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ABSTRACT

This paper addresses the contributions that brain research makes to education. Topics pertaining to typical brain research findings and their educational significance, caution in the application of findings to explain differences by population, and the types of research that could be potentially helpful to educators are discussed. Among the research findings that are useful to educators are that perception is constructive, the brain works as a whole system, brain function requires self-knowledge, multiple memory mechanisms are present in the brain, learning happens in an active brain, brains change with experience, organization is critical, and concrete knowledge is different than abstract knowledge. Lists of suggestions of strategies for educational research related to brain research and statements of goals of learning based on brain research are also included. (DDR)

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What Brain Research Has To Tell Educators: Mandates and Metaphors

by

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What Brain Research has to tell Educators: Mandates and Metaphors

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Brain research is growing at a phenomenal rate. Interest in that research, helped by the powerful fruits of new neuroimaging techniques, has grown almost faster in a public eager for a greater self-understanding and a foundation greater in fact and less faith for personal and public policy decisions. Educators, under continuing pressure to educate all children, have labored to gain a greater understanding of the neurological basis of learning and its individual differences. The question arises, what has brain research shown that educators should know and use; and, how should it be used. This rather brief overview suggests that, on the one hand there is very little specific research that has a direct bearing on educational practice; but on the other hand, there are important broader mandates and metaphors that educators and educational researchers should heed.

Let's begin with a consideration of some typical brain research findings and their educational significance. Ever since phrenology a high percentage of brain research has tried to identify what function occurs in what brain location. Assuming we get answers, what should we change if we know that structure X appears active in spatial learning, but not language learning? While this might suggest that the brain does some different things when working with spatial issues from linguistic issues, it is unclear what it might lead an educator to do differently. What if we discovered that there are some differences in the types of processing done by one half of the brain rather than another (you might consider left and right hemispheres, I was thinking of front and back)? While it may be interesting to know that those types of processing engage different parts of the brain, and thus may truly be different, it is unclear what a teacher should change as a results.

Much research has looked to identify differences in the brains of different populations -= a "diagnostic model." What if we learn that the brains of one type of person are different in a significant way from another (e.g. learning disabled vs. "normal")? It may be reassuring to some to learn that there is a biological basis for this difference - not just laziness, but it tells us nothing about the source of this difference, the potential to change it, or the potential to utilize other brain mechanisms to produce desired learning. The data may provide the basis for an excuse or for discrimination as much as providing the freedom from the sense of personal responsibility or personal failure - and the data tell us nothing about what to do about it.

Suppose I identify that a particular pattern of electrical events occurs when a person is doing X, but not when doing Y. Again, this provides evidence that X and Y are different activities in the brain, but little clear guidance as to how I, as an educator or educational researcher use that information. When I look at a beautiful functional magnetic resonance image of a brain engaged in a task and see the right frontal lobe stunningly illuminated, the awe of the display may overshadow fact that it provides no basis for understanding the origin or consequences of this difference. It provides no insights into how that information may be used to produce more effective education.

As some of the above suggests, the premature or selective application of brain research may actually be dangerous and counterproductive. If we find that there are differences in the brains of folks who are less successful in some aspects of education, it is quite easy to assume that the educational performance is determined by the fixed and limited contribution of a deficient brain. Studies of gender differences in mathematical ability have produced females who say, "I can't do that because I am a girl." Studies of left/right hemisphere differences have produced folks explaining their failures by saying that, "I'm right brained and school is left brained." Studies of the neural basis of reading problems have produced people who say, "I need special help and more time because I'm learning disabled (i.e. my brain is different)." At the same time, knowing there is a neural basis for a particular pattern of strengths and weaknesses may diminish the tendency toward personal attribution (e.g. Johnny could do math if he just tried harder, or different) and move toward thinking that a different pattern of utilization of the brain, or of technical or social compensations might produce student success.

Are there things that educators can learn from existing brain research that couldn't be learned without it? Probably not! Are there things that can be learned from brain research that have not been learned (or more importantly, accepted) from those other sources? Certainly yes! The history of education is full of sound and reasonable ideas for the improvement of educational practice that have been tried, maybe worked some for awhile, discarded, replaced, then rediscovered and reintroduced again later. The beauty of brain research for the educator lies in the power of the assumption that these observations are about where learning is really happening - not just the local sociocultural context in which public policy and personal educational decisions are made.

