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Students' Ideas Regarding Science and Pseudo-science in Relation to the Human Body and Health

Abstract

This study investigates the pseudo-scientific and superstitious ideas Swedish upper-secondary students articulate and if there is a relationship between their ideas and their knowledge of the human body and health. The study is based on a questionnaire among 300 students in which the students were asked to consider statements related to different treatments that may influence the human body and health, and questions about physiology, health and nutrition. The analysis reveals that a relatively large group of students give credance to statements such as that some people can transfer thoughts or that the phases of the moon can affect a person's health. The analysis also shows that there is no apparent relationship between the students' pseudo-scientific beliefs and their scientific knowledge about the human body. Furthermore, although the results do not indicate a gender difference with regards to the power of faith in pseudo-scientific ideas, they do indicate that male and females consider these questions differently. The results imply a need for discussion and critical investigation in school science concerning the relationship between science and pseudo-scientific ideas in order to enhance critical thinking and development of the understanding of the nature of science.

Introduction

Studies within the field of science education and in other areas, such as psychology or religion, demonstrate a rather complex image of people's understanding of the relationship between science, pseudo-science and New Age ideas. The National Science Foundation (NSF, 2006) and the European Commission (EC, 2005) recently revealed that about fifty percent of Americans and Europeans concur with the statement that society depends too much on science and not enough on faith. Other studies (e.g. CBS, 2002; Preece & Baxter, 2000; Sjödin, 1995) describe an image in which large groups of individuals in contemporary Western society believe in pseudo-science, superstition and paranormal phenomena such as crystal therapy, lucky numbers and telepathy. In a CBS news poll (2002), 57% of the respondents make manifest their belief in extra sensory perception (ESP), and in the Eurobarometer (EC, 2005) nearly four of ten participants state that they consider some numbers to affect their luck. In addition, studies about students' ideas concerning these questions reveal a similar picture. Sjödin (1995) investigated upper-secondary students' paranormal beliefs and found that more than one third of the students' agree or partly agree with statements that there exist people who are able to contact spirits, tell the future, or read other people's thoughts. About one fifth of the participants communicated that they believe in astrology, reincarnation, and that some people have the ability to move objects through telekinesis. According to the Eurobarometer (EC, 2005), many Europeans find it problematic to determine what science is and to conclude if a subject is scientific or not. For example, more than one third of the participants of the Eurobarometer study categorise homeopathy as science.

On the other hand, some studies (EC, 2005; NSF, 2006) conclude that the majority of Americans and Europeans express explicitly that research in science is crucial for a society's welfare and development. According to these studies, people are of the opinion that science and technology can both make our lives easier and solve problems. Furthermore, they believe that science and technology - particularly within the spheres of medicine, energy and ICT - will have a positive effect on our lives in the future. The study results also indicate that citizens in the USA and in Europe, to a high degree, want society to economically support research, even if the outcomes cannot not be immediately utilised. Roughly fifty percent of Europeans convey that in the future the scientific community will be able to give us an entire image of nature and the universe. Furthermore, almost 90% of Europeans assume that research will produce a cure for AIDS and cancer, and also contribute to a healthier life. According to the EC (2005) and the NSF (2006), individuals communicate a confidence in science, as well as a positive attitude towards science, technology and, in particular, medical and environmental issues.

In short, two different images of how people tend to experience science, pseudo-science and New Age ideas have materialised. On the one hand, studies indicate that relatively large groups of individuals in modern society believe in pseudo-science, superstition and paranormal phenomena. On the other hand, the majority of Americans and Europeans communicate that they are fairly confident that research in science can make our lives healthier and that it can contribute to finding cures for serious deceases. This gives rise to the following questions: Is it possible that individuals may hold these two different views simultaneously and, if so, how is it possible to express both of these conflicting ideas? Unfortunately, there is, in general, a lack of studies regarding the relationship between an individual's ideas about science and pseudo-science, and, in particular, research that investigates how these conflicting ideas may be cohabitants within the worldviews of an individual. Instead, most research in this area has focused on the impact of education in science on students' pseudo-scientific and non-scientific ideas.

Consequently, this study intends to investigate what pseudo-scientific ideas people actually hold and how their ideas are related to their scientific knowledge. In essence, this study seeks to explore upper- secondary students' ideas about science and pseudo-science related to their knowledge about the human body and health. In addition, it seeks to investigate existing gender and educational differences in relation to these issues.

