

Science & Uncertainty

Dear Editor:

Very often one sees words like the following in articles by teachers: "Scientific knowledge is fundamentally and irrevocably uncertain," "tentative nature of all science," "all facts, laws, and theories are forever uncertain," "reflects the tentative nature of scientific knowledge" and "what is known is ephemeral." The wavering student who hears words like these may say to himself or herself, "Why bother to learn this science? All will change in a few years."

To say that *all* scientific knowledge is irrevocably uncertain is as untrue as saying that the Earth is 10,000 years old. There are millions of facts for which no uncertainty exists. *Some* facts, laws and theories are tentative and uncertain, but it is incorrect to say that *all* scientific knowledge is uncertain.

When considering well-established theories, these words from Einstein and Infeld (*The Evolution of Physics*, 1957, pp. 158–159. Simon and Schuster, NY) should be kept in mind:

To use a comparison, we could say that creating a new theory is not like destroying an old barn and erecting a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connections between our starting point and its rich environment. But the point from which we started out still exists and can be seen, although it appears smaller and forms a tiny part of our broad view gained by the mastery of the obstacles on our adventurous way up.

Popper, the late philosopher of science, introduced confusion because he considered only falsification for support of a theory. A third possibility exists when testing a theory. This is limitation. Newly discovered facts may not agree with predictions from a theory. These facts may be beyond the boundaries of the theory, and thus do not falsify it. The deficiency diseases did not falsify the germ theory of disease; they established one boundary of the germ theory. So despite the presumed negative evidence, the germ

theory still stands and functions well within its boundaries.

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Separate Science Classes an Issue

Dear Editor:

The editorial *Separate Science Classes for Females* by Steven E. Dyche and Sherry D. Ceperich is very annoying. I can only assume it was printed with the intent of stirring up some discussion, so I am offering an opposing point of view. I have been teaching at the college level for 28 years, and I taught high school biology for three years before returning to graduate school. Both experiences have convinced me that the claims for a need for separate science classes for females and males is rubbish. A similar view was expressed by my newest colleague who used a familiar gender-specific term for a common barnyard item to express her sentiment.

At the college where I teach about half of the biology majors are female. On the other hand, the winners of our departmental awards are female far more often than male. Indeed, there have been some years when all our award winners (six to eight, depending on the year) have been female. In our graduating class of 1995, we designated five students as departmental scholars. All are female, and all had GPAs above 3.5. One went to medical school, one to veterinary medical school, one entered a PhD program in microbiology, and two entered optometry school. None of them received preferential treatment or would have wanted it. They certainly didn't need it. The class of '96 had one male who was designated a departmental scholar. The rest were female (sorry I don't have an update on what they are all doing). Females do very well here, thank you very much.

If one attends meetings of biological societies (NABT for example), it is obvious there are many females teaching and doing science. This becomes especially evident if one goes to the poster sessions and the slide talks typical of most annual meetings, where the number of young women scientists has

grown tremendously over the last 10 years. Their numbers are growing not because women possess some innate quality that allows them to solve science problems differently, but because they are doing good science period. They see the opportunities, and they are achieving their goals. The genetics and microbiology societies in particular are very well represented by women with many sessions dominated by women. Granted, physics lags way behind genetics and microbiology in attracting women, but that may have more to do with unfortunate advising at the high school level than anything else. (Perhaps we should do more to encourage high school students to take physics rather than AP biology in those schools where it often comes down to an either-or situation.)

Up through the 1970s the sciences were clearly dominated by men, many of whom still hold tenured positions in our high schools and colleges. As those men die or retire, their positions will make way for more and more women who will be hired because they are well-educated, productive and available. That will do far more to change the sex ratio of scientists than will sequestering women under the notion that their psyches can't deal with males in the classroom. At what point are these women supposed to be deemed capable of dealing with males on an equal intellectual level after essentially being brainwashed into thinking they were incapable of doing so? If women are "turned off to science..." as is suggested, perhaps we should do more to inform those women that they should transfer to a college that will eagerly accept students who are motivated to do science whether they have Y chromosomes or not. In today's climate where admissions is one of the most important functions of a college, departments that lose enrollment will soon get the message. Given the success rate of women graduating from the sciences at my own college I would unashamedly recruit them to transfer here. Dyche and Ceperich need to look around at what is happening today rather than what happened 10 years ago. Women have made tremendous gains in the sciences. Women don't need to be cloistered from men in order to succeed. They simply need to be given equal opportunity. Separate but equal is not likely to happen. We

should know that in this country by now.

Data exist that support the contention that males do less well than females on verbal tests. Should we also have separate classes for males in English so that males can develop language skills in an environment that frees them from the discriminatory behaviors of their English teachers? Give me a break!

