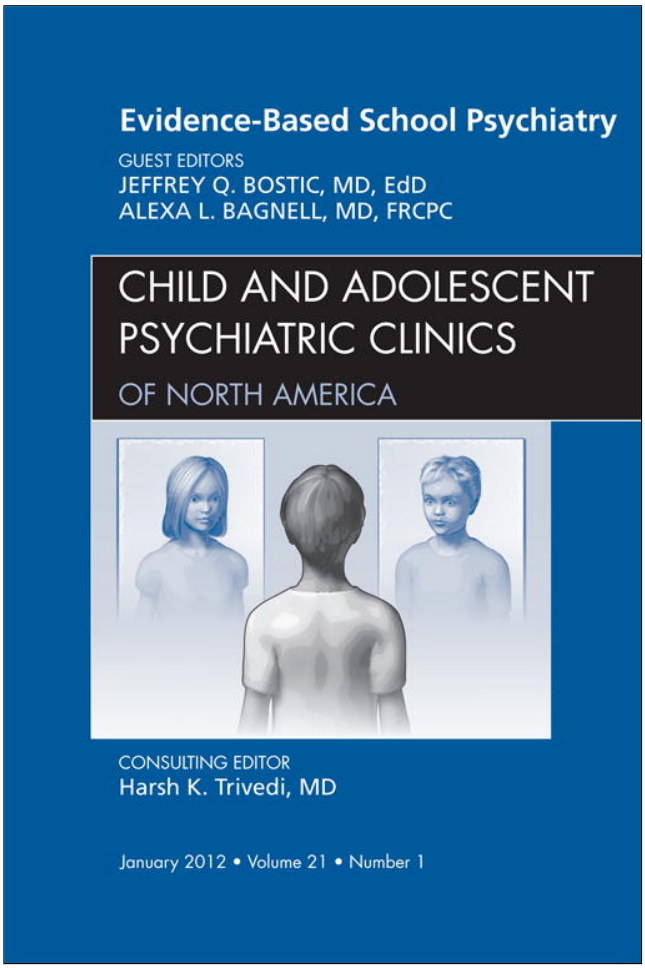

Building Better Brains: Evidence-Based Interventions to Enhance Contemporary Schooling

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• School • Mental health • Academic success

The vast majority of young people attend school. School provides a rich environment for cultivating academic skills such as reading, writing, and mathematics, but also for developing interpersonal skills, metacognitive skills such as executive functioning skills, and emotional regulation skills. The 15,000 hours most students spend in school are often guided by familiar but not evidence-based practices driven primarily to prepare students for antiquated needs rather than by contemporary findings about how the brain best learns and grows. Specifically, most schools still rely on a school day driven by previous social designs to prepare students for working on farms or in factories. The school day begins at sunup for most high school students despite clear evidence that adolescents require more sleep and stay up later because of biological changes surrounding puberty. Often, learning is still by rote methods, with a teacher-supervisor presenting information, then directing students to demonstrate understanding in the classroom and having them practice and extrapolate this learning independently at home. Although this approach may have some value and may be economical in terms of staff time, it is not predicated on emerging principles about how students best learn. In this article, biological conditions favorable to brain development, psychological skills associated with effective school functioning, and school practices associated with academic and interpersonal success are described so that schooling may increasingly be shaped more by brain development than social custom. Emerging findings about child development position child psychiatrists to influence school practices to better prepare children to enjoy their lives in the 21st century.

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MODERN BIOLOGY AND SCHOOL PRACTICES

Advances in understanding of brain development and human growth have significant implications for school practices. Some of these findings provide support for previous educational practices, whereas others favor substantial departures from conventional school practices.

Nutrition, Obesity, and Exercise

The epidemic of obesity among young people requires different priorities within the school day. The availability of inexpensive but unhealthy foods and the increased frequency of eating throughout the school day of high-fat, low nutritive–value snacks contributes to unhealthy patterns of eating; because practice makes permanent, altering these unhealthy patterns becomes increasingly difficult the longer schools allow them.

