

United Nations Division for the Advancement of Women (DAW, part of UN Women)
United Nations Educational, Scientific and Cultural Organization (UNESCO)

Expert group meeting
Gender, science and technology

Paris, France
28 September - 1 October 2010

**Gender, Science Anxiety, and Science Attitudes:
A Multinational Perspective**

Expert paper prepared by:

Jeffrey V. Mallow*
Loyola University Chicago
Chicago, Illinois, United States of America

I. SCIENCE ANXIETY¹

In 1977, I recognized the phenomenon for which I coined the term “science anxiety”: a debilitating interaction of emotion--fear, with cognition--science learning. It often manifests itself as a crippling panic on examinations in science classes, but it is distinct from general test/performance anxiety. Students suffering from science anxiety tend to be calm and productive in their non-science courses, including their mathematics courses.

The Science Anxiety Clinic. I was co-founder and co-facilitator, with the Loyola University Counseling Center, of the first Science Anxiety Clinic. Techniques developed in the clinic reduce science anxiety by blending three separate approaches: science skills learning, changing of students’ negative self-thoughts, and desensitization to science-anxiety-producing scenarios. I

* The views expressed in this paper are those of the author and do not necessarily represent those of the United Nations.

¹ Footnotes are in italic superscript; endnotes are in ordinary superscript.

have described the science anxiety phenomenon, its causes, and its remedies in *Science Anxiety: Fear of Science and How to Overcome It*¹.

The Science Anxiety Questionnaire. A Science Anxiety Questionnaire was developed to measure the effectiveness of the Clinic². This is a 44 item instrument which asks students to imagine themselves in certain situations and to rate their level of anxiety on a 5-degree scale: “not at all,” “a little,” “a fair amount,” “much,” and “very much.” Items are evenly divided between science and non-science content, with emphasis on analogous situations; e.g., studying for a physics exam vs. studying for a history exam. See Table 1 for an excerpt of the questionnaire. It was administered to students at the beginning and end of the clinic. The results showed that the clinic had in fact alleviated their science anxiety.

Table 1. Science Anxiety Questionnaire--excerpt. (The examples below appear in random order in the actual questionnaire.)

The items in the questionnaire refer to things and experiences that may cause fear or apprehension. After each item, place a number that describes how much YOU ARE FRIGHTENED BY IT NOWADAYS.

1	2	3	4	5
Not at all	A little	A fair amount	Much	Very much

In a philosophy discussion group, reading a chapter on the categorical imperative and being asked to answer questions.

Studying for a midterm exam in chemistry, physics, or biology.

Having a fellow student watch you perform an experiment in the lab.

In a physics discussion group, reading a chapter on quantum systems and being asked to answer some questions.

Having a fellow student listen to you read in a foreign language.

Having your music teacher listen to you as you play an instrument.

Studying for a midterm in an history course.

Having your professor watch you perform an experiment in the lab.

Having a teaching assistant watch you perform an experiment in the lab.

Having a teaching assistant watch you draw in art class.

II. SCIENCE ANXIETY AND GENDER

Gender in the Science Anxiety Clinic. Clinic enrollment was voluntary. We found that typically 2/3 of the clinic clientele was female. Thus, science anxiety was identified as a factor inhibiting women’s success. Males and females still tend to follow traditional patterns of choice of course of study. Females especially tend to interpret their relative absence in certain areas of

science such as physics as a sign of their inability to succeed in those areas. These attitudes work as negative feedback, reinforcing science anxiety, and the cycle perpetuates itself. The phenomenon is international³. Comprehensive references for gender in science and mathematics education, including science anxiety, can be found in Hake and Mallow: *Gender Issues in Science/Math Education (GISME)*⁴.

The first binational project. While I was studying science anxiety and trying to reduce it in the United States of America, a group of Danish female physics teachers, under the rubric “Piger og Fysik” [Females and Physics] were doing similar work, especially with regard to female students⁵. Using the Science Anxiety Questionnaire and interviews with students, we established that gender-related science anxiety was a multinational phenomenon⁶.

