Science & Education 3: 357–371, 1994.

Pseudoscience, the Paranormal, and Science Education

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Abstract. The study of pseudoscience and the paranormal is an important but neglected aspect of science education. Given the widespread acceptance of pseudoscientific and paranormal beliefs, science educators need to take seriously the problem of how these can be combated. I propose teaching science students to critically evaluate the claims of pseudoscience and the paranormal, something that can be accomplished in a variety of ways.

Should science students learn about pseudoscience? Should science educators be concerned about the paranormal? The answers to these questions may seem obvious. Pseudoscience is false science, pretending to be a true science. But then, as something that appears to be a science yet is not, it is precisely what science students should not be learning. Claims about the paranormal – for example, that some people have ESP, that there are mysterious disappearances in the Bermuda Triangle, that faith cures have occurred – are thought to be scientifically suspect. So again it seems that science education should not be concerned with them.

Nevertheless, I will argue that these answers are mistaken. I will maintain that learning pseudoscience and the paranormal should be part of the goal of science education. The goal should not be to instill such beliefs in students but to get them to think *critically* about such beliefs. Science education, I will maintain, should not be narrowly conceived. The goal of science education should not just be to get students to understand science but *to be scientific*; that is, to tend to think and act in a scientific manner in their daily lives. Learning to think critically about pseudoscientific and paranormal beliefs is part of being scientific.

Despite the fact that the study of pseudoscience and the paranormal is a legitimate goal of science education, science educators have in general neglected it. Indeed, science educators seem almost to have a strong aversion to mentioning pseudoscience and the paranormal in textbooks and curriculum material; detailed discussions of pseudoscience in science education material are virtually unknown. The same thing is true of the paranormal. Science educators avoid mentioning the paranormal as if it were a taboo subject.

Perhaps science educators avoid pseudoscience because they believe that if students study it, they will become pseudoscientific. Similarly perhaps they avoid the paranormal because they believe that if students study the paranormal they will accept paranormal claims. These beliefs are similar to the views of those who were opposed to studying communism in school because they thought that it would make students communists. However, there is no reason to suppose that a critical study would have this effect. This is undoubtedly true for the study of pseudoscience and the paranormal. There is no reason to suppose that those who study pseudoscience and the paranormal in the proper way will be taken in by the claims of pseudoscience and the paranormal. Indeed, the evidence indicates just the opposite. But, it may asked, what is the proper way?

In the study of communism, there is a distinction to be drawn between teaching students *to be* communists and teaching them *to evaluate critically* the doctrines of communism. Similarly, one can distinguish between teaching students *to be* pseudoscientists or *to accept* paranormal claims and teaching students *to critically* evaluate pseudoscientific or paranormal claims. What I am recommending is science education in the sense of teaching students to critically evaluate pseudoscientific or paranormal claims.

It may be objected that there is no need to introduce the critical study of pseudoscience and the paranormal into science education. It may be assumed that the scientific thinking educators teach their students to use in investigating physical and biological phenomena will automatically be applied outside the classroom and laboratory, when, for instance, students are confronted with the false or unsupported claims made in the popular media in the name of science. It may also be thought that few people hold pseudoscientific and paranormal beliefs and, consequently, that it is not necessary for science educators to expend energy on trying to keep their students from accepting these.

However, as I will show here, there is little reason to suppose that science students are being scientific in their daily lives. On the contrary, the scope of pseudoscientific and paranormal beliefs is surprisingly wide; indeed, the evidence suggests that pseudoscientific and paranormal beliefs are rife among the general population, students, and even science educators. I will argue that the extent of the acceptance of paranormal and pseudoscientific beliefs should be of great concern to science educators. Then after clarifying the concepts of pseudoscience and paranormal, I will suggest specific ways that pseudoscience and paranormal beliefs can be taught from a critical point of view.