The power that current brain research provides for educators comes from the assumptions that are called into question and that researches ability to make other sources of information coalesce into mandates for action and the metaphors that transform. As an example, lets look at the most central educational issues - change and variability. Education is about changing people, but we frequently build into our research and thinking assumptions of stability - especially when brain research is used as the basis for the decision. If we find that the brains of learning disabled are different from those of the non-learning disabled, there is a tendency to assume that difference to be permanent. Furthermore, a high percentage of educational practice still acts as though there is only one way to do something (witness the language of the partisans in the phonics debates) rather that a variety of ways in which to reach the same goal. Brain researchers established that brains do change with activity, and do so throughout life. There is good evidence that brains can do the same task in a variety of different ways and still achieve the same end. These types of research are not the primary focus of brain researchers, but contain some strong assumption shaking for educators. When a school district adopts a new curriculum (e.g. a brain based curriculum) does it assume there is one right way to do things? Does it assume that the brains of the learners can change? How much? By what actions? Does it make assumptions about everyone learning at the same rate or the same way? The potential to see learners as complex, varied and changing; and to see teaching methods as mandated to engage that complexity and variety is a powerful mandate for educators - one that changes many of the metaphors we use.

What are the questions that should be kept in mind in applying brain research to education?

- Assuming there are differences in brains and their use, how did they get there?
  - What was the genetic contribution?
  - What was the maturational contribution?

What was the early experience contribution?
What was the contribution of learning?
What is the contribution of non-learning (contextual) factors?

- But more importantly, what is the potential for these differences to change
  - How much of that potential is real brain change?
  - How much of it is learning to use the same brain differently?
  - How can the change best be produced?
    - How important is self-regulation central to change?
  - How much does the potential for change decrease with age?
- Are there multiple ways in which the same learning goal can be accomplished?
  - Are the functionally equivalent?
- What metaphors or models do we use in thinking about brain function and thus import them into our thinking about applications?
  - Where do we assign responsibility?
  - Where is responsibility for change?
  - Do we deal with functions as isolated, or interacting?
    - e.g. is reading ability influenced emotion, prior learning, etc?
  - Do we assume things are either A or B, rather than when and how are they A, when and how are they B?

What have we learned from brain research (combined with other research) that is useful for educators?

• Perception is constructive, synthetic, multisensory and sensitive to context.

Our perceptions are produced by the synthesis of information from multiple parallel pathways combined with past experience and the current state of the perceiver. This means that all perceptions are personal constructions that combine what is actually happening with our past experience, emotional states, internal bodily conditions, etc. You can never be sure that a person perceives something the way you do unless you have confirmation - words usually do, but preferably actions.

• Even though there are functional units to the brain, it works as a whole system.

There are multiple subunits of the brain that can work independently. For example we can produce language that doesn't correspond with our feeling, or we can drive a can to a location, but not necessarily be able to draw a map of what we just did, etc. But the various sub-systems of the brain work together all the time. This means that the behavior observed depends on the way in brain is used, which parts are activated as much as which parts are there and what each can do.

• Brain function involves self-management, which requires self-knowledge.

The owner of a brain has much more potential to influence how it is being used than others. A learner has the potential to engage emotions or not, reflect on past experience or not, select a learning strategy or not, attend to something or not, try or not, etc. Thus, a critical thing for learners to learn is how to regulate their own brains. This is not just discipline in the usual sense, but a purposeful self-regulation which may be very different for different learners. Successful self-regulation requires self-knowledge - what is in my brain, how do the pieces work, what are my strengths and weaknesses, etc. This requires the learner to have directed reflection of what is being done and how. It also requires that learners has opportunities to make personal choices, reflect on their consequences and learn from them.

• There are multiple representational system (sensory and motor) available for any type of knowledge.

The same information can take quite different forms in different brains, or the same brain. The same thing may be visual images, auditory stories to another, verbal outline form to another. Different people have different representational inclinations. Being able to talk about something doesn't mean I can do it. Being able to remember things I make into visual images doesn't mean I can remember the same thing as auditory images. All learners can transform from one representational form to another - usually only with prompting and practice. This requires active effort by the learner. Motor representations (skills) require practice - mental practice can be as good as physical practice. Multiply represented information is most easily retrieved and used, as well as best understood. Thus the best learning will be multisensory and active.

• There are multiple memory mechanisms in the brain.

In the brain memory for facts/skills (things you can be conscious and talk about) is handled differently (different brain areas) from memory for emotions, which is different from memory for "automatic" skills, which is different from simple conditioned responses, which are somewhat different from spatial memories, and there are probably others. This means that there are several independent components to a memory; or, that we may learn/remember different components differently, or, that there are different ways to learn/remember the same thing. People are not necessarily equally skilled in all approaches. Memories with specific sensory components are retrieved through that sensory system. So remembering visual images of something activates the visual area, while remembering the sound of what someone said activates the auditory area. Remembering is recreating the same pattern of activity as if the real event (or whatever form it is being remembered in) were actually happening again. Thus memory will work best to the extent that you can recreate the context - internal and external - that was present when the event happened and was stored. Skills at self-regulation and imagery are valuable.