Analysis of the Science Anxiety Questionnaire data for Danish and American students. The questionnaires were analyzed in two different ways: (1) by regression analysis on all responses, and (2) by chi square analysis on “acute anxiety”: the number of students who gave “much” or “very much” responses to one or more of the 44 items. This acute anxiety was characterized as “acute general anxiety,” GA, if there were “much” or “very much” responses to any item. We thus eliminated from the pool of respondents those who had not expressed any acute anxiety. Acute general anxiety (GA) was then subdivided into science anxiety (SA): “much” or “very much” responses to at least one of the 22 science items, and non-science anxiety (NSA): those whose responses were only to non-science items². The measure we chose to use was SA/GA: the proportion of GA students who were also SA. Note that when this fraction is less than 1, students expressing science anxiety also express non-science anxiety.

Binational results. The binational research carried out in the 1990’s showed that science anxiety was correlated with non-science anxiety, gender, and choice of course of study³. See Figure 1. The chi-square analysis yielded a more robust correlation with gender and with nationality as well. See Figure 2.

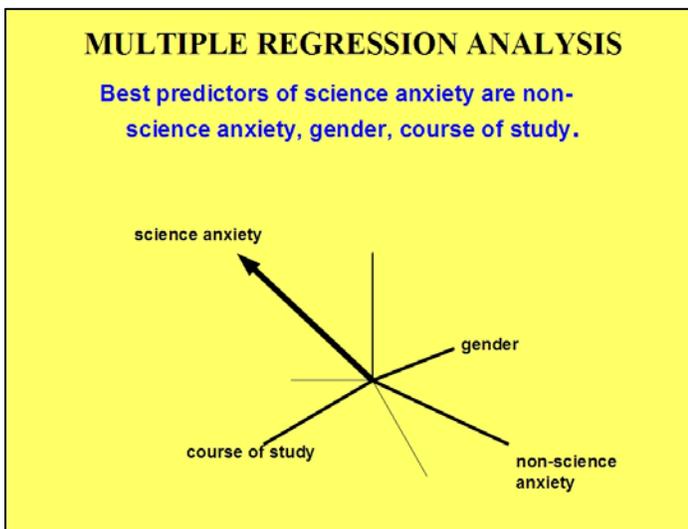


Figure 1. Results of all studies to date

² One could ask why the answer to a single item characterizes the respondent as acutely science anxious. First, *any* manifestation of acute science anxiety calls for an intervention, therefore the single-answer criterion is appropriate. Second, single answers are rare: approximately 78% of the Danish students who expressed acute science anxiety did so on two or more items. The equivalent number for the American students was 90%.

³ This has proved true for all subsequent studies: American, Danish, and binational.

Both Danish and American females exhibited significantly more science anxiety in proportion to general anxiety than did their male counterparts. However, the Danish group's level was lower than that of the American group; in particular, Danish females manifested slightly less science anxiety than American males. Various hypotheses have been proposed; among them the earlier exposure to science in Danish primary schools, different cultural influences, different teacher-student interactions, and different curricula. The least likely explanation is a difference in teacher-student interactions, which we measured and found to be insignificant⁷. Since the Danish school curriculum changes every few years, and overlaps the American in content, it is not really possible to assess the validity of that hypothesis. The question remains unresolved.

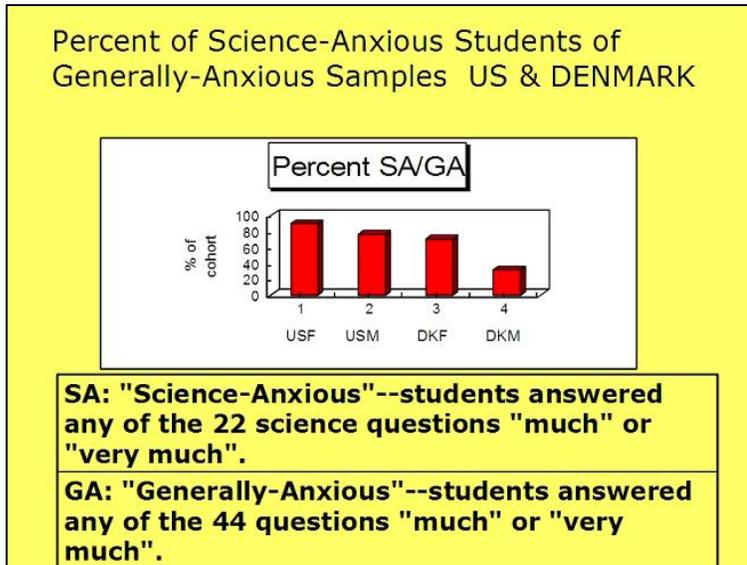


Figure 2. SA/GA
USF =US Female, etc.