Students consume a significant amount of their daily caloric intake at school. The National School Lunch Program served over 5 billion lunches, and the National School Breakfast Program served almost 2 billion breakfasts in 2010[1] not including snacks available to students through cafeterias and vending machines during and after school. Schools that participate in the National School Lunch or Breakfast Programs are required to follow nutritional guidelines.[1] Unhealthy foods are usually found in vending machines, and "the strongest risk factor for buying snacks or beverages from vending machines instead of buying school lunch was availability of beverage vending machines in schools."[2] Changes such as removing sugary beverages (soda, sport drinks), chips, and candy bars from a la carte cafeterias, vending machines, and school stores are essential to improved dietary behavior.[3]

Soft drinks are known to contribute to childhood obesity because of the increased energy intake and the subsequent decline in nutrient intake. There have also been associations made between adolescent soft drink consumption and mental health problems. "High consumption levels of sugar-containing soft drinks were associated with mental health problems among adolescents even after adjustment for possible confounders."[4] The mental health problems examined in this Norwegian study were mental distress, hyperactivity, and conduct problems, whereas the control variables were eating habits and social and behavioral variables.

A healthy diet is crucial to reducing a child's risk of several physical health problems, and recent evidence suggests that good nutrition also protects mental health.[5] The need for schools to prioritize nutrition by fostering a healthy food environment targets the child obesity epidemic, although exercise in schools is another critical part. Students spend a significant amount of their day at school, and therefore to get the recommended amount, exercise must be a fundamental component of their day. The physical activity guidelines for children and adolescents are at least one hour (60 minutes) each day.[6]

A study looking at several health indicators in school-aged children including depression found that greater health benefits were linked to more physical activity. Although vigorous-intensity exercise may provide the greatest health benefits for children, it is indicated that even for those considered high-risk such as the obese, small amounts of physical activity can be beneficial.[7] A variety of physical activity opportunities in schools can be offered to accommodate students of all fitness levels and ages.

Similarly, the National Association of Sport and Physical Education recommends 150 minutes of physical education a week for the entire school year. Middle schools and high schools are encouraged to provide 225 minutes a week throughout the

entire school year.[8] Nationally, there are severe shortcomings in physical education recommendations, with only 6.6% of first grade children meeting guidelines.[9] The relationship between physical activity and better health outcomes has been largely demonstrated. School as an institution has a meaningful impact on student lives and can counter the effect of obesity by providing sufficient physical education programs and recess.

The direct association between the lack of physical activity and childhood obesity is well documented.[10] Daily physical activity suggests beneficial health affects according to this study by Katz and colleagues.[10] It is also important to consider the relationship between physical fitness and academic achievement. "Results show statistically significant relationships between fitness and academic achievement . . . . Promoting fitness by increasing opportunities for physical activity during PE [physical education], recess, and out of school time may support academic achievement."[11]

An argument against daily PE in schools is that it takes away from teaching time. The study by Katz and colleagues[10] discusses a school program that provides multiple, brief, structured physical activity breaks throughout the day. The program is led by classroom teachers, does not require a special facility, and does not reduce teaching time. This particular study and program was implemented in an elementary school; however, "the program can easily be incorporated into almost any school routine."[10]

Nutrition, obesity, and exercise as topics to prioritize for the school day will give students the healthy advantage they need to excel academically and in their lives. The trend of increased poor food options in schools as students get older coupled with declining activity levels as students age creates an environment unfit for academic achievement and positive health choices.[10] Schools can counter this effect by reevaluating existing policies, creating new policies, and introducing programs that value nutrition and exercise.

Exercise and the Brain

Prioritizing academic achievement has in some cases culminated in the elimination of school-based exercise and physical education programs, at great if not yet recognized costs. Humans are designed to exercise, and one of the most prominent findings surrounds the overlapping action between antidepressants and exercise. Antidepressants, from tricyclic antidepressants to selective serotonin reuptake inhibitors, have a common action of increasing brain-derived neurotropic factor (BDNF), which increases neuronal growth in hippocampal regions associated with mood improvement. Stress decreases BDNF, and exercise increases BDNF[12,13]; accordingly, exercise remains a vital component of physical and mental health. Exercise exerts an antidepressant effect in those experiencing clinical depression.[14] Sociocultural factors, however, already influence exercise, because girls prefer "physical activity" to "exercise." The latter term has become associated with body size and sometimes eating disorders.[15] The replacement of physical education with additional classroom instruction and increased academic demands on students seems dissonant with these brain findings and seems to come at a price regarding student mental health.[16]