Scientific knowledge in relation to New Age and pseudo-scientific beliefs

There exists no uniform definition of the concept New Age, but in everyday language it is commonly described as a movement with supernatural explanation models containing, on the whole, religious features. Hammer (1997) defines the phenomenon as a mixture of beliefs and confessions about the world. According to him, it is distinguished from traditional religion because there no central authority or complete system of ideas, myths and rituals exists. Preece and Baxter (2000) describe most New Age ideas as pseudo-science, and they define the phenomenon as a set of ideas or theories that are claimed to be scientific but are at variance with science. This means that the phenomena have failed empirical tests or are impossible to investigate by using scientific methods. Preece and Baxter also point out that well-organised groups, often with commercial interests, and the popular media propagate a number of expanding pseudo-scientific enterprises, such as astrology and homeopathy.

With regards the relationship between scientific knowledge and pseudo-scientific ideas, Sagan (1995) argues that an education in science may function as "enlightenment," and he describes science as a "candle in the dark." It is evident, according to Sagan, that when students use and understand scientific methods, they thereby develop a form of critical thinking that leads to a marginalization of their pseudo-scientific beliefs. Wallace (2000) expresses similar thoughts and argues that only education and investment in educational programmes, such as project 2061, can contribute to the development of an individual's critical views about these issues. However, research in this area reveals that there is a more complex relationship between people's education in science and their beliefs in pseudo-science. For example, Goode (2002) found a distinctly negative correlation between the level of students' education and their belief in astrology. At the same time, he refers to several public opinion polls which describe an inconsistent relationship between education and classic forms of belief in the paranormal. Shermer (2003) refers to three different studies that have investigated the same relationship; however, the factors measured were different in the three studies (critical thinking skills and educational performance). Shermer concludes that it is hard to find a consensus among researchers concerning a distinctly marked correlation between scientific knowledge and scepticism of pseudo-scientific ideas.

In a definitive study, McLeish (1984) investigated students' superstitions and related the results to the subjects the students were studying. The analysis revealed that students studying science, mathematics, language and literature showed a lower degree of superstition than those students studying social science and practical subjects, such as catering or typing. On the other hand, Walker, Hoekstra & Vogl (2002) did not find any relationship between the level of student's scientific knowledge and their scepticism regarding paranormal beliefs. These results were also confirmed by Ryan et al. (2004), who found that science majors had a larger base of knowledge in science compared to other majors. However, this did not influence their acceptance of non-scientific concepts such as extra-sensory perception (ESP), alien abductions and the misfortune associated with broken mirrors.

Gender differences and pseudo-scientific ideas

The discussion, so far, indicates a divergence concerning in what ways the level of education is related to students' ideas about pseudo-scientific ideas. Research results and conclusions also differ regarding how pseudo-scientific beliefs are related to gender. In a study by Preece and Baxter (2000), female subjects, to a higher extent than their male counterparts, reveal they give credence to pseudo-scientific and paranormal concepts, such as crystal healing, astrology and ghosts. There is, however, one exception; males tend to more readily accept that aliens from outer space have visited earth. Preece and Baxter's results are, to some degree, a confirmation of an earlier study by McLeish (1984), in which he describes significant gender differences with respect to superstitious ideas. Similarly, Sjödin's analysis (1995) reveals gender differences among students, for example, females express a greater confidence in general occult phenomena, astrology and reincarnation. As in the study of Preece and Baxter (2000), males, to a greater extent than females, seem to believe in the existence of UFOs. Pettersen (2007) demonstrates that female health science students are more positive to alternative medical treatments than male students. Preece and Baxter (2000) discuss possible explanations for the existence of these gender differences and argue that they could derive from the influence of magazines aimed at females. As a general explanation, the researchers refer to a combination of social and cultural factors.