Physics courses and science anxiety. In a subsequent study in the United States of America, we measured science anxiety levels before and after students had studied a semester of physics⁸. See Figure 3.

We were pleased to find that science anxiety was in general reduced. We found some correlation between science anxiety reduction and role modeling. Male and female students' science anxieties were lowered in physics classes taught by an instructor of the same gender, provided that the instruction was interactive⁹; e.g., included Socratic dialogue and group projects as opposed to just lecturing. In Figure

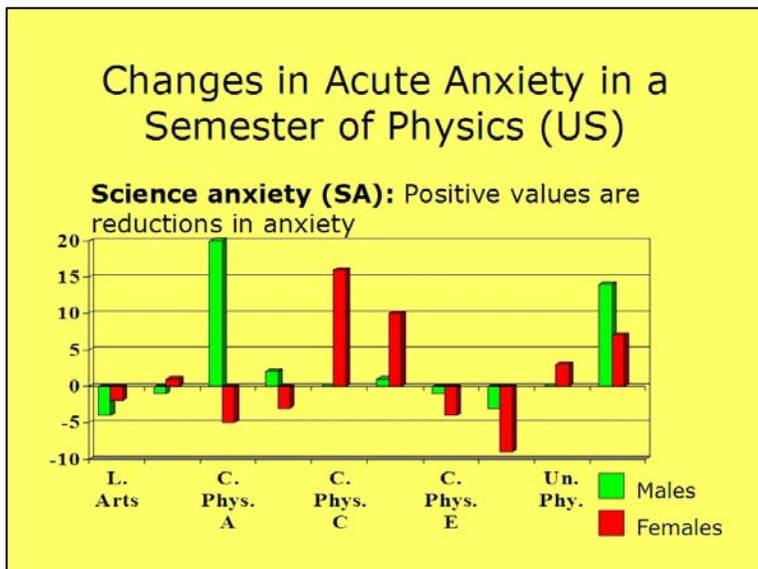


Figure 3. SA/GA
L. Arts=Liberal Arts Physics,
C.Phys. A=College Physics section A, etc.,
Un. Phy.=University Physics.
Labels for every second course are deleted for space.
Final histogram is the total for all courses.

3, C. Phys. A was taught by a male, C. Phys. C by a female.

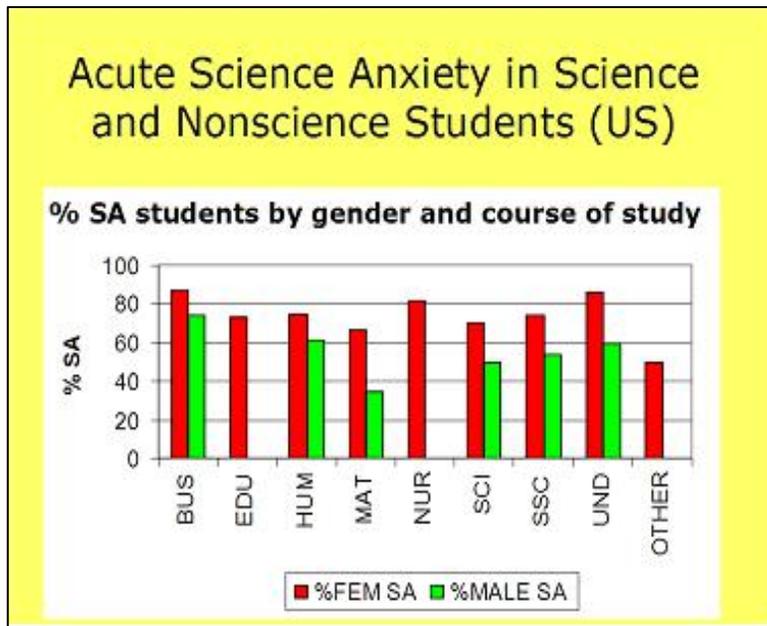


Figure 4. SA/GA
Courses of study are Business, Education, Humanities, Mathematics, Nursing, Science, Social Science, Undecided, Other.

