AEB 7453: Natural Resource Economics

Fall 2017

Instructor Information:

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352-794-7633
Office hours: Mondays 2:00 – 3:00 PM, Wednesdays 1:00 – 2:00 PM

Course Logistics:

Tuesdays 3:00 - 4:55
Thursdays 4:05 – 4:50
Classroom: 51 Matherly

Course Description:

Without the land, the rivers, the oceans, the forests, the sunshine, the minerals and thousands of natural resources we would have no economy whatsoever
- Satish Kumar, ecological campaigner (2008)

We never know the worth of water till the well is dry
- Thomas Fuller, historian

The best time to plant a tree is 20 years ago. The second best time is now
- Dambisa Moyo, Zambian economist

Natural resource economics is the study of use of Earth's resources. It examines the allocation of scarce resources across time and space. It examines the incentives in place that lead to excessive exploitation of resources and presents ways to alter incentives to reach socially optimal use patterns. Natural resource problems usually include dynamic and/or spatial components, creating challenging but intellectually rich problems to study.

Course Objectives:

By the end of course, each student should be able to do the following:

1) Solve renewable and non-renewable resource problems using dynamic optimization.
2) Illustrate resource use equilibria with phase diagrams.
3) Provide intuition for mathematical answers to dynamic resource use problems.
4) Critique scholarly articles pertaining to natural resource economics.
5) Develop models to address a wide range of natural resource problems.

Required Knowledge:
Students are expected to know how to graph basic equations, take derivatives, and integrate basic functions. If this knowledge has gotten rusty, it is the student's responsibility to re-learn these skills.

UF Grading Policy:
For information on current UF policies for assigning grade points, see https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Course Grade and Assignments:
Your grade will be determined by:

- Four problem sets (20% in total, 5% each)
- Take-home midterm (20%)
- Take-home final (20%)
- Research project proposal (20% in total)
- Three in-class application exercises (15% in total, 5% each)
- Effort (5%)

Letter grades will be assigned as follows:
A = 93 and higher
A- = 90-92
B+ = 87-89
B = 83-86
B- = 80-82
C + = 77-79
C = 73-76
C- = 70-72
D+ = 67-69
D = 63-66
D- = 60-62
E = less than 60

Problems Sets:
There will be a total of 4 problems sets. Each will count for 5% of your grade, making problems sets 20% of your grade in total. Students are encouraged to discuss problems with others, but must write up their problem sets separately. Late problem sets will not be accepted.

Exams:
There will be one take-home midterm and a take-home final. Each take-home will be worth 20% of your grade. Students must work independently on these exams. Evidence of collaboration will result in a grade of 0 for the exam for all involved. Late exams will not be accepted.

Research Proposal:

Throughout the course, each student will develop a research proposal on a topic of his/her choice.

- Students must submit a 1-paragraph summary of their topic by the beginning of class on September 12. Students are encouraged to talk with me during office hours before then to discuss possible topics. All students who submit a topic by the date will earn complete credit, worth 2% of your grade.
- A rough draft is due on November 7. This will be worth 8% of your grade. I will provide comments to be incorporated into the final draft.
- The final proposal is due in class on November 30, and this will be worth 10% of your final course grade.

In-Class Application Exercises

We will have three in-class application exercises. For each, I will create real-world natural resource problems for which students will create and solve models. This work will be done in randomly assigned groups. We will utilize our double class period day to ensure that students have enough time to develop models and then share them with the class. Students will be graded on participation in their group's work (50% of exercise grade), and the final model and model solution (50% of exercise grade). If a serious, unforeseen, and documentable situation arises that prevents a student from participating in any of the application exercises, the average of the other 2 exercise grades will be entered for the missed exercise.

Field Trips

Coursework will be supplemented with field trips to experience natural resource problems in our area. A survey of availability and interest will be completed at the end of the first week of class. Past fields trips have included a trip to Cedar Key to learn about the aquaculture industry that replaced the fishing industry when fishing gear bans limited fishing activity and a trip to Austin Carey Forest to learn about forestry issues in Florida. We will be considering a trip to area spring(s) to learn about the environmental problems they face. All field trips outside of class time are highly encouraged but optional.