However, other studies imply that there are no general gender differences concerning the extent to which males and females express acceptance of or faith in paranormal phenomena. For example, Johnson and Pigliucci (2004) compared males' and females' pseudo-scientific ideas and found no apparent gender differences. However, this study also contains content-related issues in which males and females had diverging levels of conviction. Males communicate a pronounced acceptance of the existence of the Loch Ness monster, while females more readily believe that animals can sense ghosts. With regards to giving credance to magnetic healing, telepathy and voodoo, the researchers found no differences to speak of. The authors argue that the content matter is decisive when discussing gender differences and paranormal phenomena. By the same token, Wiseman and Watt (2004) conclude that males and females seem to be superstitions to different degrees, depending on what paranormal area they are asked about. These claims are supported by Shermer (2003), who argues there is no gender difference in the power of belief, only in what phenomena subjects choose to believe in.

Pseudo-scientific beliefs related to knowledge about the human body

Research about students' understanding of the human body and its function has often focused on their understanding of specific concepts or different internal organ systems. But very few studies investigate students' understanding of the relationship between scientific explanations, alternative explanation models and different pseudo-scientific health claims. As mentioned before, studies about these issues are often related to students' general proficiencies, such as their level of education, but they are not specified to a certain area of knowledge, although some studies explore attitudes towards alternative medical treatment methods in health care. Pettersen (2007) studied health science students' and health science teachers' ideas about complementary alternative medical treatments (CAM) and found that none of the treatments which the respondents considered in the study have been empirically explained. The study reveals that the majority of the students have a positive attitude towards 8 of 15 CAM-treatments. For example, more than 70% of the subjects expressed positive attitudes about zone acupuncture and therapeutic touch, but they were less positive to iris- or hair diagnostic, crystal therapy and aura photos.

The study

So far, we have described and discussed different studies with the objective to investigate what pseudo-scientific, paranormal and superstitious ideas people, in general, and students hold. Some of these studies also investigated the relationship between students' scientific knowledge and their pseudo-scientific beliefs, or the relationship between gender and superstition. The image that emerges on the basis of these studies seems to be rather complex, incomplete and, in some cases, even contradictory. For example, there are different understandings concerning to what extent people's pseudo-scientific ideas are related to their knowledge about science. Some scholars (e.g. Sagan, 1995; Wallace, 2000) claim that enhanced knowledge in science could be an antidote towards paranormal beliefs. Others (e.g. Goode, 2002; Shermer, 2003) do not seem to find any relationship between scientific knowledge and paranormal beliefs at all. Even when it comes to the relationship between gender and pseudo-scientific ideas, the image seems to be sprawling or diffused. Some studies (e.g. Preece and Baxter, 2000; Sjödin, 1995) imply an existing gender difference, while others (e.g. Shermer, 2003) claim that such a relationship does not exist.

Hence, the aim of this study is to explore what pseudo-scientific, paranormal and superstitious ideas students in upper-secondary school actually hold and how their ideas are related to their scientific knowledge concerning the human body and health. The study also seeks to investigate if there are any gender or educational differences related to these issues. The research questions in this study are:

- What pseudo-scientific ideas concerning the human body and health do students hold and how do they relate these ideas to scientific explanations?
- In what ways is students' knowledge about the human body and health related to their pseudo-scientific beliefs?
- Are there significant gender differences related to these questions?
- Is it possible to identify differences concerning students' ideas, depending on what educational programme the students study?

Methodological considerations

In order to get a general view of the research questions, as well as a means of attending to the rather complex, incomplete and sometimes contradictory image that emerges from empirical studies in this area, a questionnaire was chosen for the study. This is the first part of a larger project that aims to explore student's epistemological understandings of the relationship between scientific- and non-scientific explanations. As a first data collection, a questionnaire gives an opportunity of mapping a relatively large group of respondents and, above all, it serves to create a stable starting point for further investigations. Further, it makes statistical analysis of the data possible. In this way, the survey functions as one part of a method triangulation in which ethnographical methods such as participating observations and interviews will be included in future phases within the larger study.