THE EXTENT OF PSEUDOSCIENTIFIC BELIEFS AND BELIEFS IN THE PARANORMAL

How widespread is belief in pseudoscience and the paranormal? There is good reason to suppose that belief in paranormal phenomena is widespread among students. For example, a 1979 survey of University of Washington undergraduates showed that a majority of those sampled – excluding those who were Born Again Christians – thought they might have had an extra-sensory experience and a substantial percentage of them thought that ESP definitely exists.[1] A 1984 survey of students at Hollins College, Virginia indicated that before taking a course on the scientific investigation of the paranormal 37% believed in ghosts, 64% believed in mental telepathy, and 46% believed that you can make plants grow by talking to them.[2] A survey of students at Concordia College in Montreal, Canada showed that before they took a course on the scientific investigation of the paranormal 85% believed in ESP, 55% in astrology, 49% in psychic healing, and 43% in ghosts.[3] A survey of students at the University of Texas at Arlington in 1981, 1982, and 1983 showed that 34% believed in Black Magic, 59% believed that some people can predict the future by psychic powers, 28% believed that there is a supernatural force operating in the Bermuda Triangle, and 35% believed that ghosts exist.[4] A 1984 survey of six graders in four Charleston, South Carolina area schools revealed that they tended to believe in miracles, in the Loch Ness monster and in reincarnation.[5]

Such beliefs also seem to be widespread among the general population. A 1987 survey of 1400 American adults found that 67% had 'experienced ESP'.[6] Surprisingly even those in the general population who have had scientific training believe in the paranormal. Thus, a survey of high school biology teachers showed that 34% agreed that psychic powers could be used to read other people's minds, 22% believed that ghosts exist, 18% believed there is a supernatural force operating in the Bermuda Triangle.[7]

Pseudoscientific beliefs are also widespread. Consider the wide acceptance by the general public of astrology – a paradigm case of a pseudoscience[8] – as well as of pseudoscientific medical theories and techniques such as iridology, chiropractic, homeopathy[9] and also of Erich von Däniken's ancient astronaut theory.[10] In addition, the rejection of the theory of evolution is widespread. A recent Gallup poll found that 42% of those surveyed in the general population believed in the direct divine creation of human beings within the past several thousand years.[11] A 1986 survey of students at the University of Texas at Arlington indicated that 24% believed that creation occurred in six twenty four hour days, and that 27% did not believe that evolution explains the history of life.[12] Even more surprisingly a 1988 survey of high school biology teachers indicated that 30% rejected the theory of evolution.[13]

These surveys themselves do not show that the people who rejected evolution hold beliefs associated with so-called creation *science*, the pseudoscience that rejects evolution for allegedly sound scientific reasons. They might do so for purely religious reasons. However, given the criticisms of evolution by creation scientists[14] that have gained popular acceptance,[15] it is likely many of the people surveyed believe that there are good scientific reasons for rejecting evolution even if they do not know exactly what they are. Furthermore, even if this is not so, the arguments of creation science give the ordinary religious believer's rejection of evolution scientific respectability.

WHY BE CONCERNED

The widespread belief in pseudoscience and the paranormal is not surprising given the way such beliefs are presented by the popular media.[16] For example, ABC,[17] PBS's NOVA,[18] *Readers' Digest*,[19] *Science Digest*[20] and television pseudo-documentaries[21] such as the 'In Search of' series have uncritically accepted pseudoscience and paranormal claims. Why should the widespread belief in pseudoscientific ideas and the paranormal be of concern to science educators?

One practical reason is that people with pseudoscientific and paranormal beliefs may be at greater risk than those who are not. For example, iridology, acupuncture, chiropractic, homeopathy, and therapeutic touch are all based on pseudoscientific theories yet they have unproven therapeutic value.[22] The same thing can be said of therapies based on paranormal beliefs. For example, faith healing's effectiveness is unproven and in many instances is based on fraud and deception.[23] Sick people who rely on these practices might well be neglecting therapies that are more reliable and proven, thus indirectly harming themselves. Moreover, actions based on pseudoscientific beliefs – for example, that massive doses of vitamins have therapeutic value – can directly harm people.

But why should this be of concern to science educators? It is not, if one embraces a very narrow view of science education according to which the entire task of science education is to convey factual information to students that has no direct relevance to their daily lives; for example, information about cells, pendulums, and rock strata. On this conception of science education it will be said that if people act on dubious medical assumptions, science education is not at fault. If they choose to rely on, say, iridology, that is their business.