School Start Times

During adolescence, melatonin levels shift to a later peak, at approximately 11 PM. Adolescents further require approximately 9.25 hours of sleep per night, although currently most high school students receive 7.5 hours or less per night. The vast majority of high school students enter school sleep-deprived. Wahlstrom[17] found that

when the high school start time was changed in the Minneapolis area schools from 7:15 AM to 8:40 AM, students slept an additional hour, counter to predictions that they would simply stay up later. Students were less likely to be tardy and less likely to fall asleep during classes, and staff reported that students were "calmer" and there were fewer discipline referrals. These findings have been replicated in multiple other districts, and to date no discordant findings have been reported.[18–21] Resistance, however, to changing school start times remains the rule rather than the exception, but it is usually based on bus scheduling or fears that after-school activities such as sports will be compromised if the school day is extended. Whereas no evidence has disputed the benefits to high school students of delaying school start times, most American school districts continue to prioritize other logistics over this developmental finding.

Adolescent Brain Changes

Recent findings reveal that brain architecture changes markedly in adolescence. Adolescents "prune" brain cells, eliminating neurons not required by the environment, making way for increasing connections between those neurons currently most valued in the adolescent's environment. The brain experiences marked reorganization, with decreases in neurons (gray matter) to allow more efficient transmission by increasing white matter.[22] Educationally, this reorganization represents tremendous brain activity, and thus differences in individual attainment of higher order cognitive skills such as the Piagetian "formal operation" abstract reasoning skills. Whereas some students consolidate abstract thinking by approximately age 14, research reveals that this consolidation is usually accomplished much later, with less than 50% of college freshman having attained these formal operations skills when they enter college.[23]

In addition, adolescents preferentially valence emotional content compared with adults. Using magnetic resonance imaging, Yurgulen-Todd[24] found that adolescents processed photographs of facial emotions more through amygdalar regions, whereas when presented with similar photographs, adults relied more on frontal regions. Using a much larger database, Giedd[25] has replicated these findings. The emotional valence ascribed to content by adolescents results in different reactions to similar stimuli presented, including within school settings. Accordingly, students process stimuli differently than adults and ascribe different emotional meanings (eg, seeing anger rather than fear in facial expressions) than adults. Educationally, this is important in at least three ways.

1. Adolescents process information in emotional centers rather than rational centers of the brain, so information presented in class may stimulate emotional reactions in adolescent students beyond what teachers would anticipate. Efforts to address, examine, and respond to these adolescent reactions should similarly be anticipated by teachers as they prepare lessons.
2. Adolescents seek and read emotions in others (perhaps useful as they begin dating) inaccurately. Accurately identifying emotions of others warrants didactic instruction in how to detect emotions by nuances in facial expressions, voice changes/inflections, eye contact, and body posture. Perhaps this identification is not as automatic as has been previously presumed, despite the significance of these increasingly important (in potential mate selection) and complex (with less parental participation) social interactions.
3. Adolescents may "see" anger where fear is present and thus trust their perceptions and deny adult instruction dissonant with their perceptions. Trusting one's perceptions is an important component in developing self-esteem, so teachers

must be sensitive to the responses and resistance of students to invalidation of these perceptions. Concretely, this will require teachers to objectively examine the evidence to show how conclusions are reached about emotions expressed in photographs, literary descriptions, art, and so forth. Moreover, students may not be able to distinguish their own reactions to material from those identified in a character or photographic subject. Therefore, disentangling student projections of their own reactions from what is actually present may need to gently be addressed. This can be done by clarifying first the students' individual reactions to a photo or description and then a having a discussion/examination of the attributes exemplified in the material that reveal that subject's emotions.

PSYCHOLOGICAL ASPECTS OF SCHOOLING

Developing positive mental health concurrent with academic learning has become increasingly important, particularly as rates of mental illness illuminate the impacts of stress despite living in a better and safer world than ever before.

Mindfulness

Mindfulness has become increasingly infused into school settings. Kabat-Zinn[26] describes it as "the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience.'' Mindfulness is not a strategy, tactic, or philosophy (despite being most often ascribed to Buddhism), but rather a way of living in the present.