The web-based questionnaire referred to in this article was responded by 293 upper-secondary student participants, 175 males and 114 females, aged between 17-19 (mean value 18.4). The total respondent rate was 83.7%. The respondents were not randomly sampled but chosen with the objective of reflecting the general population in Swedish upper-secondary school with reference to educational programme and size of residential area. However, this objective has only partly been fulfilled as random factors have skewed the proportion between boys and girls. This circumstance has to be included in the analysis and the interpretation of the results.
In Sweden there are 17 national educational programmes in upper- secondary school. These programmes consist of primary subjects, character subjects, eligible subjects and project work. All of the national programmes contain the same eight primary subjects (e.g. Swedish, mathematics, history and general science), which means that these subjects are part of all educational programmes. The character subjects are specific, depending on which programme students choose, which means that they can be preparatory for higher studies or a future profession. In this study, the 17 educational programmes were categorised into four main groups depending on the alignment of the education: a theoretical programme (e.g. science, civic programmes), a practical-technical programme (e.g. car engineers or carpenters programmes), and a practical-service programme (e.g. hairdressers or childcare programmes). The fourth group is comprised of those students who do not participate in a national programme but instead choose an individual programme. However, all students have to attend a compulsory science course comprising of 50 hours. On a national basis, about one fifth of the students choose to study the science programme, which offers more extensive courses in biology, chemistry and physics.

In the first part (A) of the questionnaire, the respondents were asked to consider ten different statements concerning pseudo-scientific ideas about the human body, health and different treatments such as that the phases of the moon can affect a person's health or that some people can move objects through telekinesis. The statements in this part were inspired by questions used in earlier studies by Preece and Baxter (2000), Walker et al. (2002), and Johnson and Pigliucci (2004). The students responded to the statements on a four-grade Likert scale, from totally agree (4) to totally disagree (1). This means that a high value for a statement expresses a high student belief in the statement. Part B of the questionnaire consisted of 13 knowledge questions about physiology, health and nutrition. For example, 1) Where in the body is urine produced? 2) In which way

Table 1. Numbers of students in each programme

Programme	Boys	Girls	Unknown	Total
Theoretical	56	33	1	90
Practical (service)	39	67	2	108
Practical (technical)	43	4	1	48
Individual/Special	33	10	0	43
Unknown	4	0	0	4
Total	175	114	4	293

are our thoughts transmitted in the brain? In this part of the questionnaire, the contents, to some extent, were influenced by the TIMSS (2003) and the PISA (2003) studies.

The questions in part B offered multiple-choice options, and sometimes more than one answer was correct in order to decrease the possibility for the respondents to randomly give the right answer. But it is important to remember that the respondents only were asked to consider a limited number of questions about the human body and no complex reasoning was requested. According to Patton (2002), it is actually not possible to get a multifaceted understanding of students' lives, their thoughts and experiences, and what these beliefs mean to them when using quantitative methods and statistical analysis of a questionnaire. In a future phase of the project, other methods such as participating observation and focus groups interviews will be used in order to deepen the understanding of these phenomena.

Analysis

Since the research questions are related to a possible correlation between students' knowledge about the human body and health, and their pseudo-scientific ideas, two different indexes were constructed: Pseudo-Scientific Belief Index (PSBI) and Human Biology Knowledge Index (HBKI). To be able to measure whether the different statements and questions were related to each other, a reliability analysis of homogeneity was carried out. The advantage of carrying out the analysis was the possibility to create a common index that could describe the students' opinion or understanding about the statements, or the questions. The reliability analysis examines the homogeneity or cohesion of the items that comprise each scale. Items with a high internal consistency were then used to construct the two indexes. Values (Cronbach's alpha) between .70 and .90 indicate that the items are strongly related to each other, and values between .60 and .70 indicate that the items are relatively-to-strongly related to each other (Ntoumanis, 2001). The analysis displayed that the Pseudo-Scientific Belief Index (PSBI) had a reliability value of .76 and the Human Biology Knowledge Index (HBKI) had a value of .66.

However, the PSBI consists of the nine items with high internal consistency and was constructed by adding the value of the nine different items (see Table 2). The exception was the statement *Astrology has no impact on what diseases a person gets.* As it is likely that the negation in this statement may have caused some confusion or misunderstanding, it was therefore excluded in the analysis. A low PSBI-value indicates a low confidence in the statements. Hence, the minimum PSBI-value was 9 and the maximum 36. The Human Biology Knowledge Index (HBKI) was constructed in a similar manner. Since all items had a high internal consistence, the HBKI also consists of all 13 items related to scientific knowledge and can take a value of 0-36. The indexes can also be correlated to the background variables, and in that way they contribute to the resolution of the research questions in this study.