But given the broader view of science education that I endorse, science education cannot escape blame. On a more generous conception, one of its goals is the acquisition of reliable factual information that is relevant to practical life. Another goal is that students should also acquire the tendency to act on that information in the light of their goals. In other words, science education should make a difference in how people conduct their lives![24]

Practical reasons for science educators being concerned about the widespread acceptance of pseudoscientific and paranormal beliefs aside, on any conception of science education in which one of its goals is that students understand science, this phenomenon represents a failure of science education. For example, the wide acceptance of astrology[25] and chiropractic[26] indicates that many people do not understand astronomy and physiology. And insofar as people reject the theory of evolution for the reasons given by creation science, it would seem that they simply do not understand the theory and its evidential support.[27]

Now it is important to note that a belief in ESP, dowsing, mysterious disappearances in the Bermuda Triangle, ghosts and other paranormal phenomena is not necessarily unscientific. After all, paranormal phenomena might be real: for example, there might be mysterious disappearances in the Bermuda Triangle that cannot be explained by present day science. However, belief in the paranormal usually seems to be based on misinformation, on a failure to critically evaluate alternative hypotheses, and on the general neglect of the fundamental principles of scientific investigation. These problems would be addressed in the broad conception of science education that I am advocating.

THE CONCEPT OF A PSEUDOSCIENCE

Given that we should be concerned with the wide acceptance of paranormal claims and pseudoscientific theories, theoretical questions remain. In particular, we need to clarify the concepts of pseudoscience and paranormal.

What is a pseudoscience? Different accounts of it have been given, but on my view it is a systematic body of propositions, practices, and attitudes that gives the appearance of being a science but is not.[28] This means that a pseudoscience has some properties that are characteristic of science and others, often not so easily discernible, that are not. The discovery of these latter reveals the unscientific nature of the body of propositions, the practices and attitudes that constitutes a pseudoscience.

Let us call the properties that give pseudoscience the appearance of science *surface properties*, and the ones which are hidden but which reveal its unscientific nature *depth properties*. Among the surface properties of a pseudoscience are these: (1) Its propositions are couched in technical language used to express far-ranging and impressive sounding theories. (2) Its practices include claims by its practitioners that these theories are well supported by the evidence and the use of complex and ingenious arguments to meet criticisms of their theories. (3) Its practices include special training for the practitioners, the formation of special organizations, the publication of journals, and the use of an authoritative text. Among the depth properties of a pseudoscience are these: (1) Its propositions are untested, untestable or perhaps already refuted. (2) Its practice will include attempts by the practitioners to prevent their theories from being exposed to critical tests and evaluations, and the attempt to explain away any possible negative evidence. (3) Its practice will also include attempts of the practitioners to isolate themselves from the mainstream of scientific inquiry and from critical interaction with the scientific community. (4) The attitude of the pseudoscientist will be dogmatic and slightly paranoid; he or she will be intolerant of all other theories.[29]

One might say that the basic methodological difference between pseudoscience and science on my account lies in what Joseph Schwab called the *syntactical structure*; that is, in the differences between the cannons and standards of proof and evidence used in pseudoscience and science.[30]

Science critically tests its theories and hypotheses and modifies them in the light of the evidence; pseudoscience does not. Moreover, although the surface properties of pseudoscience and science are the same, they have different functions and also reflect the basic differences in the depth properties. Science's technical vocabulary, journals, and professional organizations have as one of their primary functions the furthering of the critical spirit of science. For example, technical vocabulary is used to state hypotheses precisely so that more severe testing is facilitated. Professional journals not only publish new scientific discoveries but enable critical responses to be voiced. Even authoritative texts are subject to critical review and are replaced as science progresses. In pseudoscience, technical vocabulary has as its function obscuring what is being said, thus preventing testing and criticism. Journals (if they exist) function to reinforce the dogmas of the pseudoscientists who contribute to them. The authoritative text in pseudoscience is authoritative much as the Bible is authoritative to religious fundamentalists – it is not a framework to critically evaluate, test, and perhaps overthrow.

Let us contrast my account of pseudoscience with an analysis by Paul R. Thagard.[31] According to Thagard, there are three elements involved in the demarcation between science and pseudoscience: theory, community and historical context. Under theory Thagard includes 'familiar matters of structure' such as confirmation and verification, explanation, and problem solving. He says, however, that these considerations are not enough to distinguish science from pseudoscience. In particular, it is also important to consider the community of advocates of the theory. In this context several questions are important. Are the practitioners in agreement about the principles of the theory and how to go about solving problems? Are they concerned about explaining anomalies and comparing the success of their theory to the record of rival other theories. Are the practitioners involved in attempts at confirming and disconfirming their theory?