Courses of study, science anxiety, and gender. We have measured science anxiety in populations of science and non-science students taking general education science courses, science courses for students aspiring to the health professions, and science courses for science students at Loyola University Chicago¹⁰. See Figure 4.

One of our findings was that among the most science anxious students are, unfortunately, our predominantly female education students, our future teachers.

Science anxiety and gender in Danish upper secondary schools.

The Danish Ministry of Education asked us to assess the effect on science anxiety and gender of their new school reform: instead of requiring physics for only those students who have declared a specialization in science (including mathematics), the Ministry instituted a physics requirement for all first-year students: science, humanities, and social science. The Ministry provided us with student groups of various socioeconomic backgrounds. Using the Science Anxiety Questionnaire we found that:

- a. Pre-reform students of both genders in all courses of study were significantly more science-anxious than post-reform students.
- b. There were no significant gender differences among either pre-reform or post-reform students. This was true for all courses of study and for all gymnasia.
- c. There were no significant differences between the various gymnasia, which span socioeconomic class, country of origin, and ethnicity/religion.
- d. For both pre- and post-reform students, the proportion of generally anxious students who were also science anxious was considerably higher than in our earlier studies (Figure 2): in some groups 100%.

Thus, while anxiety differences existed between groups, no gender differences were apparent. Detailed comparison of the older and newer curricula may shed some light on this. Utilization of our study in conjunction with the new reform should aid in the analysis of the successes and failures of that reform and lead to modifications in curriculum and pedagogy, in Denmark and likely beyond.

We found similar results for the American students: there were no significant gender differences and the ratio SA/GA was approximately the same as for the Danes. Note however that while SA/GA is a powerful statistic because it removes the non-anxious students, it does not reflect the separate values of SA and GA. Some have changed since the earlier studies, and there appear to be gender differences therein. These are currently under investigation.

III. SCIENCE ANXIETY, SCIENCE ATTITUDES, AND GENDER

The Science Attitudes Questionnaire. We decided to examine attitudes regarding the nature of science and its participants, especially what role these attitudes might play in undercutting the pedagogy itself, driving students, especially girls and women, away from science. We began to seek evidence of correlations between science attitudes and science anxiety. Our binational research group⁴ developed a 40-item Science Attitudes Questionnaire, to which was appended the 44-item Science Anxiety Questionnaire¹¹. The attitudes questionnaire is excerpted in Table 2.

Table 2. Science Attitudes Questionnaire-excerpt. (The examples below appear in random order in the actual questionnaire.)

Please circle the number that best describes the degree to which you agree or disagree with each item below, using the following scale:

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced.

Science is a “level playing-field” in which men and women have equal status and opportunity. Although interpretations can be ambiguous in things like personal relationships or poetry, in science the facts speak for themselves.

There are no such things as objective facts.

Science is a conspiracy between governments and scientific agencies formed to keep ordinary people from taking part in the democratic process

The difference in number of men and women scientists is primarily due to biological differences.

Science is by its nature hostile to women.

Scientists’ ideas apply to some physical objects in the universe but not others.

⁴ *Loyola U.:* Fred Bryant, Psychology; Nelda Hislop, Education; Jeffry Mallow, Physics; Rachel Shefner, Center For Science and Mathematics Education; Maria Udo, Physics.
University College Capital Copenhagen: Helge Kastrop, Mathematics and Science.

The questions included feelings about science and its relationship to the student. A good number of the questions were designed to assess student attitudes across the range from the traditional view of science, *empiricism*, which places facts outside of theory and emphasizes prediction and validation of theory as determined by facts, to *radical constructivism*, which claims that all knowledge is determined by gender, culture, and politics, and questions the existence of facts in the common sense of the word. Most modern science teachers tend to be *moderate* constructivists in their pedagogy. They believe in facts, but know that learners construct knowledge, in which facts play an important but not exclusive role. The role of constructivism in science education has been the focus of ongoing debate¹². Thus, a special concern is the possible influence of various forms of constructivism on attitudes of both females and males toward science.

