The Prospect of Prescriptive Education Driven by Student Genetic Information

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ABSTRACT

As researchers dig more deeply into the human genome, they are uncovering the genetic basis for more and more human behaviors and characteristics. It is not unreasonable to consider the possibility that a student's aptitudes and preferred learning style may be determined at least partially by heredity. It is also not unreasonable to consider the possibility that genetic testing, which may become a routine part of life in the relatively near future, will be able to acquire that information. This information could assist students in selecting academic majors and individual courses. It might even allow the development of educational programs customized to match the individual aptitudes and learning styles of each student.

INTRODUCTION

This is admittedly a very strange paper for an academic business conference. It doesn't report on the results of a research study. It doesn't summarize and integrate the results of many studies. It doesn't even propose a new study. Further, it isn't on a topic that falls within my own disciplines - management and operations management. I do not have a background in biology, biochemistry, genomics, medicine or any of the other fields that play such a prominent role in the study and use of genetic information. Therefore, before going any further I need to provide some explanation.

I teach management and operations management in a college of business. I was recently assigned to join a team developing a new program in healthcare management with an emphasis on biotechnology. Having little background in either health or biotech, I began reading feverishly to prepare to teach in the new program. In order to develop the basic science vocabulary needed to be able to talk intelligently to the scientists and medical people who make up much of biotech, I began my reading with what was intended to be a brief study of some of the science that provides the foundation for the industry. I found this information fascinating and, instead of jumping to the management aspects of biotech as quickly as possible, I lingered on the science. In the process of doing so I came across quite a few intriguing ideas – ideas to which business faculty generally wouldn't have been exposed. This paper discusses one of those ideas.

James Watson (2003, pp. 398-399), co-discoverer with Francis Crick of the structure of DNA, briefly raises the issue of using genetic information to enhance learning in the last "where we might go from here" chapter of his book. While noting that we don't yet know the degree to which genetics impacts learning, he suggests that we someday will. He further proposes that we will be able to develop educational programs designed around the characteristics of individual students and that we may even reach a point at which a pill could help a student overcome a mental disability or enable a slower learner to keep up with a rapidly moving class. Although these things certainly won't happen by tomorrow, they may be possible much sooner than we think. Spurred on by the mapping of the human genome, researchers are progressing at a phenomenal pace. Thus it is time for educators to begin considering this idea of customized prescriptive education and to begin discussing some of the issues that it might raise.

THE IMPACT OF HEREDITY ON HUMAN BEHAVIOR AND ABILITIES

Determining the extent to which a particular trait or behavior is genetically induced can be an extremely complex process. Most of us first learned about genetics and dominant versus recessive genes in high school biology through rather simple examples using traits such as eye color. These examples can mislead us into believing that genes relate to characteristics in a straightforward one-to-one fashion. Such is not generally the case.

In the blue eyes versus brown eyes example from high school the resulting eye color was completely determined by the genetic material inherited from the parents. To put it simply, a person's eye color is determined at the moment of conception and doesn't change based on life experiences. Many traits and behaviors, however, are not quite so straightforward. Some are largely determined by heredity. Some are, in contrast, largely determined by experience and environment. But even those characteristics that are significantly impacted by experience and environment often have an underlying genetic component. Many genes, called promoters, have as their primary role the responsibility to turn other genes on and off. These promoters do so in many cases in response to environmental stimuli. Thus environment and heredity act together to cause many human characteristics. This can make it very difficult to accurately determine the true impact of heredity on a particular trait of interest and even more difficult to determine which gene or genes contribute to the trait. This determination is further complicated by the fact that even those traits that are gene-induced are generally induced by multiple genes.

Some examples using more complex traits than eye color may help to develop a greater appreciation for heredity's possible impact on student aptitudes and learning. Consider religious fervor, a complex behavior (Ridley, 2003, pp. 79-80). In a large study of twins raised apart (e.g. twins adopted by two different families) in which each twin responded to a questionnaire about his or her beliefs, identical twins were found to be much more similar than fraternal twins ($R = .62$ versus $R = .02$). Note that identical twins come from the same egg and sperm combination and thus share identical genetic information. Fraternal twins, although sharing the same parents, are the result of two separate egg and sperm combinations and thus do not have identical genetic makeups. The differing correlations suggest that a fairly large portion of a person's tendency toward religious fervor is genetically based.

Other similarly designed twin studies have consistently shown that various factors of personality, which psychologists break down into the five categories of openness, conscientiousness, extroversion, agreeableness and neuroticism, are significantly impacted by heredity (Ridley, 2003, pp. 82-83). It is interesting to note that characteristics such as personality and religious fervor, characteristics that we would intuitively believe to be almost entirely a function of upbringing and experience, are driven by heredity to such a large extent.

