective the purpose of education is to transmit knowledge to the student accurately and efficiently, any error on the part of the student is an indication that something has gone wrong in the transmission process, usually with the student considered at fault for inattentiveness or laziness. In contrast, for selectionism, the educative environment reveals errors of behavior or thinking to the student and is responsive to the student's attempts to revise his behavior or thinking for the better. Thus, a teacher's primary responsibility is not to transmit knowledge, but to *assist the student in discovering the ways in which his current knowledge is inadequate*. But since such revelations of inadequacy can be quite threatening to a student's self-esteem, the teacher must provide an environment that is supportive of the student's attempt to better his knowledge. This environment should also be free, so that the student will be not be prevented from attempting bold new solutions.[14] In short, students should be eager to encounter their mistakes and will, it is hoped, find themselves in an environment that encourages them to revise their thinking and actions to arrive at better solutions to their problems.

The Dangers of Instruction

This century has seen the development and spread of selectionist views of education; however, many if not most educators retain an instructionist approach. That is because education as usually practiced admittedly looks like transmission. And learning obviously does take place in classrooms where teachers believe and act as if they are in the business of transmitting knowledge.

According to Perkinson, the learning that takes place in such environments is not due to the transmission of knowledge that is attempted (which is both logically and psychologically impossible) but rather despite such efforts. Even a transmission-oriented classroom is free to some extent, and effective teachers usually do provide a supportive environment for their students (although this support may be limited to the "good" students). Furthermore, the teachers provide critical feedback to their students in the form of question-and-answer sessions, discussions, quizzes, and test results, which reveal errors in the students' knowledge and lead them to modify what they know. Thus at least some learning does take place for at least some students, but Perkinson points out some serious disadvantages of a transmission approach. As already mentioned, these classrooms tend to be authoritarian and coercive. This leads to one of three possible reactions.

> First, there are those pupils who withdraw, either from fear or from resentment of the coercion. They do not participate in the trial-and-error elimination and so do not improve those skills and understandings of concern to the teachers. The teacher classifies them as the stupid ones.
>
> Second, there are those pupils for whom schooling becomes a game--the game of finding out what the teacher *wants* and then fabricating those skills or understandings. These are the hipsters, those who create pseudo-knowledge, knowledge created especially for the teacher, which, in the course of events, usually disappears--after the test.
>
> The third group are the true believers. These are the pupils who have undergone intellectual socialization. They regard the teacher (or the textbook or the experts in the field) as final authorities, and they modify their own knowledge into accord with whatever pronouncements the authorities promulgate.[15]

Many educators and parents might at first consider this last possibility as a positive outcome. It must be realized, however, that such a student would be unable or at least reluctant to revise and improve his or her knowledge or skills when they were found to be inadequate.

Selectionist Teaching

What are the alternatives? Is it possible to move educational practice away from a coercive, transmission orientation? It certainly is, and teachers influenced by Piaget, Montessori, and other selectionist-oriented psychologists and educators have shown how it is possible. Perkinson has offered suggestions to educators to facilitate students' intellectual growth within the existing arrangements of most schools:

> 1. It is possible to *present* the subject matter rather than try to transmit it.
>
> 2. It is possible to invite students to *encounter* the subject matter critically rather than try to get them to accept it.
>
> 3. It is possible to view these critical encounters as a selection procedure of *trial-and-error elimination* wherein knowledge grows.
>
> 4. Regardless of institutional constraints, teachers can facilitate this growth by construing their role to be that of creating a classroom environment that is more free, more responsive, and more supportive: a place where students can more readily learn from their mistakes.
>
> 5. Finally, it is possible, in the schools as they presently are, for teachers to reconceptualize the aim of schooling as an attempt to develop concerned critics who can and will facilitate the growth of our culture.[16]

Education as the Reorganization of Perceptual Control Systems

Although Perkinson provides convincing arguments for a selectionist view of education, he does not attempt to describe the specific mechanisms by which learning takes place, or examine teaching and learning as purposeful activities. To address these aspects, we will now consider educational growth from the perspective of perceptual control theory as described in chapter 8.

It will be recalled that perceptual control theory sees adapted (that is, fit) behavior as allowing an organism to control some aspect of its environment. And since it is only through perception that an organism can know anything of its environment, adapted behavior is in effect the control of perception. This view contrasts sharply with all other psychological theories that consider an organism's perception to be in control of its behavior. For perceptual control theory, learning is the reorganization of an organism's control systems that allow it to control perceptual variables it could not previously control, a reorganization resulting from a Darwinian process of cumulative blind variation and selective retention.