Although a variety of mindfulness-based approaches have been investigated in adults, data on the utility of these practices in youth are emerging. Some of the types of therapy teaching mindfulness include mindfulness-based stress reduction (MBSR), mindfulness-based cognitive therapy, dialectic behavior therapy (DBT), and acceptance and commitment therapy. Whereas the methods for teaching mindfulness skills vary, all of these therapies focus on developing and practicing mindfulness. At North Shore Medical Center in Salem, Massachusetts, MBSR has been taught to forty 14- to 17-year-old adolescents using the Cool Minds program developed by Florence Melo-Meyer and colleagues at the Center for Mindfulness at University of Massachusetts Medical School. This is an 8-week program composed of 2-hour weekly sessions and home practice. Cool Minds uses body scan, eating meditation, walking meditation, mindful movements (ie, yoga), and sitting meditation. Several of the practices are summarized by the acronym STOP:

S = Stop the same old reaction and pause, being aware something is difficult. What is difficult to be open to? Where can you soften? Can you try less hard? Effortless.

T = Take a breath through your nostrils; exhale (extending the out-breath relative to the in-breath engages the parasympathetic nervous system and can be calming), then inhale (extending the in-breath relative to the out-breath can engage the sympathetic nervous system and can be energizing). Take these breaths for as long as you need to.

O = Observing your thoughts, feelings, and body sensations, what do you notice?

P = Proceed in a direction that is in line with what is important to you, to your intention.

These practices have been well-received and reported by students as helpful physically, emotionally, and behaviorally. Black[27] reviewed the literature on the efficacy and tolerability of mindfulness practices in children and adolescents and concluded that these practices were accepted by subjects and their families and well-tolerated by the participants. Burke concluded that it was too early to make conclusions about the efficacy of these interventions. There are a variety of excellent

resources to learn more about mindfulness and its practice. A few of these include the new programs and current offerings at the University of Massachusetts (www.umassmed.edu/cfm) and the NSCH Web site (http://nsmc.partners.org/web/support/pediatrics_resource_center).

Emotional Regulation, Conflict Resolution, and Fundamental Cognitive-Behavioral Training

A more didactic program for promoting emotional growth is available at www.schoolpsychiatry.org. A recent program for facilitating social growth has been created (Brain Driver Education), which includes components of Greene's[28] collaborative problem-solving (CPS), Linehan's[29] DBT and Beck's[30] cognitive-behavioral therapy (CBT). Beck's Web site (www.beckinstitute.org/) provides this traditionally psychiatric content in terms more familiar and palatable to educators. The techniques of CPS emphasize minimizing escalations of conflict, in particular, options for teachers to clarify what issues require adherence by students; options for collaborating by providing and investing students in choices that are feasible, doable, and helpful for both parties in a conflict; and teaching students how to consider the point of view of others.[28] DBT techniques seem useful for emotional regulation. These techniques include breathing exercises, noticing how others are reacting to the student, recognizing when emotions are too "cold" or "hot" and interfere with effective decision-making, attending to other sensations (touching comfortable fur, listening to calming or distracting music, and so forth), using medication and calming words ("peace" or "love"), channeling energy effectively by moving one's body, deliberately acting in ways opposite the behaviors associated with distressing emotions, and using desired activities to distract from preoccupations of distressing emotions. CBT techniques are effective and essential, because everyone has moments of distress and these techniques allow one to harness painful emotional reactions by relying on the cognitive skills of the frontal lobes. Specifics include evaluating the evidence for painful conclusions ("I'm stupid because I did badly on a math test"), overvalencing negative events and dismissing positive experiences, projecting what this event realistically portends for the future, assessing pros and cons surrounding choices and anticipating consequences, considering how an event fits in the big picture, and using positive self-talk rather than ruminating about negative attributions.

Preparing Students for Happiness

School practices may benefit from consideration of the emerging science about what cultivates happiness. Layard[31] described seven variables associated with happiness in adulthood:

1. Connectedness and the ability to relate effectively to others
2. Resilience and the ability to respond to adversity
3. Community and the ability to contribute and participate with familiar others
4. Sharing and the ability to partner and rely on others
5. Health and the ability to physically take care of oneself
6. Freedom and the ability to exert control over one's life choices
7. Spirituality and the ability to engage with matters larger than oneself.

These variables provide direction for schools as they prepare students for happiness in adulthood. Each of these variables can be infused into the school day, both within curricular content and amid student practices. Consideration of how these attributes can best be fostered in diverse school environments with diverse

populations would seem among the more important missions of schools addressing students' future needs.