According to Thagard, the historical context is also important in distinguishing science from pseudoscience. By this he means the progressiveness of a theory: its success in adding to its set of facts explained and problems solved relative to the success of other theories. Thomas Kuhn and others have argued that a theory is rejected only if it has faced anomalies over a long period of time and it has been challenged by another theory.

Given these three elements, Thagard defines a pseudoscience as follows:

A theory or discipline which purports to be scientific is pseudoscientific if and only if:

1. It has been less progressive than alternative theories over a long period of time, and faces many unsolved problems; but
2. The community of practitioners makes little attempt to develop the theory towards solutions of the problem, shows no concern for attempts to evaluate the theory relative to others, and is selective in considering confirmation and disconfirmation.

Thagard's analysis of pseudoscience and my own account are complementary. Whereas he says virtually nothing about the pseudo aspect of pseudoscience except that a pseudoscience purports to be scientific, I deal with this in some detail. On the other hand, I neglect the historical context while he pays this special attention. Further, what my account says about the community of advocates is compatible with Thagard's analysis. I stress their isolation and intolerance whereas he emphasizes their lack of agreement in principle about how to solve problems and their lack of concern about explaining analogies and comparing the success of rival theories. Both analyses point out the failure of the community of advocates to test their theories.

There is one further contrast that should be noted. Thagard puts his account forward as a definition in form of a biconditional whereas I offer mine more informally as set of properties that are characteristic of a pseudoscience. These properties do not constitute a set which would form either individually necessary conditions or a jointly sufficient condition for being a pseudoscience.

THE CONCEPT OF THE PARANORMAL

A sophisticated analysis of the paranormal has been provided by Stephen Braude:[32]

> Phenomena *P* is paranormal = d*f*. (a) *P* is inexplicable in terms of current scientific theory; (b) *P* cannot be explained scientifically without major revisions elsewhere in scientific theory; (c) *P* thwarts our familiar expectations about what sorts of things can happen to the sorts of objects involves in *P*.

One might well wonder if condition (c) is needed. Why not consider a paranormal phenomenon one that simply meets conditions (a) and (b)? Braude's rationale is that without (c) exotic phenomena connected with blackholes and subatomic processes might be categorized as paranormal, yet they are not paranormal in the way that television sets turning into people or raining blood would be. The difference, according to Braude, is that "raining blood (say) would thwart our ordinary expectation about meteorological phenomena . . . whereas phenomena connected with black holes conflict with none of our familiar expectations. Although members of the scientific community may have certain expectations about what they will encounter in deep space, in general the really odd phenomena investigated in astronomy violate no *familiar* expectations".[33]

Braude's definition has implications that need to be explicated. According to it, paranormal phenomena are in principle explainable by science although they are not explainable by current scientific theory and not without a major revolution in our scientific scheme. In consequence, what is paranormal is relative to time. Phenomena that are paranormal now might not be in the future if there is a major scientific revolution that enables science to explain them. The definition also makes what is paranormal relative to culture since what people's familiar expectations are will vary from one culture to another.

It should be noted that there is no necessary connection between paranormal phenomena as defined by Braude and pseudoscience as characterized above. Not all pseudosciences posit paranormal phenomena. For example, on the one hand, chiropractic is considered by many to be a pseudoscience but no one thinks it is concerned with paranormal phenomena; on the other hand, psychic surgery is a pseudoscience that is based on paranormal beliefs.[34] Cures allegedly brought about by religious faith are, in turn, considered to be paranormal phenomena but the related religious practices and beliefs are not pseudoscientific since they usually have no scientific pretensions.[35]

WHAT CAN BE DONE

It is quite clear that education can change people's beliefs about pseudoscience and the paranormal. For example, we know from before and after surveys that Thomas Gray's course "The Science and Pseudoscience of Paranormal Phenomena" at Concordia College significantly reduced students' belief in various paranormal phenomena, as did Paul Woods' course "The Scientific Investigation of the Claims of the Paranormal" at Hollins College and Jerome Tobacyk's course at Louisiana Tech University.[36] Moreover, although no formal survey was conducted, there is no question in my mind that a course that I taught at Boston University for many years entitled, 'Philosophy of Science and the Occult' reduced many students' belief in the occult and the paranormal. Nevertheless, one cannot expect too much from a single course at the college level. As before and after surveys make clear, a surprisingly large percentage of the students retained their belief in paranormal phenomena even immediately after taking courses that taught them to be critical of the paranormal. Moreover, as a follow-up study at Concordia College showed, the influence of a single course becomes diluted with time. One year later students' belief in the paranormal at Concordia was greater than it was immediately after taking the course, although it did not return to its precourse level.