To apply the idea of reorganization to education, let us use the example of a person learning to swim. In its most rudimentary form, being able to swim can be defined as staying alive in water that is deeper than one is tall, that is, being able to tread water. One way to "teach" a nonswimmer to swim is to throw the person into a body of deep water (we could call this the immersion method). This will likely create error, since the student will have difficulty keeping her head above the water.[17] This perceived error in a crucial variable will trigger reorganization so that the student will immediately begin to move her arms and legs vigorously in random patterns to find some way to maintain her ability to breathe. If she finds a behavioral pattern (actually a perceptual-behavioral control loop) that allows her to breathe, if even only a few gasps before she disappears below the surface again, the randomness of the movements will decline until she is able to keep her head above water continuously, at which point we would say that she has learned to swim. In effect, the student has now gained control over a variable that she could not control previously, and so by our definition learning has taken place.

Since the student did not initially know how to swim, her initial movements were of necessity blind attempts to do so. But although she did not know how to keep her mouth above water, she could perceive how successful she was in her attempts (getting her eyes above the water is better than below, but not quite good enough). This then provides a criterion for selection among the various behavioral patterns attempted, and allows the student to learn from her mistakes, eliminating patterns that did not succeed in getting her head above the surface and retaining those that did.

It is easy to imagine that the learner would be very highly motivated, since failure to learn to swim would result in death from drowning. According to perceptual control theory, motivation simply refers to error (that is, a difference between a perception and the reference level for that perception) that results in action to eliminate the error (see figure 8.1). Motivation is therefore considered to be *internal* to the student, since the reference level of the controlled variable is determined by the student, not by the environment.

We must point out, however, that the immersion method of swimming instruction may well fail for any particular student, since there is no guarantee that the student will come up with an effective control system for treading water within the few minutes available before lack of oxygen leads to unconsciousness and death. Clearly, a less drastic approach is called for.

This method could be improved in a number of ways. First, we could simply allow more time for learning to take place. This could be accomplished by having the student practice at the edge of a swimming pool so that she could reach out and hold onto the edge of the pool when she felt herself going under water. Or she could practice in water that was only neck deep so that she could simply stand in the water at any time to breathe. Given more time to try out new patterns of movement and eliminate those that are ineffective, the likelihood of successful learning would increase.

Another approach would be to attempt to accelerate the learning process with verbal instructions ("move your hands horizontally in the water from your sides to the front and back again"), demonstrating a model for imitation,

or a combination of the two ("do it like this"). Such instruction might be useful in *constraining* the student's attempts; for example, she would not now attempt vertical movements of her hands. But no matter how effective, it could not *transmit* the skill to be learned from teacher to student. Even if the teacher provides a model, the student must still learn on her own how to imitate it. The perceptions the student has of the teacher demonstrating the technique are very different from the perceptions she will have when she is able to perform the technique successfully herself (watching someone else swim is a very different experience than that of actually swimming oneself). Models and instruction can provide useful information in the form of constraints on what not to try, but they cannot provide explicit instructions concerning exactly what to do.

In addition to giving the student more time to learn and offering constraints in the form of models and verbal instruction, the teacher can provide easier access to the knowledge or skill by suggesting a series of lessdemanding intermediate goals. One way is to break down the skill into a number of subskills and make opportunities for them to be acquired. The swimming teacher could have the student stand in shoulder-depth water and make horizontal movements with her arms until she feels an upward force lifting her weight from her legs. After she masters this, the student could hold onto a float and kick her legs until she feels herself rising from the water. After practicing the arm and leg movements separately, she could attempt to combine them, first in shoulder-depth and then in deeper water.

Breaking down a complex problem into easier subproblems facilitates learning since the probability of finding a solution to each subproblem is higher than that of finding a solution to the more complex problem. Success in learning to make effective arm movements alone in swimming is more likely than success in learning to make both arm and leg movements together.[18] A selectionist-reorganization view of learning sees the teacher as constantly aware of the student's current abilities and continually imposing upon her tasks that are just a bit beyond these abilities. Assuming that the student wants to be able to gain control over this new situation, reorganization will take place until she achieves control, at which time new demands are imposed (after learning to tread water, the breaststroke is attempted; after addition is learned, subtraction is introduced).

Such a view of learning is consistent with Russian psychologist Lev Vygotsky's (1896-1934) concept of the "zone of proximal development" in which the student tries and eventually successfully masters new problems that are beyond her independent capabilities but can be learned with the assistance of a teacher.[19] Note that the teacher is not a transmitter or instructor of information or knowledge, but rather one who provides support to the student and arranges the learning environment in such a way that she is continuously challenged by problems that are just a bit beyond her current competence. In other words, the teacher arranges the environment so that the student is continually encountering error, but error that is not too large, so that any reorganizing efforts are more likely to be successful and set the stage for the next introduction of error. This view is also consistent with the idea now popular in education that a successful teacher provides educational "scaffolds" for students. These are platforms that provide support in breaking down complex physical and cognitive problems into more easily mastered subproblems.[20] All this is applicable to the physical skill of learning to swim, as well as other more cognitive skills such as learning mathematics, developing reading skills, and learning to write.[21]

But how can we account for knowledge that is acquired without any essential accompanying behavior, as when a university student is expected to learn by listening to lectures and studying textbooks? How can perceptual control theory help us to understand how this is possible?