Intelligence is a characteristic that is obviously relevant to student academic success and thus deserves some comment here. Despite the fact that the issue is clouded to a large extent by the difficulty in defining and measuring intelligence, this trait also appears to have genetic component, although it seems be much more seriously impacted by upbringing and environment than the personality traits discussed above (Ridley, 1999, pp. 87-94). Unfortunately, despite much effort there has been very little progress so far in the search to identify specific genes that impact intelligence. Although the genetic mutations that cause certain forms of mental retardation have been found, the search for the genes that separate the smart from the average has not yet had much success.

Note that one of the obvious weaknesses of twin studies is that virtually nothing is learned about the specific genes that might be causing the differences and the underlying mechanisms behind the observed effects. Scientists are just beginning to be able to identify the specific gene or genes associated with complex characteristics such as those discussed above.

This search for genetic causes is complicated by the fact that many phenomena are more the side effects of genes than the direct results. For example, there probably isn't a gene for criminal behavior. However, characteristics such as impulsiveness, lack of emotional stability and a taste for alcohol are likely inherited. And possessing characteristics such as these will encourage the types of behavior that we recognize as criminal (Ridley, 1999, p. 87).

With the recent completion of the mapping of the human genome scientists and doctors now have a tremendous opportunity to discover many of the as yet unknown genes and, eventually, to determine the outcomes caused, encouraged or inhibited by these genes. Currently, much of the effort in this search is directed at finding the genes that cause serious genetic diseases, but as the research proceeds and broadens its focus there will undoubtedly be more attention paid to some of the education-related characteristics that are being considered in this paper.

STUDENT APTITUDES AND THE SELECTION OF AN ACADEMIC MAJOR

Obviously, different students have different aptitudes and interests. In a perfect world, each student would carefully consider those aptitudes and interests when selecting a major. Unfortunately, an eighteen-year-old freshman generally won't yet fully know exactly what his or her skills might be. Further complicating things, this freshman won't have much understanding of the skills required for many of the disciplines from which a major might be chosen. Aptitude tests might help this student determine his aptitudes and interests and academic counseling could help a student learn more about the disciplines of interest. However, although most universities make these services available to their students, many students never bother to take advantage of them.

Genetic information, possibly obtained as part of the admissions process, could be used both by the student and by academic counselors to help the student do a better job of picking a field of study in which he or she would be most likely to succeed. It is unlikely that a student's DNA would ever suggest something as specific as "be an accountant but not an auditor." More general traits, however, such as creativity, mathematical ability or the ability to think abstractly, are likely to have at least some genetic basis.

LEARNING STYLE

Each student will learn most effectively when taught in the ways that best fit his or her individual characteristics. Learning styles, which have been studied by educators and psychologists for decades, provide a way to classify these differences. A student's learning style defines the ways in which the student tends to process incoming information, organize the information after it has been perceived, and retain that information for subsequent use. Keefe (1987) provides a summary of the topic. Without going into detail, some of the many ways in which students might differ are:

- degree of structure and guidance needed
- preferred mode of perception, e.g. visual versus auditory
- breadth of focus, i.e. seeing primarily the forest versus seeing primarily the trees
- ability to tolerate new ideas that conflict with preconceptions
- susceptibility to distraction
- ability to recognize subtle differences
- speed of information processing
- categorization of ideas and the relationships between those ideas
- curiosity
- persistence
- reaction to being given a highly challenging learning task
- degree of competitive versus cooperative behavior
- reaction to reward or punishment from the instructor
- tendency to imitate
- desire to achieve an internal standard of excellence
- personal interests
- physiological characteristics such as health and time-of-day rhythms

Gregorc (Keefe, 1987, p. 5) notes that a learning style represents "qualities in the behavior of individual learners that persist regardless of the teaching methods or content experienced." In other words, the student will continue to possess the same learning-related traits and preferences regardless of which teaching method we faculty might employ. Therefore we should not count on the student eventually becoming fully adapted to our methods. Instead we should make some effort to adapt our methods to the student's learning style.

Note that Gregorc's statement also suggests that learning styles will not change in reaction to content changes. For example, a student who had a particular learning style when taking a financial accounting course last semester will not change his learning style now that he's taking a

course in organizational behavior, despite the fact that the course content of the second course (and the teaching methods often used) is so drastically different from the first. Because learning styles tend to persist, educational institutions would only have to obtain the learning style information once and would then be able to make valuable use of it throughout the student's entire college career. The student, of course, would be able to make use of this information for life.

A variety of instruments are available, each of which measures a particular subset of learning-related characteristics (Keefe, 1987, pp. 16-25). Currently most university students do not take these learning style tests and thus don't fully understand their own learning preferences. It is to be hoped that the genetic information that might eventually become available would be both more complete and easier to obtain than the information provided by each of these instruments.