Effort:

This portion of the grade used to be titled "participation." After researching about the effects of rewarding the learning process instead of rewarding learning outcomes, I have changed this to "effort." Please see the attached article for more information on this line of research. You will be rewarded for demonstrating effort in this class. Effort includes, but is not limited to, the following:

- Attendance: Attending class and actively participating in activities, asking questions, and providing comments and insight regarding course material are the basis of the learning process.
- Arriving on time: Late arrivals impede your learning process as well as the learning process of your classmates. Tardiness will result in lowered effort

scores, with the penalty increasing with each day of tardiness.

- Engagement: Use of cell phones, laptops for non-noting takes purposes, etc. during class interferes with your learning process and will result in lowered effort scores.
- Time and energy spent on assignments and exams: Assignments and exams are meant to be learning experiences. There is little learning benefit from rushing through them at the last minute. Rushed, sloppy, and/or "bare bones" answers demonstrate a lack of effort.
- Utilizing office hours for additional help or clarification: Most students will face at least some material that they do not immediately understand. Following up with questions during office hours is a great way to gain a better understanding of course material.

<u>Academic Honesty:</u>
Any student found to be in violation of the Student Honor Code will receive, as a minimum penalty, a grade of "0" on the assignment or exam. Students may also be asked to attend seminars on ethical decision making and/or avoiding plagiarism.

<u>Attendance:</u>
Attendance is not mandatory, but students are highly encouraged to attend class and actively participate in discussion. Questions and comments raised by students in class often lead to a richer understanding of the complex problems we will be discussing. It is expected that all students will contribute to this public good.

<u>Tardiness:</u>
Tardiness is disruptive and disrespectful to those who arrived on time. Repeated tardiness will not be tolerated, and repeatedly late students will not be allowed into the classroom after class begins.

<u>Make-up Work:</u>
There will be no make-up work for missed assignments or exams.

<u>Course Outline:</u>

1) Renewable Resource Problems
    a. Growth Processes
    b. Fisheries
        i. Open Access/Common Property vs. Private Property
        ii. Policy Options
    c. Forests
        i. Optimal Harvesting
        ii. Ecosystem Services
        iii. Non-timber Forest Products
2) Non-Renewable Resource Problems
    a. Non-renewable Sources of Energy

        i. Perfect Competition vs. Monopolist
        ii. Effects of Renewable Options
3) Water
    a. Groundwater
    b. Allocation across space
4) Spatial-dynamic Models
    a. Invasive Species
    b. Management of Wildlife Disease
5) Conservation
    a. Habitat conservation
    b. Species conversation
    c. Biodiversity
6) Topics requested by students if time allows

Textbooks:
This course will draw on material from a variety of texts and articles. The following textbooks, in combination, provide coverage of topics covered in this course. They are all on reserve at Library West. You are not expected to purchase all of these books.

Amacher, G.S., M. Ollikainen, and E. Koskela. 2009. *Economics of Forest Resources.* Massachusetts Institute of Technology.

Clark, Colin W. 2005. *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*. Wiley-Interscience.

Dasgupta, P.S. and G.M. Heal. 1979. *Economic Theory and Exhaustible Resources*. Cambridge University Press.

Leonard, Daniel and N.G. Van Long. 1992. *Optimal Control Theory and Static Optimization in Economics*. Cambridge University Press.

The following books are not directly used in this course but are excellent books on the methods used in this course:

Caputo, M.R. 2005. *Foundations of Dynamic Economics Analysis*. Cambridge University Press.

Kamien, M. and N.L. Schwartz. 1991. *Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management*. Elsevier Science Publishing Co.

Miranda, M.J. and P.L Fackler. *Applied Computational Economics and Finance*. MIT Press.

Articles:
This list is subject to change and will be adjusted according to students' research interests. Required reading will be announced in the class prior to the discussion of the reading(s). All peer-reviewed articles used for this course can be found electronically through the library's online resources.

Renewable Resource Problems

Fisheries

Clark, Chapters 1-4

Smith, M.D. 2012. The New Fisheries Economics: Incentives Across Many Margins. *Annual Review of Resource Economics* 4:379-403.

Gordon, H.S. 1954. The Economic Theory of Common Property Resource: The Fishery. *Journal of Political Economy* 62(2):124-142.