Here we will have to consider not just one control system as in figure 8.1, but see the person as made up of a complex hierarchy of control systems as described in chapter 8 and illustrated in figure 8.2. It will be recalled that

this hierarchy has two principal features. First, it is a hierarchy of *perception*. At the bottom level, perception is limited to perceived *intensity* of stimulation of the sense organs--sounds can be loud or soft, lights can be bright or dim. But as we move up the hierarchy, more and more complex perceptions are possible. Certain combinations of intensities give rise to particular *sensations*, for example, the taste of orange juice or the color red, and certain combinations of sensations result in perceptions of *configurations*, such as those involved in seeing and recognizing an apple or a pencil. Perceived changes in configurations result in the perception of *transitions*, as when a baseball batter senses the approach of a baseball. This combination of lower-level perceptions into more complex, higher-level ones continues in Powers's current model to include a total of 11 perceptual levels ending in what he refers to as a *system concept*.

The second major characteristic of this hierarchy is that control systems are organized so that the reference level of any lower-level control system is given by the output of the next higher-order system. So this is a hierarchy of goals as well as perception. This means that to answer the question of why a person is controlling a certain variable, we have to consider the reference level of the system above it. Why, you ask me, am I now opening my car door and getting behind the steering wheel? Because I am going to drive to Peoria. Why drive to Peoria? To visit a sick friend in the hospital there. Why visit a sick friend in Peoria? Because he is a good friend and I feel I should visit good friends who are ill. Why do you feel you should visit good old sick friends? Because I consider myself to be a kind and compassionate person. Why do you consider yourself to be kind and compassionate? Because that is the type of person I want to be. Why be this kind of person? I am not sure. When one reaches a high enough level, it becomes difficult to answer any more "why" questions. Nonetheless, a hierarchy of control systems in which higher-level systems pass down reference levels (goals) to lower systems makes sense out of much of human behavior as well as our perceptions of our own behavior by which higher goals (being a kind and considerate person) influence behavior by setting lower-level goals (getting in my car and contracting my muscles in such a way as to drive to Peoria). And it provides a very useful framework for understanding behavior as being purposeful at many different levels.

But note that in this hierarchy only the very bottom level interacts with the physical environment outside of the person. My driving to Peoria, although dependent on higher-order goals, can be accomplished only by the integrated contraction of dozens of muscles in my feet, legs, hands, arms, and neck. That is the only way that I can actually perceive myself driving to and eventually arriving in Peoria. However, I am able to plan and imagine the drive without moving a single muscle. I can imagine seeing the highway entrance ramp approach through my windshield, accelerating onto the highway that will bring me there, hearing the whine of the motor as it revs up in third gear, and feeling the stickshift in my hand and accelerator and clutch pedals beneath my feet. And again, all this without moving a muscle.

One way of explaining how we can plan and imagine certain experiences is to suppose that "imagination connections" can exist in the control system hierarchy between the outputs at a given level and the input at the same level. When these are activated, as indicated in figure 12.1, lower-level systems are in effect bypassed so that perceptions can be made to match reference levels *without having to act on the environment at all*. Powers provides an example from playing chess:

> Suppose one is trying to find a good program--say a program for dealing with the next few moves in a chess game. "If he moves his knight *there*, I'll move my rook *here*, but if he moves his knight the other way, I'll take it with the pawn." Of course in chess one is not permitted to move the pieces freely, nor would a good chess player (as I imagine him) babble to himself like this. Instead, he would simply *imagine* the relationships, not actually making the memory-derived images into active

reference signals, but looking at them as if they had been accomplished. That is how a reference signal would look via the imagination connection--as if the lower-order systems had acted instantly and perfectly to make perception match the reference image.[22]

From this example we can recall that this hypothesized process of imagination is essentially what we considered in chapter 9 as *thinking*. But such thinking does not necessarily yield the instantly perfect world to which Powers refers. Indeed, the power of thinking lies in its ability to reveal problems that would not have become apparent otherwise--realizing, for instance, that taking the knight with my pawn would expose my queen to danger from my opponent's bishop, and that therefore I had better come up with another plan. Seen in this light, thinking becomes the vicarious trial-and-error-elimination process that was presented in chapter 9, equivalent to Campbell's visually and mnemonically supported thought.