• Learning happens in an active brain.

The brain is always active - but not necessarily actively focused on the learning task at hand. An active brain does not necessarily mean an active body. An active brain can transform things that happen in one sensory system into others. For example, a learner can listen to a learner and create multisensory experiences in his/her brain - including representations of the actions that might be taken as a consequence. Learners need opportunity and time to "play" with what they are learning. Teachers can help focus the activity of the brain; but, the learner controls it.

• Consciousness is still a puzzle, but probably less important than we think.

There is little evidence that there is much, if anything that we can do with consciousness that we can't do without it - except use it to modify and regulate what is not working properly without consciousness. Much of what educators do has consciousness for them and for the learners. But the ideal situation if for the actions to become "skilled" - which means sufficiently automatic so that consciousness is not required for their use. This includes things like control of motivation, learning strategies, active learning, making multiple representations, etc. Consciousness is most useful in initial sharing of information and in alerting us to problems and helping develop strategies for solving them.

• Brains change with experience. The potential for change decreases with age.

Brains actively engaged in their environment can change at any age. At early ages they change more, and more easily than later. The brain starts out with nearly all of its cells and produces lots more connections (synapses) than will continue to be used. Additional activity can produce some more cells and more synapses; but, the most important changes over the school years are the selection of which connections will be lost. Those that are not functionally used tend to disappear. Thus, the more active early learning the better - but old dogs can learn new tricks. It is important to remember that all learning is in relation to prior learning, thus earlier learning generally will have greater stability and impact than later. The human brain develops through adolescence (the last parts to complete development are the frontal lobes that are critical for self-regulation). The development of the brain depends on its use (learning) during development.

• What the brain does, and can do aren't necessarily the same.

The capacity for change makes clear that what a brain does should not lead to any assumptions about what it can do. At present, the only way know what an individual and his/her brain can do is try and see. It is better to assume change is possible and see how much desirable and appropriate change can be produced than to assume the way it works is the way it will always work. This is true at all ages, but moreso at younger ages.

• There are optimal levels of arousal and of complexity. These are established in relation to what is already in an individual's brain.

Independent of brain research we have long known that there are optimal levels of arousal and that the optimum level varies depending on the complexity of the task. What brain research helps make clear is that the optimum can vary with the person and that the complexity depends on the prior learning of the learner. Thus, knowing the optimal level or arousal, complexity of the task and appropriate rate of progress is significantly dependent on information only the learner has. Learners need to play a bigger role in selection and direction of their learning if it is to be optimally effective. Note: in light of earlier comments about self-management, learners can learn to adjust their own levels of arousal and restructure tasks to create optimal complexity - but only if they learn how to do this, are encouraged to do it, and have the time and types of learning tasks that provide the opportunity.

• Organization is critical.

Since all of the brain is active all the time, any particular piece of learning is likely to utilize many of the same brain cells as any other piece of learning. The more similar the learning tasks the more this will be true. If learning is to be retrievable in the future it must be stored in the brain with an organization or cues that are distinctive and discrete. This means the learner must actively organize and differentiate - produce patterns of sorting through "knowledge structures" (memory) to find specific information. Otherwise we have the "what they know in June but can't remember in September" phenomenon. As noted in discussing multiple representational systems above, learners can organize in quite distinctive and unique ways. They must do the organization. Memorization (i.e. rote repetition) of discrete pieces of information is quite poor at creating organization. It requires active creation of structures or categories, recognition of relationship - similarities and differences, thought about areas of use and means of application, etc. - elaborative processing by the learner.

• **Concrete knowledge is different from abstract knowledge.**

We don't know very much about how the brain handles abstract or general concepts, except that it is different from the concrete and the first to go if there is brain damage. There is a long and heated debate about whether learning is concrete and/or situational or whether generalizeable principles can be taught and widely applied. For an abstract principle (e.g. I can be a successful learner if I find the right strategy for me on a particular learning task) to be useful it needs to operate in a general way in a wide variety of domains. It is clear people can and do learn and utilize abstract principles such as the example above. It is likely language plays an important role (articulation of the principle) and multiple representations of it (using it often in different situations) and the frontal lobes play a role in self-regulation (reminding us to check our memories for abstract principles that may apply to this situation. All these can be learned. All require practice to become automatic.