Clark, C. and G. Munro. 1975. The Economics of Fishing and Modern Capital Theory: A Simplified Approach. *Journal of Environmental Economics and Management* 2(2):92-106

Homans, F.R. and J. Wilen. 1997. A Model of Regulated Open Access Resource Use. *Journal of Environmental Economics and Management*

National Oceanic and Atmospheric Administration. 2012. Developing and Delivering the Promise of U.S. Fishery Management. Available at: http://celebrating200years.noaa.gov/transformations/fisheries/welcome.html

Forests

Clark, Chapter 9 and/or Amacher et al., Chapters 2 and 3

Koskela, E. and M. Ollikainen. 2001. Forest Taxation and Rotation Age under Private Amenity Valuation: New Results. *Journal of Environmental Economics and Management* 42(3): 374-384.

Lopez-Feldman, A. and J.E. Wilen. 2008. Poverty and Spatial Dimensions of Non-Timber Forest Extraction. *Environmental and Development Economics* 13:621-642.

Tahvonen O, Pukkala T, Laiho O, Lahde E, Niinimaki S (2010) Optimal Management of Uneven-aged Norway Spruce Stands. *Forest Ecology and Management* 260:106-115.

Grogan, K.A. and M. Mosquera. 2015. The Effects and Value of a Resistant Perennial Variety: An Application to Pudricion del Cogollo Disease. *American Journal of Agricultural*

Economics 97(1):260-281.

Sims, K.R.E. and J.M. Alix-Garcia. In Press. Parks versus PES: Evaluating Direct and Incentive-Based Land Conservation in Mexico. *Journal of Environmental Economics and Management*.

<u>*Non-Renewable Resource Problems*</u>

Dasgupta and Heal, Chapters 6 and 10

Hotelling, H.C. 1931. The Economics of Exhaustible Resources. *Journal of Political Economy* 39(2):137-175.

Lin. C.C., and G. Wagner. 2007. Steady-State Growth in a Hotelling Model of Resource Extraction. *Journal of Environmental Economics and Management* 54(1): 68-83.

Brounen, D., N. Kok, and J.M Quigley. 2012. Residential Energy Use and Conservation: Economics and Demographics. *European Economic Review* 56: 931-945.

<u>*Water*</u>

S.N. Yadav. 1997. Dynamic Optimization of Nitrogen Use When Groundwater Contamination is Internalized at the Standard in the Long Run. *American Journal of Agricultural Economics* 79(3):931-945.

Hellegers, P., D. Zilberman, and E. van Ierland. 2001. Dynamics of Agricultural Groundwater Extraction. *Ecological Economics* 37(2):303-311.

Chakravorty, U., E. Hochman, and D. Zilberman. 1995. A Spatial Model of Optimal Water Conveyance. *Journal of Environmental Economics and Management* 29:25-41.

<u>*Spatial-dynamic Models*</u>

Smith, M.D., J.N. Sanchirico, and J.E. Wilen. 2009. The Economics of Spatial-Dynamic Processes: Applications to Renewable Resources. *Journal of Environmental Economics and Management* 57:104-121.

Invasive Species

Olson, L.J. 2006. The Economics of Terrestrial Invasive Species: A Review of the Literature. *Agricultural and Resource Economics Review* 35(1):178-194.

Mehta, S.V., R.G. Haight, F.R. Homans, S. Polasky, and R.C. Venette. 2007. Optimal Detection and Control Strategies for Invasive Species Management. *Ecological Economics*

61:237-245.

Epanchin-Niell, R.S. and J.E. Wilen. 2012. Optimal Spatial Control of Biological Invasions. *Journal of Economics and Management* 63:260-270.

Management of Wildlife Disease

Horan, R., C.A. Wolf, E.P. Fenichel, and K.H. Mathews, Jr. 2005. Spatial Management of Wildlife Disease. *Review of Agricultural Economics* 27(3):483-490.

Habitat, Species, and Biodiversity Conservation

Shogren, J.F., J. Tschirhart, T. Anderson, A. Whritenour Ando, S.R. Beissinger, D. Brookshire, G.M. Brown, Jr., D. Coursey, R. Innes, S.M. Meyer, and S. Polasky. 1999. Why Economics Matters for Endangered Species Protection. *Conservation Biology* 13(6): 1257-1261.