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Dear Editor:

Professional women scientists and engineers are outnumbered six to one by their male colleagues (Kahle & Meece 1994). Of the college degrees awarded for these fields, women earn only 30% of the bachelor's degrees, and 21% of the doctorates (Kahle & Meece 1994). In high school, females constitute 39% of calculus students, and only 15% complete a physics course (Kahle & Meece 1994). According to a National Science Foundation study, the science achievement test scores of college bound females are consistently lower than are the scores for males (NSF 1990). Yet throughout the primary grades, math and science test scores for females and males do not differ significantly (Kahle & Meece 1994). This leads to the question: what happens to create a gender gap in science beginning around age 13, and what can be done to narrow or eliminate it? Have science educators been guilty of gender bias in the presentation of science and math coursework? Yes. Will separate sex science and math classes ameliorate the imbalance? No. Segregating students on the basis of sex in order to close this chasm is a simplistic and dangerous band-aid approach. Learning research supports an integrated education in math and science.

An instructional strategy persists in too many science and math classrooms which allows for subtle gender bias that is a disservice to female students (Bailey 1996). Boys have been found to dominate classroom discussion, garner the majority of teacher praise, and be subjected to higher performance expectations than are girls (Kahle & Meece 1994). Moreover, the science role models depicted in textbooks, or invited as guest speakers, and teachers themselves, are predominantly male. But it hardly makes sense to segregate females from males in these courses rather than attack the problem at its

core. That problem is a curricular and behavioral deficiency in the way science and math are taught. We'd do well to encourage workshops, conferences and college coursework that emphasize pro-active gender equity techniques for all teachers. It's a safer and longer term solution that places responsibility for inequity upon the deserving shoulders of teachers, administrators and parents instead of upon uprooted students.

Teacher enlightenment of the subtle behaviors that perpetuate gender bias in science is but one step toward closing the gap in science performance amongst boys and girls. Perhaps an even greater need is for teachers and parents to recognize that boys and girls learn in different ways, necessitating an appropriate overhaul of the curriculum. According to Doreen Kimura, a Canadian neuropsychologist considered a leading authority on brain differences in males and females, "women and men differ not only in physical attributes and reproductive function, but also in the way in which they solve intellectual problems" (Kimura 1992). Unfortunately, the idea of "different" connotes "deficiency" in the minds of many, and valuable insight into how to more effectively teach young men and women gets buried under an avalanche of political correctness. Kimura's findings on the powerful influences of sex hormones on brain function, coupled with behavioral research into instructional strategies that benefit girls as much as boys, point toward the need for dramatic change in how science and math are predominantly taught in American schools.

Susan McGee Bailey, the principal author of the landmark study *How Schools Shortchange Girls*, and herself an opponent of separate sex classes, points out specific remedies for a gender neutral classroom that are consistent with Kimura's brain research (Bailey 1996). Two of those recommendations are:

1. Place less emphasis on competition and speed, and more emphasis on cooperative group work.
2. Increase the focus on practical, real life applications of mathematics and science (Bailey 1996).

These and other interventions which focus on problem solving in a social context are more than just gender-neutralizing techniques in science, they are sound methods that work for all learners, and mirror the recommendations of the recently released National Science Education Standards (NRC 1996).

Again, it hardly makes sense to seg-

regate males and females in science and math courses when a better way is to restructure the curriculum to reflect the research. In a sense, the onus for closing the gender gap in math and science is placed upon kids by advocates of separate sex classes, when the onus should be borne by teachers, administrators and parents who can and should see to it that science is portrayed as equally accessible to all. As imperfect as mixed gender classes are, they're real life. The children in those classes rise to a level of expectation we hold for them, so it's vital that the message they get is one of high expectations, without contrived settings, and regardless of sex.

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References

- Kahle, J.B. & Meece, J. (1994). Research on gender issues in the classroom. In Dorothy L. Gabel, Ed. *Handbook of Research on Science Teaching and Learning*. Arlington, VA: NSTA Publications. pp. 542-550.
- National Science Foundation. (1990). *Women and Minorities in Science and Engineering*. NSF document #90-301. Washington, DC: Author.
- Bailey, S.M. (1996, May). Shortchanging Girls and Boys. *Educational Leadership* (Alexandria, VA: Association for Supervision and Curriculum Development Publication). pp. 75-77.
- Kimura, D. (1992, September). Sex differences in the brain. *Scientific American*. p. 121.
- National Science Education Standards. (1996). National Research Council. Washington, DC: National Academy Press.

Dear Editor:

We agree with Dyche and Ceperich's desire to encourage more women to enter science, but we are not convinced by their reasoning or their proposal. Most worrisome is their implication that science is too "harsh" for females or that they are misserved by being "expected to do as well as males." We disagree with this suggestion that females could not compete in science if given a fair chance. They rightly identified a number of common problems with education of females in science classrooms: males often get called on first, males are allowed to dominate in mixed sex lab partnerships, and males are allowed to misbehave and harass

females. Rather than merely postpone the time when female students are forced to deal with these problems, we as teachers should actively work against these problems in mixed sex classes.

The authors also seem to be confused about where the major forces discouraging and undermining women in science lie: inside or outside the class-

room. While we agree that single sex classes may have many merits, several of the problems identified by Dyche and Ceperich are societal and not pedagogical; others may yet be solved by better teaching practice in the classroom. We support their conclusion that science benefits from the different approaches that women use and we need to encourage male and female students

to learn from each other as we have learned from each other as colleagues.

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