Correlations between science anxiety, science attitudes, and gender. We administered the full 84-item attitudes/anxiety questionnaire to various groups at Loyola University Chicago: physics students, non-science students, pre-health students, education students, and Chicago Public School (CPS) science teachers taking classes at Loyola's Center For Science and Mathematics Education. Data from a study of 500 students have been analyzed, and correlations found between science anxiety, attitudes toward science, and gender. Females scored significantly higher than males on "inherent bias against women," whereas males scored significantly higher than females on "negativity of science toward the individual." Males who believed in "subjective construction of knowledge" and/or in "negativity of science toward the individual" expressed science anxiety. Females who believed in "negativity of science toward the individual" (*not* just women) expressed science anxiety.

We subsequently administered the questionnaires to 1000 participants from various Loyola student populations and Danish institutions of higher education. Analysis of the data from this larger study is nearing completion. The science anxiety component of the questionnaire has been analyzed for acute science anxiety⁵. In comparison to our earlier studies in the 1990's, we found a closing of the "anxiety gender gap" and the "anxiety national gap," but not in the way we might have hoped. The proportion of science anxious females in the United States of America has remained stable near 90%, while the proportion of Danish females and Danish and American males has increased. Possible causes include changes in curriculum and requirements before and at the university, increased permission for males to admit anxiety, and possible as-yet unknown changes in both cultures. Any of these and others should be the subject of further investigation.

Interviews. We then carried out interviews with small subgroups from each population. Interview discussion questions were based on those in the questionnaires, and, like the former, designed to investigate females' and males' attitudes toward and anxiety about science. An excerpt of the interview questions in our newly published results¹³ appears in Table 3.

⁵ I am grateful to Ann Mallow for her assistance in the data analysis.

Table 3. Interview questions—excerpt. There were 16 questions, and each group chose to answer which and as many as it wished.

How many of your teachers in science have been male? Female? How has that affected you?

Do they teach differently?

What causes of anxiety in science can you identify?

Why do you think gender differences exist in subject choices?

Do you experience anxiety in any subjects or situations?

Some people have suggested that there are no such things as objective facts and that science is simply constructed from the personal opinions and subjective beliefs of scientists. How do you feel about this particular viewpoint?

Some people have suggested that science is inherently hostile and biased toward women. How do you feel about this particular viewpoint?

Some people argue that science is one way of describing the natural world among others to be considered as well; for instance, astrology, creationism/intelligent design. What is your opinion of this?

We were able to draw a number of conclusions:

a. While we did observe differences in responses from students in different courses of study, we observed no arguments across a gender divide in our interview groups. Nor did we detect any tension between males and females. Teachers should thus be wary of assuming that the conflicts of earlier decades persist among current students.

b. Teachers matter. Many of our interviewees noted discriminatory gender differences in both male and female teachers' behavior toward students. All cited the importance of earlier teaching experiences on attitudes toward and anxiety about science. We suggest explicit discussion of these attitudes and anxieties in the classroom, as part of a general discussion of meta-cognition—how one learns science.

c. Radical constructivism may be popular in some academic circles, but our interviewees did not defend it, if they were aware of it at all. In fact, most of the students appeared to be moderate constructivists like their teachers. Thus, while it is important for teachers to explain how scientists really work, it is not necessary to defend ourselves against a radical constructivist position that our students do not hold.

d. Belief in creationism and intelligent design were not prevalent among our interviewees, but not entirely absent. The greatest difference of opinion was between two groups comprising females only: the CPS science teachers and the education students. Some education students tended to believe that the Darwinism/intelligent design conflict still needed to be resolved, albeit by data. Two argued that these alternatives could coexist as valid explanations of the natural world. The strongest attacks on such views came from the CPS teachers. Following their example, science teachers must directly challenge the idea that the truth lies somewhere in the middle.