Polasky, S., J. Camm, and B. Garber-Yonts. 2001. Selecting Biological Reserves Cost-Effectively: An Application to Terrestrial Vertebrate Conservation in Oregon. *Land Economics* 77(1):68-78.

Ronseau, D. and E. Bulte. 2007. Wildlife Damage and Agriculture: A Dynamic Analysis of Compensation Schemes. *American Journal of Agricultural Economics* 89(2):490-507.

Bulte, E.H. and R.D. Horan. 2003. Habitat Conservation, Wildlife Extraction, and Agricultural Expansion. *Journal of Environmental Economics and Management* 45(1): 109-127.

University Policies

Academic Honesty:
As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: "*We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.*" You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment.*"

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated.

Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: http://www.dso.ufl.edu/SCCR/honorcodes/honorcode.php.

Software Use:
All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

Campus Helping Resources
Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,* **www.counseling.ufl.edu/cwc/**
    - Counseling Services
    - Groups and Workshops
    - Outreach and Consultation
    - Self-Help Library
    - Training Programs
    - Community Provider Database

- *Career Resource Center,* First Floor JWRU, 392-1601, **www.crc.ufl.edu/**

Students with Disabilities Act
The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation

0001 Reid Hall, 352-392-8565, **www.dso.ufl.edu/drc/**

Tentative Schedule of Assignments and Exams

	Week	Mon	Tues	Wed	Thurs	Fri
Aug	1	21	**22 First Day of Class**	23	**24**	25
Sept	2	28	**29**	30	**31**	1
	3	4	**5**	6	**7 Problem Set 1 Given**	8
	4	11	**12 Topics Due**	13	**14 Problem Set 1 Due**	15
	5	18	**19**	20	**21 In-Class Exercise 1**	22
Oct	6	25	**26**	27	**28 Problem Set 2 Given**	29
	7	2	**3**	4	**5 Problem Set 2 Due**	6
	8	9	**10**	11	**12 Midterm Given**	13
	9	16	**17**	18	**19 Midterm Due**	20
	10	23	**24**	25	**26 In-Class Exercise 2**	27
Nov	11	30	**31**	1	**2 Problem Set 3 Given**	3
	12	6	**7 Rough Drafts Due**	8	**9 Problem Set 3 Due**	10
	13	13	**14**	15	**16**	17
	14	20	**21 Problem Set 4 Given**	22	**23 No Class**	24
Dec	15	27	**28 Problem Set 4 Due**	29	**30 In-Class Exercise Proposals Due**	1
	16	4	**5 Last Day of Class Final Given**	6	**7**	8
	17	11	**12 Final Due**			

Dates subject to change

Research Proposal

Content of proposal

- Background information
- Motivation: Why should we care?
- Literature review: What has already been done on the topic? Include previous work both on topic and on methods used.
- Your contribution: What is the gap in the literature that you are going to fill?
- Specific research question(s): What questions do you want to answer? (related to the gap/contribution above, but explicitly state the questions)
- Preliminary outline of methods: How will you go about filling that gap?
    - Possible sources of data
    - Possible sources of funding
    - Potential pitfalls

Length

- Approximately 15-20 pages, double-spaced, 12 pt. font, 1 – 1.25" margins

Possible topics

- A natural resource topic that you think you might pursue for your dissertation
    - i.e.- Examining the consequences of a community supported fisheries project (CSA for fish/seafood)
- A policy question that might arise from your research if you are not an economist
    - i.e.- Policy extension for an ecology project, how does human use of the ecosystem/habitat/species affect it and how could that use be altered if it is inefficient?
- Applying dynamic and/or spatial methods to a non-resource topic
    - i.e. – Comparing theoretical results of a specific agricultural policy analysis with static vs. dynamic models

Scope of topic

- Will vary by student and the intended outcome of the proposal
    - Entire dissertation, 1 dissertation chapter, possible article to work on after completion of dissertation, side project

Rubric to be used for both rough draft and final proposal

	Points	Comments
Background Info (10)		
Motivation (10)		
Lit Review (20)		
Contribution (15)		
Research Question(s) (15)		
Preliminary Methods (20)		
Data		
Funding		
Pitfalls		
Overall Quality (Spelling, grammar, organization, etc.) (10)		
Total		

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Early Intervention at Every Age Pages 34-39

http://www.ascd.org/publications/educational-leadership/oct07/vol65/num02/The-Perils-and-Promises-of-Praise.aspx

The Perils and Promises of Praise

Carol S. Dweck

The wrong kind of praise creates self-defeating behavior. The right kind motivates students to learn.