In order to compare the two indexes with variables such as gender or educational programme, a one-way ANOVA-test was used. The correlations between the two indexes were calculated through using the correlation coefficient Pearson's r. This analysis aimed to measure the strength of the relationship between the two variables. In other words, it aimed at explaining whether there exists a relationship between students' knowledge about the human body and health and their tendencies to either accept or reject pseudo-scientific statements. The coefficient (Pearson's r) will be 1 if there is a perfect co-variation between the indexes and -1 if the co-variation is the reverse (Djurfeldt, Larsson & Stjärnhagen, 2003). Another method to conduct a deeper analysis of the results is to use a cluster analysis. A cluster analysis is an exploratory data analysis tool which seeks to sort different objects into groups depending on the degree of association between two objects (Statsoft, 2006). In a nutshell, all students' answers are placed in a coordinate system in which the x-axis is the HBKI-value and the y-axis is the PSBI-value. Upon completion, some clusters become visible, which means that some groups of respondents are deemed to answer in a similar way (see Figure 1).

Results

The main intention of this study has been to explore what pseudo-scientific ideas students actually hold regarding the human body and health, and how they relate these ideas to scientific explanations. One way of gaining knowledge about these phenomena has been to investigate students' views about the human body and health, and how they relate these issues to scientific explanations or pseudo-scientific ideas. The results from this part of the questionnaire are presented in Table 2. The table reveals a ranking of how students experience the credibility of the statements. The items are ranked from the item that students believe to be the most plausible to the item that they believe to be the least plausible. The statement with the superior highest mean value is *acupuncture can relieve pain* (3.20), which, consequently, signifies that the students express a rather strong belief in the statement. An explanation for this assertion is that acupuncture is currently an approved pain-relief treatment in the Swedish healthcare system (Socialstyrelsen, 2006). Other statements that obtain relatively high scores are *some people can transfer thoughts* (2.32), and *the phases of the moon can affect a person's health* (2.27). These results are confirmed in Sjödin's (1995) and Preece & Baxter's (2000) studies, in which students distinctly express that they believe that some people can transfer thoughts. The lowest credibility is obtained from statements such as *inflammations can be cured by placing noble crystals on the skin* (1.80), and *it is possible to decide the sex of a foetus by swinging a pendulum above the pregnant woman's body* (1.60).

As mentioned before, Cronbach's alpha coefficient is .76 for these nine items. A low PSBI-value indicates a low confidence in the statements and a low pseudo-scientific belief. The mean PSBI-value for all students was 19.15 (SD 4.58).

In Table 3 the PSBI-value is compared to factors such as gender and students' different educational alignment in upper-secondary school. The PSBI-values in Table 3 point to only small gender differences and the analysis reveals no general significant difference between boys and girls. Only one statement out of nine shows a significant difference between the sexes; girls seem to have higher confidence in acupuncture than boys ($p = .047$), which Johnson and Pigliucci (2004) confirm in their study (a study which failed to find any general gender differences). Statements concerning magnetic bracelets or telepathy did not show any differences at all; however, the authors found a gender gap in declarations about the *Loch Ness Monster* and whether *animals can sense ghosts*. As mentioned earlier, previous studies about gender and belief in pseudo-science and superstition are divergent. On the one hand, Preece and Baxter (2000), as well as Wiseman and

Table 2. Statements, mean score. (n= 293) A high mean value expresses a high student belief in the statement.

Statement	Mean	SD
Acupuncture can relieve pain	3.20	0.86
Some people can transfer thoughts (telepathy)	2.32	0.98
Phases of the moon can affect a person's health	2.27	0.95
Rheumatic pain decreases if carrying a magnetic bracelet	2.16	0.74
Many diseases can be discovered through iris diagnostic	2.14	0.80
Some people can move objects with their mind	1.85	0.92
Some people can heal when putting their hands on the sick	1.84	0.97
Inflammations can be cured by placing noble crystals on the skin	1.80	0.79
It is possible to decide the sex of a foetus by swinging a pendulum above the pregnant woman's body	1.60	0.81
[Astrology has no impact on what diseases a person gets]	2.67	1.23

Watt (2004), claim that females are more inclined than males to acknowledge different pseudo-scientific statements. On the other hand, Shermer's (2003) and Johnson and Pigliucci's (2004) studies do not describe any general gender differences at all. One possible explanation for these alleged gender differences is that some differences are actually present, depending on the explored pseudo-scientific content. Nevertheless, this does not necessarily entail that females generally are more superstitious than males.