ACCOMMODATING LEARNING STYLE DIFFERENCES IN BUSINESS EDUCATION

Those of us who teach business have been encouraged for many years to use a variety of teaching methods in addition to traditional lecture as a way of reaching more students. Garvin (1991) and Lundberg (1993), for example, discuss the benefits of case discussion as a way to promote greater student involvement with the material and hence a higher level of learning. Sternan (1992) and Parmenter (1999) discuss the benefits of hands-on experiential exercises. Thompson and Stappenbeck (2002) promote the use of computer simulation games.

Implicit in our use of this variety of teaching methods is an assumption that different methods will succeed at different levels with different students. We recognize that each of our students learns in slightly different ways. We therefore use multiple methods in the hope that every single student will be reached by at least one of these methods and will thus effectively learn the concepts we are attempting to impart.

Although we are not guilty of a "one size fits all" mentality here, we are somewhat guilty of "many sizes fit all" thinking. Although we use multiple methods, with the hopes of satisfying all students at least partially, we don't generally go to the trouble to learn which student is best served by which method. Thus, although we apply a variety of methods to the class as a whole, we don't attempt to customize our instruction to the individual student. The customization that might become possible through student genetic information would represent a significant improvement for many students in that they would then be taught in the ways most appropriate for them.

RESISTANCE TO USE OF GENETIC INFORMATION

As Watson (2003, pp. 398-399) points out, the key question is not so much whether it will become possible to make use of genetic information but rather whether society will be willing to do so. Many people and governments have been resistant to the genetic engineering advances of the last several decades. And many people are, with some justification, fearful of the possible misuse of genetic information.

The fear of genetically engineered products is widespread although not entirely reasonable. After all, for centuries farmers and animal breeders have been developing improved versions of various plants and animals by selecting parents with the desired characteristics. The vast majority of what most of us eat has been developed through the artificial selection process of controlled breeding. And unless it's a wolf, your pet dog isn't really all that much more "natural" than Dolly the cloned sheep. Some of those who resist the developments in genetic engineering are unhappy with the idea of mankind, in essence, "playing God." Others are afraid of the unintended side effects that might occur when a particular plant or animal is genetically altered. Genetically altered foods, termed "Frankenfoods" by their detractors, are illegal in some nations.

Fear of the misuse of genetic information, however, seems quite reasonable. Possible misuses might include an insurance company's withdrawal of medical coverage for a patient determined to suffer from a serious genetic disease or a potential employer's rejection of a job applicant for the same reason. Governmentally oriented fears might include the inability of two people to obtain a marriage license because both carry the gene for a genetically based malady. Although such fears may sound somewhat paranoid, it should be noted that in the first half of the 20th century the U.S. government used the genetically based "science" of eugenics as a basis for restricting immigration and even mandated forced sterilization for those with particular mental problems (Ridley, 1999, pp. 286-300). Luckily, the research done so far on genetic cause and effect suggests that the vast majority of genetic differences are not racially-, nationality- or gender-based and thus the use of genetic information should not engender too much complaint from those driven by political correctness.

In the context of education, many will have similar fears concerning the potential misuse of data. It would not seem too unreasonable to fear, for instance, that students might be tracked into slow-learner classes against their will or that schools might use information concerning learning disabilities as a rationale for denying admission to certain students. If student genetic information does indeed become obtainable there will have to be a tremendous amount of discussion on the part of the educational community to determine just how that information should be used. It would be irresponsible on the part of universities to ignore the availability of the information and thereby forego the potential benefits that might be gained by both the schools and the students. But it would be equally irresponsible to use that information in haphazard and possibly unethical ways.

PREPARING FOR THE CHANGES

Although the specific nature of the coming genetically-based educational developments is not yet clear, it is fairly safe to assume that some, possibly many, of the characteristics that impact student success will be discovered to have a genetic basis. It is also fairly safe to assume that genetic testing will become readily available in the future and that such testing would be able to inform us of these characteristics for each of our students. We would be remiss as educators if we wrote off these potential developments as science fiction or as something to be dealt with by a future generation of faculty. They may be here sooner than we think. Thus we should begin to consider these issues and prepare ourselves for some of the possible changes that our careers may undergo.

Here are some of my predictions. First, business faculty will be expected to develop increased expertise concerning learning styles and the applicability of various teaching methods to those learning styles. We won't be able to make use of our students' genetic information effectively if we don't fully understand the relevant learning style issues. While doing research is obviously one of the key components of academic life and developing discipline-related expertise is one of our primary tasks, it is a shame that so many of us were not taught more about learning styles and teaching while in graduate school. It will become increasingly important for us to learn some of the concepts and techniques that faculty in colleges of education take for granted.