We often hear these days that we've produced a generation of young people who can't get through the day without an award. They expect success because they're special, not because they've worked hard.

Is this true? Have we inadvertently done something to hold back our students?

I think educators commonly hold two beliefs that do just that. Many believe that (1) praising students' intelligence builds their confidence and motivation to learn, and (2) students' inherent intelligence is the major cause of their achievement in school. Our research has shown that the first belief is false and that the second can be harmful—even for the most competent students.

As a psychologist, I have studied student motivation for more than 35 years. My graduate students and I have looked at thousands of children, asking why some enjoy learning, even when it's hard, and why they are resilient in the face of obstacles. We have learned a great deal. Research shows us how to praise students in ways that yield motivation and resilience. In addition, specific interventions can reverse a student's slide into failure during the vulnerable period of adolescence.

Fixed or Malleable?

Praise is intricately connected to how students view their intelligence. Some students believe that their intellectual ability is a fixed trait. They have a certain amount of intelligence, and that's that. Students with this fixed mind-set become excessively concerned with how smart they are, seeking tasks that will prove their intelligence and avoiding ones that might not (Dweck, 1999, 2006). The desire to learn takes a backseat.

Other students believe that their intellectual ability is something they can develop through effort and education. They don't necessarily believe that anyone can become an Einstein or a Mozart, but they do understand that even Einstein and Mozart had to put in years of effort to become who they were. When students believe that they can develop their intelligence, they focus on doing just that. Not worrying about how smart they will appear, they take on challenges and stick to them (Dweck, 1999, 2006).

More and more research in psychology and neuroscience supports the growth mind-set. We are discovering that the brain has more plasticity over time than we ever imagined (Doidge, 2007); that fundamental aspects of intelligence can be enhanced through learning (Sternberg, 2005); and that dedication and persistence in the face of obstacles are key ingredients in outstanding achievement (Ericsson, Charness, Feltovich, & Hoffman, 2006).

Alfred Binet (1909/1973), the inventor of the IQ test, had a strong growth mind-set. He believed that education could transform the basic capacity to learn. Far from intending to measure fixed intelligence, he meant his test to be a tool for identifying students who were not profiting from the public school curriculum so that other courses of study could be devised to foster their intellectual growth.

The Two Faces of Effort

The fixed and growth mind-sets create two different psychological worlds. In the fixed mind-set, students care first and foremost about how they'll be judged: smart or not smart. Repeatedly, students with this mind-set reject opportunities to learn if they might make mistakes (Hong, Chiu, Dweck, Lin, & Wan, 1999; Mueller & Dweck, 1998). When they do make mistakes or reveal deficiencies, rather than correct them, they try to hide them (Nussbaum & Dweck, 2007).

They are also afraid of effort because effort makes them feel dumb. They believe that if you have the ability, you shouldn't need effort (Blackwell, Trzesniewski, & Dweck, 2007), that ability should bring success all by itself. This is one of the worst beliefs that students can hold. It can cause many bright students to stop working in school when the curriculum becomes challenging.

Finally, students in the fixed mind-set don't recover well from setbacks. When they hit a setback in school, they *decrease* their efforts and consider cheating (Blackwell et al., 2007). The idea of fixed intelligence does not offer them viable ways to improve.

Let's get inside the head of a student with a fixed mind-set as he sits in his classroom, confronted with algebra for the first time. Up until then, he has breezed through math. Even when he barely paid attention in class and skimped on his homework, he always got *A*s. But this is different. It's hard. The student feels anxious and thinks, “What if I'm not as good at math as I thought? What if other kids understand it and I don't?” At some level, he realizes that he has two choices: try hard, or turn off. His interest in math begins to wane, and his attention wanders. He tells himself, “Who cares about this stuff? It's for nerds. I could do it if I wanted to, but it's so boring. You don't see CEOs and sports stars solving for *x* and *y*.”