Table 3. Mean Pseudo-Scientific Beliefs Index (PSBI) value related to gender and educational program. (Some students have not answered all questions about pseudo-scientific statements.)

Group	Mean	SD	N
Boys	18.88	4.58	128
Girls	19.43	4.23	74
Unknown			4
Theoretical	17.91	3.31	67
Practical (service)	20.12	4.83	66
Practical (technical)	19.33	5.50	36
Individual/Special	19.21	4.92	34
Unknown			3
Total	19.15	4.58	206

Table 3 also displays an explicit difference in PSBI-value depending on what educational programme the students take. Students in theoretical programmes have a lower mean PSBI-value compared to students in other programmes. Further, the analysis reveals a correlation between educational alignment and PSBI-value (p = .04). In short, students who attend theoretical programmes in upper-secondary school, in comparison to students of other programmes, tend to disregard pseudo-scientific statements. It is also apparent that the results of the respondents studying practical programmes show a larger statistical spread and a higher standard deviation compared to the results of students from theoretical programmes.

One important question thus far is if these differences can be explained by the fact that students in theoretical programmes actually have a more extensive or a deeper knowledge about the human body and health than the other students, or are there other phenomena that can explain the results? In order to answer this question, a *Human Biology Knowledge Index (HBKI)* was constructed in the same way as the PSBI. As mentioned previously, all 13 items have a relatively high internal consistence (Cronbach's alpha is .66) and were therefore included in the HBKI. The maximum value of the HBKI is 36, and the mean value for all students is 13.53 (SD 6.55).

The HBKI-value, which can be seen in Table 4, was correlated to the factors of gender and the students' different educational alignments in upper-secondary school. The results indicate that girls have a slightly higher mean HBKI-value than boys, but the difference is small and not significant (p = .26). It is also clear that theoretical programmes in secondary schools seem to succeed in supporting students' knowledge development about the human biology and health better than other programmes. The analysis reveals a correlation with high significance between educational programmes and the HBKI (p = .005). In this study, this indicates that students in theoretical programmes have significantly better knowledge about the human body and health than students in other programmes.

Table 4. Mean Human Biology Knowledge Index (HBKI) value related to gender and educational program

Group	Mean	SD	N
Boys	12.99	6.44	175
Girls	14.35	6.71	114
Unknown			4
Theoretical programme	17.62	6.80	90
Practical pr (service)	12.32	5.42	108
Practical pr (technical)	11.83	6.41	48
Individual/Special pr	10.35	4.56	43
Unknown			4
Total	13.53	6.55	293

The successive emerging image of students' pseudo-scientific ideas about the human body and health has, so far, indicates small gender differences. At the same time, the analysis reveals significant differences depending on the particular educational programme the students attend. Students in theoretical programmes seem to exhibit less credence in pseudo-scientific statements and more knowledge about the human body and health than other students. The question is if this means that the better scientific knowledge students have, the lower confidence they have in pseudo-scientific statements. In other words, are these two phenomena related to each other, and, if so, are they related by cause? In order to answer particular questions, it was necessary to conduct an additional analysis. It was then of current interest to relate the PSBI and HBKI to the number of science courses the students had taken in upper-secondary school. The results of this analysis are presented in Table 5 and reveal that the more science courses the students have studied, the higher mean HBKI-value the students hold. This result is unsurprising, as one can assume that students who have taken more courses in science have superior or more developed knowledge of the subject.

Table 5. Mean HBKI and PSBI score related to number of studied science courses in upper secondary school.

Nr of science courses	Mean HBKI	SD	Mean PSBI	SD	n
0-1	11.39	5.28	16.36	4.68	179
2	13.03	5.51	16.76	3.65	33
3	15.69	5.79	14.10	2.88	17
4-7	17.27	7.65	15.13	3.91	64

But Table 5 also reveals that the relationship between the number of science courses and the mean PSBI seems to be more complex. The group of students that has attended at least four science courses does not have the lowest mean PSBI; rather, the group that has taken three science courses holds the lowest PSBI value. However, this group of students is relatively small (n=17) and therefore further analysis was necessary. Instead, a comparison between a group of students that have taken only one science course (the compulsory course) and those who have attended at least two courses was conducted. This analysis revealed no significant difference ($p = .17$) between the groups, and it is not possible to discover any general differences between those students that have taken one science course and those who have taken two or more courses. A similar image appears if a bivariate analysis of the relation between the PSBI and HBKI is undertaken. This analysis endeavours to measure the strength of the relationship between the two variables. In other words, it attempts to explain if there is a relationship between students' knowledge about the human body and health and their tendency to either accept or reject pseudo-scientific statements. The analysis clarifies that there is no existing correlation between PSBI and HBKI and that the Pearson's r was – .09. A value close to zero reveals a lack of a relationship between the variables (Field, 2005).