Thinking, then, becomes a way of discovering problems and attempting to solve them without overt behavior. If the problem involves variables for which control systems are already in place (for example, "what is 2 plus 2?"), it can be solved quickly and routinely. But if it does not permit the routine application of already existing control systems (for example, "what is the relationship between the roots of two polynomials whose coefficients are reversed?"[23]), reorganization as a form of blind variation and selective retention involving visually and/or mnemonically supported thought will be called on to solve the problem (with, of course, no guarantee that it will be solved).

We can thus conceptualize the type of silent, covert learning that takes place in lecture and study halls as a type of internal problem solving that involves the reorganization of existing control systems. If I am taking a course on molecular evolution and want a good grade, I will have to understand how DNA replicates and how mutations can occur during the replication process. Right now, I perceive myself as not being able to do this, and so there is error between a goal and a perception. Reorganization must therefore take place so that I can reduce this error. Attending lectures and studying my textbook will facilitate this reorganization, not by transmitting to me the required information, but by enhancing the production of new ideas concerning DNA replication and mutation (blind variation) and helping me to eliminate my wrong ideas and retain the better ones (selective retention).

Thus, a perceptual control theory view of thinking and the reorganization that must take place during the acquisition of new knowledge is consistent with a selectionist view of knowledge processes in general and with education in particular. I should not give the impression, however, that such a view is widely known and accepted in psychological and education circles. On the contrary, perceptual control theory is undoubtedly one of the best-kept secrets in psychology and education, since these fields continue to see behavior and thinking as determined by a person's environment and have no adequate explanation of how they are functions of the internal goals of the individual; that is, behavior and thinking are *purposeful* processes. Nonetheless, the selectionist perspective on learning offered by the theory is consistent with both Campbell's insight into the ubiquity of cumulative blind variation and selective retention in all knowledge processes, as well as twentieth-century theories that emphasize knowledge growth and reject the idea of education as the transmission of knowledge from teacher and textbook to student.

[1]Augustine (389/1938, pp. 47-48).

[2]Comenius (1623/1896, p. 441).

[3]Perkinson (1993, p. 34).

[4]Augustine (389/1938, p. 48).

[5]Augustine (389/1938, p. 46).

[6]Perkinson (1984, p. 15).

[7]A trip north of the Arctic Circle during the end of December (or south of the Antarctic Circle at the end of June) will clearly reveal that the belief that the sun rises every morning is mistaken.

[8]Perkinson (1984, p. 35).

[9]Popper (1963, p. 45).

[10]Piaget (1972; quoted in Perkinson, 1984, pp. 71-72).

[11]Perkinson (1984, p. 93).

[12]Perkinson (1984, p. 165). (Quotations from this and the previous three paragraphs.)

[13]Montessori (1967, pp. 246-247).

[14]Perkinson (1984).

[15]Perkinson (1984, p. 180).

[16]Perkinson (1984, p. 190). It should also be mentioned that a selectionist view of education also has important implications for educational research, implications that reject the current standard practice of attempting to improve education by investigating the relationships between independent variables (related to aspects of the transmission process) and dependent variables (measures of the success or fidelity of the transmission process). See Cziko (1989, 1992) for discussions of these and related issues.

[17]In this case, the crucial controlled variable is actually the carbon dioxide content of the blood. However, since we will assume that the student already knows that to breathe she must keep her mouth and nose above water, we will consider the latter to be the controlled variable.

[18]Recall from chapter 10 how the Wright brothers' breaking down the problem of flight into components led more quickly to a solution of the overall problem.

[19] See Farnham-Diggory (1992, pp. 173-175).

[20] A good example of scaffolding for a physical skill is holding a bicycle for a child learning to ride (or providing training wheels). In this way the child can learn to pedal and steer without worrying about balancing. As the child develops better control of balance, the instructor gradually withdraws his support (or moves the training wheels higher, eventually removing them altogether).

[21]An example of these techniques for teaching the complex cognitive skill of reading comprehension can be found in the research of Palincsar and Brown (1984) on reciprocal teaching. They were successful in teaching

reading comprehension skills to children who were having particular difficulty, by demonstrating and then having the children imitate concrete activities involving certain subgoals of reading comprehension. These included reading a text and then summarizing, questioning, clari-fying, and predicting its contents.

[22]Powers (1973, p. 223).

[23]They are reciprocals of each other. A„Ð3óï£úÓíû!~ùZ=Þ·zðÎ5H”òÞˆ³]]Å}ƒ•V¥ÔÉLðû¦tmß‚š·à¼ÿ@›g
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