A second prediction is that business faculty will be strongly encouraged to broaden their portfolio of teaching skills in order to be able to effectively teach students with various learning styles. Note, by the way, that I have no intent here to denigrate lecturing as a teaching method. A good lecture is truly a thing of beauty. However, some students are best taught using other methods and the knowledge of student learning style that we will obtain via genetic testing will make it possible for us to better fit our methods to each type of student.

A third prediction is that independent study learning will become more common. Student learning style information will allow us to determine those students who best learn in unstructured situations and who can be trusted to take full advantage of the freedom offered by independent study courses. Similarly, such information would also allow us to determine those students who should not be allowed to take independent study courses. Many schools currently limit the number of independent study courses that any one student may take. The recognition that some students might be best served by independent study will cause those limits to be removed. Faculty administering independent study work will be expected to increase their expertise at doing so. As these faculty teach more independent study students, they will become masters at determining just how much structure and guidance each student might need and how much freedom should be provided.

Similar logic would apply to online learning. Possessing student learning style information would allow us to more effectively determine which students should flourish in online courses and which students might be better off in a traditional classroom setting.

Another prediction is that student advising will become a more important component of faculty work. Many of us currently advise students on subjects ranging from which courses to take to the possible ramifications of a particular career choice. If the genetic information discussed here does indeed become available, student advising will become a much more complex and time-consuming task. But it will also ultimately be a much more useful and rewarding task, as our advice will have a much larger impact on student success, both in college and beyond.

Like teaching methods, class assignments will be customized as well. Although it sounds somewhat unfair to think of assigning different tasks to two students taking the same course, we will ultimately learn that assignments tailored to each student's preferred learning style will cause every student in the class to learn more effectively. For example, consider students who are self-directed, highly motivated by challenging tasks and skilled at integrating related concepts. These students could be given a large semester-long exercise, possibly as a group

project, in which choices concerning things such as articles to read and websites to visit would be left almost entirely up to the students. Conversely, consider students who are likely to be overwhelmed by such a large and vaguely defined assignment. Such students would need a series of small fully defined assignments, each accompanied by a detailed reading list and the questions that they are expected to be able to answer once the reading has been completed. Using customized assignments would obviously complicate the grading process. And continuing this theme of customization, note that we will likely discover that different students will require feedback and encouragement that is structured in different ways.

I have one final prediction, possibly a little more outlandish than the preceding ones. When students know their own learning styles and the teaching methods under which they most effectively learn, they will be able to make better choices concerning course selection. They will not only focus on the topics that are most appropriate for them but will also be able to select the portfolio of teaching methods, and hence the professor, that is most appropriate for any given course. If this idea were to be taken to its logical extreme, each section of each course in any given semester would be designated as primarily lecture, primarily discussion, primarily experiential exercise, and so forth. We all recognize that students talk to each other about their professors and make course selection choices based on which professor they want to avoid and which professor they think will best teach them. The learning style and teaching mode information that future students will possess should allow them to make these choices in a more informed way.

CONCLUSION

This paper has discussed the possible use of genetic information to devise an educational program that most closely matches the characteristics of a given student. It has not, however, raised what many might view as the logical next step - genetically altering the student himself in order to develop a better learner. It may become possible in the not too distant future to alleviate learning-related problems via genetic means. And, although it raises many ethical questions, we may develop the techniques necessary to enhance the abilities of even the best students, i.e. to create "super students." Scientists have already managed to genetically improve the learning speed of a fly and the memory of a mouse. It may not be too long before we can do the same thing for a human.

REFERENCES

Garvin, D. A. (1991). Barriers and gateways to learning. In C. R. Christensen, D. A. Garvin & A. Sweet (Eds.), *Education for judgement* (pp. 3-13). Boston: Harvard Business School Press.

Keefe, J. W. (1987). *Learning style theory and practice*. Reston, Virginia: National Association of Secondary School Principals.

Lundberg, C. C. (1993, Summer). A framework for student case preparation. *Case Research Journal*, 132-143.

Parmenter, D. A. (1999). Teaching process improvement and team building using origami. *Quality Management Journal, 6* (4), pp. 41-54.

Ridley, M. (1999). *Genome*. New York: HarperCollins.

Ridley, M. (2003). *Nature via nurture*. New York: HarperCollins.

Sternan, J. D. (1992, October). Teaching takes off: Flight simulators for management education. *OR/MS Today*, pp. 40-44.

Thompson, A. A., Jr. & Stappenbeck, G. J. (2002). *Business strategy game player's manual*. Boston: McGraw Hill Irwin.

Watson, J. D. (2003). *DNA: The secret of life*. New York: Alfred A. Knopf.