There is no reason why a critical approach to pseudoscience and the paranormal must be introduced initially at the college level, however. Surely the time to start is much earlier – in high school or even grade school. Instead of thinking that a single college course can eliminate the years of influence of the popular media and culture that tacitly endorse paranormal claims, science educators should make a critical approach to the paranormal an integral part of science education right from the beginning. As students become more mature the same problems can be approached from a more sophisticated perspective. The question is how to introduce this critical approach.

The analyses of pseudoscience and the paranormal given here provide the general framework and rationale for what should be taught. In teaching science students about pseudoscience, it is important that they learn how to distinguish surface properties from depth properties so that they are not taken in by appearances. For example, science students should be taught to see beyond the superficial appearances of a science and to determine whether the propositions of the theories are untested, untestable or refuted.[37] Despite the widely held belief that paranormal phenomena are beyond the purview of scientific investigation, they can and have been investigated and theories about them can and have been tested. Teaching this testing procedure can and should be a goal of science education. This will mean learning to be skeptical of the claims of believers who will naturally present their theory in its best light.

Thagard's analysis of pseudoscience suggests other goals, for example, teaching students to determine whether the practitioners of the theory have attempted to develop the theory and evaluate it relative to other theories. Thus, the comparison of the theory under consideration with rival theories should be an essential part of science education as should determining the past efforts of practitioners to improve the theory.

Braude's analysis in turn suggests a goal of science education related to the paranormal. Since before accepting a phenomenon as paranormal one must be sure that it is inexplicable in terms of current scientific theories, this means teaching students to rule out fraud, trickery, misperception, chance, and other types of explanations before a paranormal claim can be accepted. This entails teaching students a skeptical attitude toward claims of those who often either make no attempt to rule out rival explanations or do this in a superficial way. This also entails teaching students a skeptical attitude towards the stories presented in the popular media.

TESTING DOWSING: A PARADIGM

To illustrate the teaching of paranormal claims in the science classroom in a critical spirit I offer an example from my own experience. Several years ago an undergraduate student in my Boston University course, Philosophy of Science and the Occult, devised a controlled dowsing experiment.[38] The design was so simple that it can be duplicated – perhaps with only minor modifications – at the high school and even grade school level.

Dowsers claim that the movement of a dowsing rod – usually a forked stick – can locate not just water but other substances. A basic question in evaluating the claim is whether dowsers can locate water at a higher rate than one would expect by chance. In order to answer this question, in the Spring of 1981 my student, Perry Flint, tested Paul Sevigny, the President of the American Society of Dowsers after he gave an informal lecture to my class in which he made many sweeping claims about the abilities of dowsers.

The experimental design was this: Four plastic water hoses were run from one plastic trash can on one side of the room to another on the other side. A water pump was attached to one of the four hoses and was pumped from one trash can to the other. The four hoses that ran across the floor were covered by a rug and their positions were indicated by large pieces of paper on the floor with the numerals 1, 2, 3, 4 written on them. The pump, the person operating the pump, and the trash can containing the water were all hidden from the dowser's and the audience's view by a screen. Which hose the water was to be pumped through was picked at random. In order to eliminate auditory clues a loud electric drill was activated when the water pump was in use. Mr. Sevigny, with dowsing rod in hand, walked back and forth over the rug attempting to determine which hose had water flowing through it. His guesses and the correct answers were written on a blackboard in the front of the room and independently recorded on a piece of paper. Forty trials were run. If nothing but chance had been operating, then one would have expected about ten correct guesses in the forty trials. Sevigny got nine correct guesses in forty trials.