But the image of how students relate to pseudo-scientific statements seems to be even more complex. A comparison between those students who have attended at least three science courses and those who have taken only one or two reveals significant differences ($p = .02$). The analysis indicates clearly that students who have taken three or more science courses have a lower mean

PSBI-value than the other students. However, it is not possible within this study to find any simple explanation as to why such apparent differences exist. A conceivable explanation or hypothesis could be that students that have attended three or more courses take part exclusively in the science programme in upper-secondary school. This could mean that they, to a greater extent than others, are socialized into a scientific worldview and therefore tend to discount the pseudo-scientific statements. However, another possible explanation is that students that are quite sceptical of pseudo-scientific statements choose studying science in upper-secondary school. The relationship between students' knowledge in science and their ideas about pseudo-science is still not fully explained and more research is needed. One possible method of conducting a deeper analysis of the results is to use a cluster analysis. This method revealed a distinct divergence between the clusters when using a six-group cluster. The results of this analysis are presented in Figure 1.

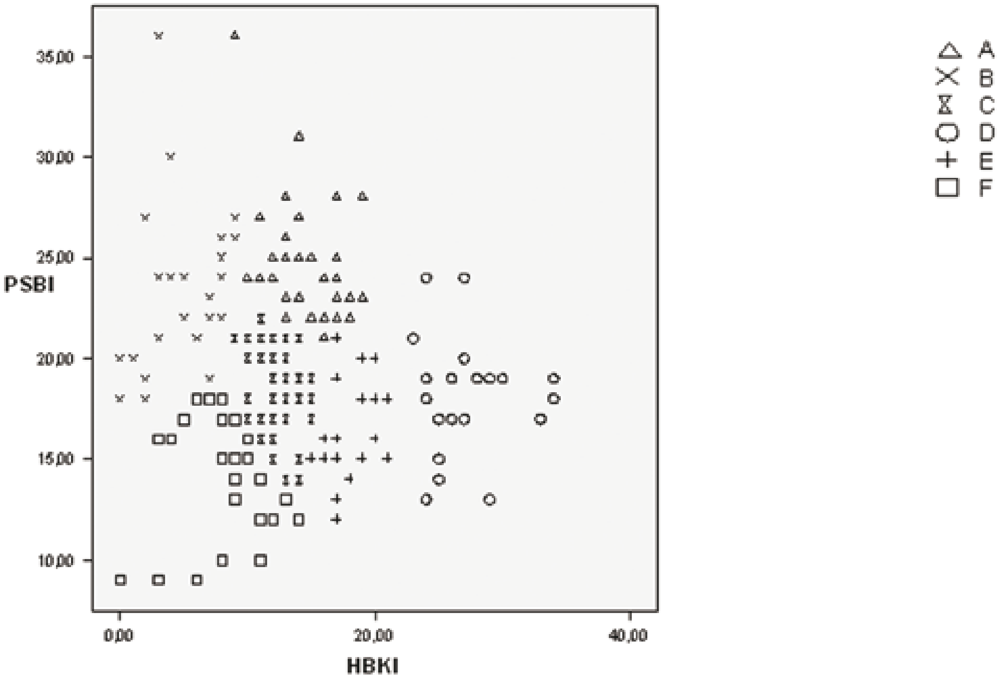

Figure 1. Cluster analysis by case

As seen in Figure 1, clusters A and B consist of students who show the highest PSBI-value and thus tend to discount the pseudo-scientific statements more than other students. The difference between these two clusters is that the students in cluster A are just beyond the mean HBKI-value whereas the students in cluster B have a very low HBKI-value. This also indicates that students in cluster B have less knowledge about the human body and health than students in other clusters. When investigating the respondents in cluster A and B, it became obvious that they to a high extent, attend the practical alignments and that students from the theoretical alignments are under represented in these clusters. Cluster A mainly consists of male and female students from the practical service alignment, which traditionally attracts females; cluster B is comprised of students from the practical technical alignment. However, there are no obvious gender differences between clusters A and B. Cluster C consists of students who attend both the practical and theoretical alignments, and it is close to the mean value of both indexes. In Table 6 the cluster centres are related to the mean PSBI- and HBKI-values.