By contrast, in the growth mind-set, students care about learning. When they make a mistake or exhibit a deficiency, they correct it (Blackwell et al., 2007; Nussbaum & Dweck, 2007). For them, effort is a *positive* thing: It ignites their intelligence and causes it to grow. In the face of failure, these students escalate their efforts and look for new learning strategies.

Let's look at another student—one who has a growth mind-set—having her first encounter with algebra. She finds it new, hard, and confusing, unlike anything else she has ever learned. But she's determined to understand it. She listens to everything the teacher says, asks the teacher questions after class, and takes her textbook home and reads the chapter over twice. As she begins to get it, she feels exhilarated. A new world of math opens up for her.

It is not surprising, then, that when we have followed students over challenging school transitions or courses, we find that those with growth mind-sets outperform their classmates with fixed mind-sets—even when they entered with equal skills and knowledge. A growth mind-set fosters the growth of ability over time (Blackwell et al., 2007; Mangels, Butterfield, Lamb, Good, & Dweck, 2006; see also Grant & Dweck, 2003).

The Effects of Praise

Many educators have hoped to maximize students' confidence in their abilities, their enjoyment of learning, and their ability to thrive in school by praising their intelligence. We've studied the effects of this kind of praise in children as young as 4 years old and as old as adolescence, in students in inner-city and rural settings, and in students of different ethnicities—and we've consistently found the same thing (Cimpian, Arce, Markman, & Dweck, 2007; Kamins & Dweck, 1999; Mueller & Dweck, 1998): Praising students' intelligence gives them a short burst of pride, followed by a long string of negative consequences.

In many of our studies (see Mueller & Dweck, 1998), 5th grade students worked on a task, and after the first set of problems, the teacher praised some of them for their intelligence ("You must be smart at these problems") and others for their effort ("You must have worked hard at these problems"). We then assessed the students' mind-sets. In one study, we asked students to agree or disagree with mind-set statements, such as, "Your intelligence is something basic about you that you can't really change." Students praised for intelligence agreed with statements like these more than students praised for effort did. In another study, we asked students to define intelligence. Students praised for intelligence made significantly more references to innate, fixed capacity, whereas the students praised for effort made more references to skills, knowledge, and areas they could change through effort and learning. Thus, we found that praise for intelligence tended to put students in a fixed mind-set (intelligence is fixed, and you have it), whereas praise for effort tended to put them in a growth mind-set (you're developing these skills because you're working hard).

We then offered students a chance to work on either a challenging task that they could learn from or an easy one that ensured error-free performance. Most of those praised for intelligence wanted the easy task, whereas most of those praised for effort wanted the challenging task and the opportunity to learn.

Next, the students worked on some challenging problems. As a group, students who had been praised for their intelligence *lost* their confidence in their ability and their enjoyment of the task as soon as they began to struggle with the problem. If success meant they were smart, then struggling meant they were not. The whole point of intelligence praise is to boost confidence and motivation, but both were gone in a flash. Only the effort-praised kids remained, on the whole, confident and eager.

When the problems were made somewhat easier again, students praised for intelligence did poorly, having lost their confidence and motivation. As a group, they did worse than they had done initially on these same types of problems. The students praised for effort showed excellent performance and continued to improve.

Finally, when asked to report their scores (anonymously), almost 40 percent of the intelligence-praised students lied. Apparently, their egos were so wrapped up in their performance that they couldn't admit mistakes. Only about 10 percent of the effort-praised students saw fit to falsify their results.

Praising students for their intelligence, then, hands them not motivation and resilience but a fixed mind-set with all its vulnerability. In contrast, effort or "process" praise (praise for engagement, perseverance, strategies, improvement, and the like) fosters hardy motivation. It tells students what they've done to be successful and what they need to do to be successful again in the future. Process praise sounds like this:

- You really studied for your English test, and your improvement shows it. You read the material over several times, outlined it, and tested yourself on it. That really worked!
- I like the way you tried all kinds of strategies on that math problem until you finally got it.
- It was a long, hard assignment, but you stuck to it and got it done. You stayed at your desk, kept up your concentration, and kept working. That's great!
- I like that you took on that challenging project for your science class. It will take a lot of work—doing the research, designing the machine, buying the parts, and building it. You're going to learn a lot of great things.