Curriculum (the "what" that is taught at schools, as compared with instruction, the "how" the curriculum is provided) can be provided to address these topics directly as well as embedded within more traditional school subjects. For example, social skills curriculum such as Garcia-Winner's[32] social behavioral mapping can be integrated in diverse classes. To embed teaching of these attributes within existing curricula, content that identifies how individuals in history and literature have responded to adversity both addresses student fears of failing and identifies specific tactics that students can consider to address their own adversities. For example, Admiral Michael Mullen, chairman of the Joint Chiefs of Staff, recently described how he learned more from his failures than his successes.[33]

Schools have long been described as microcosms of the larger societies they serve. To foster happiness, the meta-messages, or daily practices of school, also warrant mindful review. The school is a community, and how students and staff are valued and encouraged to work together versus autonomously is fundamental in shaping how young people perceive community and their roles. Providing experiences that foster cooperation as much as independent learning and rewarding collaboration among students seem much more viable traits for 21st century survival than conquering others or defeating others in the classroom by earning a higher grade. Whereas curricular content addressing health, including at different life stages, may equip students with practices to maintain their physical health, daily exercise may become more pertinent to all students. This equipping could be done by integrating myriad physical activities such as dance and yoga, easily practiced by most individuals, beyond the expensive extracurricular after-school team activities of fixed duration. Perception of freedom and choice within a school and perception that systems are responsive to their needs and aspirations are important for students to invest in a system. Whereas the separation of church and state has altered presentation of traditional spiritual content, much of fundamental practices stretch across religions and remain appropriate, if not invaluable, to all students; for example, practicing being grateful and learning to forgive remain vital skills easily practiced in all schools and useful to seeing beyond oneself.

SOCIAL PRACTICES

Many school practices throughout the school day, although familiar to generations of students, have not proven effective for cultivating 21st century students. Concretely, the impact and proper place of technology have remained complicated for schools, as has how best to configure the school day and year to optimize learning.

Review of School Variables Influencing Academic Achievement

Hattie[34] has provided the most comprehensive metaanalysis to date of the variables that impact student academic achievement. This metaanalysis involved over 52,000 studies and at least 80 million students. Hattie relied on effect sizes to compare these variables. An effect size (ES) of 1.0 indicates an increase in one standard deviation (SD) on the outcome (here improving school achievement). Practically, a 1.0 SD improvement is associated with advancing a student's achievement by 2 to 3 years (instead of the expected 1 year) or improving the rate of learning by 50%, or a correlation between a variable (eg, amount of homework) and achievement of 0.50. In simpler terms, an ES of 1.0 would be easily visible, as is seeing a person 63 inches tall next to a person 72 inches tall; an ES of 0.29 (the influence of homework on achievement) would resemble the difference between seeing a person 71 inches tall

Table 1
Evaluation of variables that impact student achievement

Student Achievement Variable	Metaanalyses	Studies (No.)	People (No.)	Effects (No.)	ES	SE
Teacher	29	2052	500,000	5379	.50	.05
Curricula	135	6892	7,000,000	29,476	.45	.07
Teaching	344	24,906	52,000,000	50,953	.43	.07
Student	133	10,735	7,000,000	37,308	.39	.04
Home	31	1998	10,000,000	3968	.35	.06
School	96	4019	4,000,000	13,609	.23	.07

Abbreviations: ES, error size; SE, standard error. (*Data from* Hattie J. Visible learning: a synthesis of over 800 meta-analyses relating to achievement. New York: Routledge; 2009.)

next to a person 72 inches tall, so there is a difference, but not one that would be visible or clearly different than someone receiving versus not receiving an intervention. The variable categories are described in **Table 1**, which shows that teacher characteristics have the greatest effects (0.50) on student achievement, whereas school characteristics have the least impact (0.23). Collectively, these data emphasize that the teacher variables are most important, then curricular programs that afford planful instruction to fit the diverse needs of students, then the school buildings in which students learn,

Hattie examined a large number of individual variables regarding school, student, curriculum, teachers, and home environment to better clarify contributions of diverse variables toward student achievement. **Table 2** shows the effect sizes of selected notable variables Hattie examined and illuminates that certain variables have significant impacts on student achievement. School variables important for student achievement include total school size (600–900 students in the building) more than classroom size. Allowing students to progress at their own rate, providing stable and cohesive classroom management, and mainstreaming students so that they imitate and learn from their peers seem important; conversely, holding students back (retention) does not have supportive evidence, nor does grouping smart students together (tracking).

Student understanding, appraisal, and investment in their own achievement are most important, as well as student advancement toward formal operations/abstract thinking. Cultivating student motivation remains significant, and early intervention program seem effective. Achievement is influenced by configuring learning tasks to increase student confidence, addressing student fears and anxieties about taking tests, and addressing specific fears such as toward math or science.