IV. FURTHER OBSERVATIONS

First, our studies and those of others⁶ have confirmed that there is work still to be done to level the gender playing field. To a great degree in the United States of America, gender disparity in the sciences has markedly decreased, although the proportion of female students is still low compared to their proportion in the university population. Physics continues to lag behind the other sciences, with about 20% of its students female, but this number is growing. Some physics departments such as ours at Loyola University Chicago have 30-40% females. Active attention to gender issues seems to be an important factor in this increase.

Second, the evidence that science anxiety reduction methods work for both genders, as well as across cultures continues to be encouraging.

Finally, it is clear that many issues are multinational⁷. Therefore, it is important to create and strengthen international forums on gender, science, and technology.

V. A NEW STUDY: TEACHERS' ATTITUDES

We have begun a study of the attitudes of Danish and American instructors of the students in our binational study. They will be given the interview questions and asked to provide written responses. We will then interview them individually to discuss their responses, compare them with those of their students, and elicit their suggestions for implementation of new strategies for effective science pedagogy.

⁶ See Hake and Mallow: *GISME*.

⁷ Hake and Mallow: *GISME* Part 2 lists these under the subject heading "International Comparisons."

Endnotes

1. Mallow, J. V., *Science Anxiety: Fear of Science and How to Overcome It*. Revised edition, H & H Publ., Clearwater, FL (1986).
2. Alvaro, R., *The Effectiveness of a Science-Therapy Program on Science-Anxious Undergraduates*. Ph. D. dissertation, Loyola U. Chicago (1978).
3. Tobias, S., Urry, M., and Venkatesan, A., "Physics: For Women, the Last Frontier." *Science* 296, 1201 (2002).
4. Hake, R.R. and Mallow, J. V., *Gender Issues in Science/Math Education (GISME): Over 700 Annotated References & 1000 URL's*.
Part 1 - All References in Alphabetical Order. [<http://www.physics.indiana.edu/~hake/GISME-5t-Part1.pdf>];
Part 2 - Some References in Subject Order. [<http://www.physics.indiana.edu/~hake/GISME-5t-Part2.pdf>] (2008).
5. Beyer, K., Blegaa, S., Olsen, B., Reich, J., and Vedelsby M., *Piger og Fysik* [Females and Physics. In Danish]. IMFUFA Texts, Roskilde University Center, Roskilde, DK (1988).
6. Mallow, J. V., "Gender-related Science Anxiety: A First Binational Study." *J. Sci. Educ. and Technol.* 3, 227-238 (1994).
7. Mallow, J. V., "Students' Confidence and Teachers' Styles: A Binational Comparison." *Am. J. Physics* 63, 1007-1011 (1995).
8. Udo, M. K., Ramsey, G. P., Reynolds-Alpert, S., and Mallow, J. V., "Does Physics Teaching Affect Gender-based Science Anxiety?" *Journal of Science Education and Technology* 10, 237-247 (2001); Udo, M. K., Ramsey, G. P., and Mallow, J. V., "Gender, Science Anxiety, and Physics Teaching." *Proc. GASAT 10* (refereed proceedings), Vol. I, 36- 41 (2001).
9. Hake, R., "Interactive Engagement vs. Traditional Methods: A Six-thousand Student Survey of Mechanics Test Data for Introductory Physics Courses." *Am. J. Physics* 66: 64-74 (1998).
10. Udo, M. K., Ramsey, G. P., Reynolds-Alpert, S., and Mallow, J. V., "Science Anxiety and Gender in Students taking General Education Science Courses." *J. Sci. Educ. and Technol.* 13, 435-446 (2004).
11. The full 84-item questionnaire can be found in Mallow, J., *et al.*, 2010. See below.
12. Matthews, M., "Constructivism and Science Education: A Further Appraisal." *J. Sci. Educ. and Technol.* 11, 121-134 (2002).
13. Mallow, J., Kastrup, H., Bryant, F. B., Hislop, N., Shefner, R., and Udo, M., "Science Anxiety, Science Attitudes, and Gender: Interviews from a Binational Study." *J. Sci. Educ. and Technol.* 19, 356- 369 (2010).