Students learned important lessons from this experiment. First, they learned how to design one type of controlled experiment. Second, they saw how alternative hypotheses, e.g., fraud, the use of auditory clues, can be eliminated by safeguards built into the experimental design. Third, they learned that paranormal claims can be tested. Fourth, they saw first hand the contrast between what a strong believer in the paranormal claims and what the evidence demonstrates. Finally, they learned a basic principle of science: that hypotheses should be subjected to critical examination before they are accepted. One can well imagine younger science students learning similar lessons from experiments similar to this.

OTHER WAYS OF INTRODUCING PSEUDOSCIENTIFIC AND PARANORMAL MATERIAL

There are many ways in which a critical study of pseudoscience can be incorporated into science education:

(1) Students might critically examine historical cases of pseudoscience along with cases of genuine science. Thus the Conant historical case method could be easily adapted to the study of pseudoscience.[39] For example, some papers of Lysenko[40] could be read in conjunction with Mendel's original papers.

(2) Contemporary research papers and contemporary pseudoscientific 'research papers' – preferably on the same topic – could be read[41] and differences in the uses of evidence and hypotheses and in the methodological attitudes manifested in the papers could be brought to light. For example, papers of the 'cure' of some particular disease from the National

Chiropractic Association could be read in conjunction with research papers from medical journals.

(3) Laboratory work could be directed to testing the scientific pretensions of pseudoscience. For example, some of the pseudoscientific theses of Charles Wentworth Littlefield on crystal formations and Morely Martin on primordial protoplasm could be tested in the lab.[42]

(4) Students could be encouraged to bring in for class discussion the examples of pseudoscientific thinking, beliefs, and theories that they find in newspapers, magazines, and other popular media. The evidential basis for, e.g., the claims found in advertisements of food faddists could be critically considered.

(5) Textbooks might be written with at least a chapter devoted to a critical consideration of some pseudoscientific theory. For example, a biology text might consider critically the pseudoscientific theory of accommodation presented by Dr. Williams Bates in 1920 and contrast it with the theory of accommodation accepted by contemporary eye-physiologists.[43]

(6) Students could be examined on their ability to recognize cases of pseudoscience not previously considered in class and to justify their reasons for their judgments.

Here are some of the ways in which testing claims about the paranormal can be incorporated into science courses:

(a) ESP experiments could be conducted using standard ESP cards (Zener Cards). One group of students could design the experiment with safeguards to eliminate fraud and unconscious cueing and administer it to another group who would attempt to thwart the safeguards designed. The objective would be to become acquainted with the problems of constructing fraud-proof ESP experiments.

(b) A magician could be invited to the class to demonstrate how fraudulent psychic wonders work and what sort of things magicians look for to determine if a psychic such as Uri Geller is legitimate. The magician could then be asked to critique the experimental design discussed in (a) above.

(c) Paranormal claims have been made about the effects of positive and negative thoughts on the growth of household plants: positive thoughts are alleged to encourage growth and negative thoughts to inhibit it. An experiment could be performed by the class to test this. At a certain period of time the class would "send out" positive thoughts to one group of plants and at another period it would transmit negative thoughts to another group. The two groups of plants would be treated identically in other respects[44] and careful records would be kept of their growth.

(d) Cases of disappearances from the Bermuda Triangle could be discussed and non paranormal explanations of the disappearances considered. How the explanations could be tested could also be discussed.[45]

(e) Cases of alleged cures by faith healers could be discussed and critical questions of the following sort considered: Was the person really cured? Was the person really ill to begin with? How could one tell? Are there nonparanormal explanations for the cure, e.g., spontaneous remission?[46]

(f) Cases in which psychic detectives have alleged to have solved crimes by their psychic powers could be discussed. The success rate of these detectives could be considered as well as alternative explanations of their success, and appropriate tests could be devised.[47] Someone from the local police department could visit the class, relate his or her experience with psychic detectives and explain how actual detectives solve crimes.

These suggestions only scratch the surface. Imaginative science teachers should be able to devise countless interesting projects, experiments and field trips connected with the critical evaluation of paranormal claims.