Ongoing teacher monitoring of what does and does not work with students remains important to optimize instruction. Teacher-student relationships strongly influence student achievement, as does teaching students how to compartmentalize and access problem-solving approaches to various types of problems. Professional development that is ongoing and provided by new voices from outside the building seems to best enhance achievement. Teacher expectations that stretch but do not break (stress) students yield positive outcomes, and avoidance of labeling students but instead focusing on each student's unique progress enhances achievement. Perhaps counterintuitive, teachers' knowledge of their subject content area seems relatively unimportant.

Table 2
Effect sizes of selected school, student, and teacher variables on student achievement

Variable	Definition and Comments	No. of Studies	Effect Size
SCHOOL			
Acceleration	Allowing gifted students to advance with same mental-age peers	37	.88
Classroom Management	Clarity of purpose; high levels of teacher-student cooperation	100	.52
School Size	Smaller student size associated with greater achievement; optimal size 600–900	21	.43
Mainstreaming	Placing special education students in regular classrooms	150	.28
Class Size	Small class size	96	.21
Ability Grouping	Grouping students based on ability; "tracking"	500	.12
Retention	Repeating a school grade over; non-promotion	207	−.16
STUDENT			
Self-Report Grades	Students' estimates of their own performance	209	1.44
Piagetian Level	Higher levels of cognitive functioning (abstract reasoning, etc)	51	1.28
Motivation	Worthwhile goals, get feedback, affirmation, and sense of autonomy over own learning	322	.48
Early Intervention	School interventions with preschool students	1704	.47
Student Self-Concept	Confidence and "can do" tasks; achievement and self-concept each increase the other	324	.43
Reducing Anxiety	Anxiety particularly for tests and math; most significant from third grade forward	121	.40
TEACHER			
Providing Formative Evaluation	Teachers using data to discern what is effective and what is not for their students	30	.80
Teacher-Student Relationships	Teacher and student mutual regard and respect; person-centered teachers achieved more critical and creative thinking by students	229	.72
Meta-Cognitive Strategies	Thinking about thinking; selecting and monitoring approaches to solve problems	63	.69
Professional Development	Extended over years for staff, provided by external experts	537	.62
Teacher *Not* Labeling Students	Labeling seems more effective for funding than for planning instruction or achievement	79	.61
Teacher Expectations	Emphasizing student progress vs perceptions of student abilities	674	.43
Teacher Subject Matter Knowledge	Teacher's knowledge of subject area content	92	.09

Effective teaching was associated with the following: instruction involving testing of hypotheses (1.09), having deeper understanding of teaching and its effects on student learning (1.02), a sense of control (0.90), high levels of passion for teaching and learning (0.90), a deeper understanding of the subject (not just subject knowledge)

(0.87), being adept at improvisation (0.84), a problem-solving disposition toward teaching (0.82), a positive classroom climate that fostered learning (0.67), and having respect for students (0.61).

Hattie further found that a number of variables historically ascribed significance in student achievement may be less important than previously assumed. Shifting students to different school buildings as they change grade level seems unhelpful (−0.34), and retention of students exerted a negative effect on student achievement (−0.16). Television exerted a negative effect (−0.14), consistent with other findings about the lack of benefit of television in students' lives. Various school practices such as open classrooms and grouping students of differing ages had minimal impact, and programs such as whole language and inductive teaching similarly exerted little effect.

Hattie's analysis of effect sizes concluded that students flourished best when

- they received correct feedback (0.43)
- about previous attempts (0.55)
- related to more difficult goals (0.51)
- that did not discourage (0.33)
- or threaten a student's self-esteem (0.47).

SUMMARY

School practices can be improved by attention to emerging findings in child psychiatry and human development. Adolescent sleep changes, brain maturation, and activity and dietary practices all afford opportunities for school development to improve conditions to optimize learning. Although parents are eager for their children to attain academically, most would prioritize their children developing patterns and skills to become happy, productive social members. School-based programs that promote mental health along with academic achievement are far preferable to perpetuating educational practices that are stressful to students and lack empiric support regarding academic achievement and that contribute to vulnerability to mental illness. Evolving brain and child development findings empower mental health clinicians to shape school practices to improve student successes across academic, emotional, and interpersonal spheres and to enhance student mental health functioning throughout their schooling and into adulthood.

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