What about a student who gets an *A* without trying? I would say, "All right, that was too easy for you. Let's do something more challenging that you can learn from." We don't want to make something done quickly and easily the basis for our admiration.

What about a student who works hard and *doesn't* do well? I would say, "I liked the effort you put in. Let's work together some more and figure out what you don't understand." Process praise keeps students focused, not on something called ability that they may or may not have and that magically creates success or failure, but on processes they can all engage in to learn.

Motivated to Learn

Finding that a growth mind-set creates motivation and resilience—and leads to higher achievement—we sought to develop an intervention that would teach this mind-set to students. We decided to aim our intervention at students who were making the transition to 7th grade because this is a time of great vulnerability. School often gets more difficult in 7th grade, grading becomes more stringent, and the environment becomes more impersonal. Many students take stock of themselves and their intellectual abilities at this time and decide whether they want to be involved with school. Not surprisingly, it is often a time of disengagement and plunging achievement.

We performed our intervention in a New York City junior high school in which many students were struggling with the transition and were showing plummeting grades. If students learned a growth mind-set, we reasoned, they might be able to meet this challenge with increased, rather than decreased, effort. We therefore developed an eight-session workshop in which both the control group and the growth-mind-set group learned study skills, time management techniques, and memory strategies (Blackwell et al., 2007). However, in the growth-mind-set intervention, students also learned about their brains and what they could do to make their intelligence grow.

They learned that the brain is like a muscle—the more they exercise it, the stronger it becomes. They learned that every time they try hard and learn something new, their brain forms new connections that, over time, make them smarter. They learned that intellectual development is not the natural unfolding of intelligence, but rather the formation of new connections brought about through effort and learning.

Students were riveted by this information. The idea that their intellectual growth was largely in their hands fascinated them. In fact, even the most disruptive students suddenly sat still and took notice, with the most unruly boy of the lot looking up at us and saying, “You mean I don't have to be dumb?”

Indeed, the growth-mind-set message appeared to unleash students' motivation. Although both groups had experienced a steep decline in their math grades during their first months of junior high, those receiving the growth-mind-set intervention showed a significant rebound. Their math grades improved. Those in the control group, despite their excellent study skills intervention, continued their decline.

What's more, the teachers—who were unaware that the intervention workshops differed—singled out three times as many students in the growth-mindset intervention as showing marked changes in motivation. These students had a heightened desire to work hard and learn. One striking example was the boy who thought he was dumb. Before this experience, he had never put in any extra effort and often didn't turn his homework in on time. As a result of the training, he worked for hours one evening to finish an assignment early so that his teacher could review it and give him a chance to revise it. He earned a *B+* on the assignment (he had been getting *C*s and lower previously).

Other researchers have obtained similar findings with a growth-mind-set intervention. Working with junior high school students, Good, Aronson, and Inzlicht (2003) found an increase in math and English achievement test scores; working with college students, Aronson, Fried, and Good (2002) found an increase in students' valuing of academics, their enjoyment of schoolwork, and their grade point averages.

To facilitate delivery of the growth-mind-set workshop to students, we developed an interactive computer-based version of the intervention called *Brainology*. Students work through six modules, learning about the brain, visiting virtual brain labs, doing virtual brain experiments, seeing how the brain changes with learning, and learning how they can make their brains work better and grow smarter.

We tested our initial version in 20 New York City schools, with encouraging results. Almost all students (anonymously polled) reported changes in their study habits and motivation to learn resulting directly from their learning of the growth mind-set. One student noted that as a result of the animation she had seen about the brain, she could actually “picture the neurons growing bigger as they make more connections.” One student referred to the value of effort: “If you do not give up and you keep studying, you can find your way through.”

Adolescents often see school as a place where they perform for teachers who then judge them. The growth mind-set changes that perspective and makes school a place where students vigorously engage in learning for their own benefit.

Going Forward

Our research shows that educators cannot hand students confidence on a silver platter by praising their intelligence. Instead, we can help them gain the tools they need to maintain their confidence in learning by keeping them focused on the *process* of achievement.

Maybe we have produced a generation of students who are more dependent, fragile, and entitled than previous generations. If so, it's time for us to adopt a growth mind-set and learn from our mistakes. It's time to deliver interventions that will truly boost students' motivation, resilience, and learning.

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