CONCLUSION

I have argued that the study of pseudoscience and the paranormal is an important but neglected aspect of science education. Given the widespread acceptance of pseudoscientific and paranormal beliefs, science educators need to take seriously the problem of how these can be combated. I propose teaching science students to critically evaluate the claims of pseudoscience and the paranormal, something that can be accomplished in a variety of ways. Introducing pseudoscientific and paranormal claims into science courses and subjecting them to critical tests has the added advantage of alerting students to the dangers of pseudoscientific medical procedures. It also can serve to motivate students to learn science. Students are often fascinated by claims about the paranormal. As much as some science teachers might wish to deny it, many students are more interested in the mysterious disappearances in the Bermuda Triangle, ESP, and ghosts than in Archimedes' Principle, the law of the lever, and the physiology of frogs. Consequently, testing paranormal claims can be judicially used to inspire hard to motivate students and in general to enliven an apathetic class. Furthermore, for the reasons already presented a science teacher need not feel guilty about using these motivational tools for teaching students to critically investigate pseudoscientific and paranormal claims is valuable on independent grounds.

NOTES

1. Bainbridge and Stark, 1981, p. 52. Twenty six percent of students with no religion believed that ESP definitely exists in contrast with 29% of Catholics and 17% of Protestants.
2. Woods 1984, p. 67.
3. Gray 1984.
4. Harrold and Eve 1986, p. 67.
5. Adelman and Adelman 1984.
6. Greeley 1987, pp. 47–49, cited by Hines 1988, p. 105.
7. Eve and Dunn 1989, p. 262.
8. See Culver and Ianna, 1984.

9. Stalker and Glymour 1985; Hines 1988, Chapter 11.
10. See Hines 1988, Chapter 9.
11. Moore 1983, pp. 95–104, cited in Harrold and Eve 1986, p. 62.
12. Harrold and Eve 1986, p. 67.
13. Eve and Dunn 1989.
14. For a critique of these arguments see Kitcher 1982.
15. See Godfrey 1979; Schadewald 1983.
16. See Kurtz 1985.
17. Larner 1985–86.
18. Ganoe and Kirwan 1984.
19. Frazier 1983.
20. Osberg and Scheaffer 1977.
21. Bainbridge 1979.
22. See Stalker and Glymour 1985.
23. See Hines 1988, Chapter 10; Randi 1987.
24. Martin 1972, Chapter 5.
25. See Culver and Ianna 1984.
26. See Crelin 1985.
27. See Kitcher 1982; Futuyama 1983.
28. Martin 1972, pp. 40–42
29. See Gardner 1957, Chapter 1.
30. See Schwab 1964.
31. Thagard 1980.
32. Braude 1979, pp. 242–263.
33. Braude 1979, pp. 259–260.
34. Hines 1988, pp. 245–247.
35. Thus, Terence Hines is wrong to suppose that the paranormal is a subset of pseudoscience. According to Hines what sets the paranormal apart from other pseudoscience "is a reliance on explanations for alleged phenomena that are well outside the bounds of established science." This is correct but does not show that the paranormal is a subset of the pseudoscience since the explanations might not pretend to be scientific. See Hines 1988, p. 7.
36. Gray 1984; Woods 1984; Tobacyk 1983.
37. Elsewhere I have contrasted two approaches to teaching theory testing in science education: the confirmation approach and the refutation approach. On the confirmation approach one deduces test implications from a theory combined with auxiliary hypotheses. The hypothesis or one or more of the auxiliary hypotheses is rejected in the light of negative evidence; their probability is increased under certain conditions in the light of positive evidence. On the refutation approach advocated by Karl Popper the theory or one or more of the auxiliary hypotheses is rejected in light of negative evidence. Positive evidence does not increase the probability. However, whichever approach is adopted by science educators, one thing seems clear. Teaching students the importance of testing scientific theories is crucial. See Martin 1972, Chapter 1.
38. Martin 1983–84.
39. For a discussion of this method see Klopfer 1969.
40. See Futuyama 1983, pp. 161–162 for the effect of his view on Soviet science.
41. This research paper approach is usually associated with Schwab 1964, pp. 73–79. He does not, of course, consider studying pseudoscience 'research' papers. See also Baumel and Berger 1969, pp. 205–207.
42. See Gardner 1957, Chapter 10.
43. Gardner 1957, Chapter 19.
44. See Hines 1988, p. 303.
45. See Hines 1988, pp. 219–227; Kusche 1975.
46. See Hines 1988, Chapter 10; Randi 1987.
47. See Hines 1988, pp. 46–48.

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