Assuming you assimilated the above information (we'll stay away from the more technical and speculative),what does it do for the teacher/learner?

1. There should be optimism from the belief that if one way isn't working another might and that change is possible.

2. There should be a conviction that learning is not about teaching or about learning but about the interaction of the two. It is a collaboration between what the teacher does and what the learner brings to the task. The teacher is both teaching and teaching learning skills in collaboration with the learner.

3. There is a framework (more complex than just using intelligence and motivation) that can be utilized in understanding successes, or lack thereof, in learning.

4. That framework provides models and alternatives to work with. There should be the acceptance of multiple modes, varied speeds, and the importance of enlisting the learner's brain in producing successful learning strategies and skills.

5. The ideas that "my brain is doing it" and "I can control what my brain is doing" are powerful vehicles to get the student focus on what needs to happen to produce success, rather than blaming the task, the teacher, etc.

What do these findings suggest regarding fruitful strategies for educational research?

1. Treat subject as subject - not object

Learning is a social interaction in which what the learner brings to the activity (knowledge, skills, motives, organization, etc.) is as important as what the teacher brings. Finding out what the subject did and thought - how the task was approached - may be as important as the performance data obtained. It is certainly critical in the interpretation of the significance of the data.

2. Focus on variability - the potential to change

Instead of looking at status data, it would be more helpful to look at the potential to change and the differences those changes make.

3. Look for how things can work - not just how they do in a given study

Lots of time and energy is spent on trying to decide if X method improves the learning of Y. It is likely to be more constructive to look for what methods can improve Y, then look for which factors contribute to the relative success of each.

4. Study interactions

Brain research suggests that educational effectiveness depends of the interaction of a variety of factors. Rather than studying whether, for example, whether homogenous ability groupings are better than heterogeneous groupings, it would be more productive (and consistent with what we know of brain function) to attempt to understand which method works best for whom, for what goals, with what methods. The resulting data will provide more functional data, less political data.

5. Look for successes - study them and their transformations

What works, in whom, where. This is sure to lead to multiple prototypes that can be adopted or transformed by users. Hybrid research models that combine more transitional data collection with multiple case studies would be a good start. The same logic applies to work with individual learners - look for what works (anywhere!) and see how those biases and strengths can be transformed to apply to the learning task at hand.

6. Create research collaborations

Research teams of brain researchers, cognitive psychologists, educators, learners (among others) are likely to much more productive than more traditional disciplinary research teams. Such collaborations may be a bit uncomfortable at first at each group learns to talk the language of the other, but the fruits are likely to be worth the effort.

What are the research types which educators should most look for and encourage

- Studies of the potential for the brain to change
- Studies of individual differences of "normal" learners brains
- Studies which identify alternative ways in which brains can work - e.g. multiple representations, different sub-components of what we tend to think is only one thing, etc.
- Studies of the ability of the brain to alter or regulate itself
- Studies of interactions - the effect of varied teaching/learning methods on the success of varied types of learners and with varied tasks - and correlates of brain activity
- Studies which engage the learner in the development and implementation of the learning strategy

Goals of learning

We have traditionally thought of learning as the acquisition of a body of information, and to a lesser extent some skills. Brain research suggests that this view misses more components of the process - those that, to a large degree determine the degree to which those goals are attained. A more constructive set of goals might be:

- A body of **organized** knowledge that the learner can use (i.e. has mastered)
  - this includes abstract and concrete knowledge and the ability to move from one to the other

- A set of **functional** skills - reading, writing, speaking, listening, etc.
  - including the ability to utilize these skills effectively in multiple contexts
- Learning skills
  - the possessions self-knowledge, self-regulation and monitoring skills , facility in effective use of a variety of learning strategies, knowledge of how to get, organize and evaluate needed information
- Learning motives
  - valuing learning, enjoying it, a sense of optimism, self-efficacy

Conclusions

This began with a cautionary warning that brain research had probably not provided us with much specific information that tells educators what to do. I further suggested that premature conclusions drawn from brain research could lead to well-intentioned but misguided application of the presumed conclusions. I then went on to suggest that there were many important confirming conclusions supported by brain research that challenge assumptions about learning and education and the methods of educational research. The list of conclusions should be regarded as tentative - a work in progress. Just as we find that particularl educational strategies may work for some in some situations, we may also find that particular models of brain function will appear true in the context of specific types of research assumptions, models and tools. Only through continued research and thoughtful reflection on that research will we continue to move forward.

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