Table 6. Cluster centres related to PSBI and HBKI.
HBKI mean for all students = 13.52
Cluster A: Students with high PSBI and mean HBKI
Cluster B: Students with high PSBI and very low HBKI
Cluster C: Students with mean PSBI and mean HBKI
Cluster D: Students with mean PSBI and very high HBKI
Cluster E: Students with mean PSBI and high HBKI
Cluster F: Students with low PSBI and low HBKI
(Two students are missing in the cluster analysis)

Cluster	A	B	C	D	E	F
n	37	20	30	24	46	47
PSBI mean	24.51	23.50	18.52	18.10	17.13	13.87
HBKI mean	14.59	4.96	12.39	27.20	18.17	8.30

The students in cluster D have the highest HBKI-value, which means that they scored the highest result on the knowledge test. At the same time, the PSBI-value of these students is close to the mean value. In this cluster female students attending the theoretical alignments and students who have taken three or more science courses are over represented. This group consists of 60% girls, despite the fact that the whole sample in the study only consists of 36.3% girls, which means that girls are clearly over represented in this cluster. It is possible to claim that the students in this cluster embody the lack of relationship between students' knowledge about the human body and health and their tendency to accept or reject pseudo-scientific statements. This also seems to be valid for students in cluster E, in which the students have a score close to the mean PSBI-value and a high HBKI-value. Compared to the students in cluster D, they have a slightly lower PSBI-value and a significantly lower HBKI-value. Cluster E consists of female and male students from the theoretical alignments, and they have attended a varying number of science courses. The last cluster consists of students who in total have the lowest PSBI-value. This means that students in cluster F, to a greater extent than others, tend to disagree with the pseudo-scientific statements. At the same time, the students in this cluster obtain a low HBKI-value. An investigation of the students in this cluster reveals that it consists of male and female students from different educational alignments. However, students who have taken only one science course are over represented.

As a whole, the cluster analysis has made some patterns explicit concerning students' ideas about pseudo-scientific statements. At the same time, the analysis raises a number of questions. For example, why is the relationship between students' knowledge about the human body and health and the tendency to disagree with pseudo-scientific statements indistinct and divergent in different clusters? Are there any differences in how students in the different clusters relate pseudo-scientific statements to scientific explanations, and, if so, are they possible to explain?

Discussion

The results demonstrate a rather complex image of how upper- secondary students in Sweden relate to pseudo-scientific statements concerning the human body and health. The first analysis revealed that students express a higher confidence in statements about acupuncture, telepathy and that the phases of the moon can affect a person's health in comparison to statements concerning pendulums and crystal nobles. This result is, to some extent, confirmed by Sjödin (1995), who shows a general tendency among people to believe that some individuals are able to contact spirits, tell the future and read other people's thoughts. With regards to gender, it is not possible to find any significant differences in the power of belief between the sexes, which is also confirmed in studies of Johnson and Pigliucci (2004) and Shermer (2003). But according to Wiseman and Watt (2004), there seems to be some gender differences related to what type of phenomena males and females choose to believe in. In this study only one statement revealed a significant gender difference: girls communicated a higher confidence in the statement *acupuncture can relieve pain*.

When it comes to the relationship between students' knowledge about the human body and health and their tendency to either agree or disagree with pseudo-scientific statements, it is not possible to find any clear and unambiguous correlation. However, students that attend theoretical alignments tend to express lower confidence in the pseudo-scientific statements than students in the practical alignment. Furthermore, they scored higher on the human body and health knowledge test than students in practical alignments. These results are significant in this study. However, does this mean that the more scientific knowledge students have, the lower the confidence in the pseudo-scientific statements they express? In other words, are these factors related to each other by cause? The analysis, which compared the students' knowledge about the human body and health and their opinions concerning the pseudo-scientific statements, showed no such correlation. This means that it is not possible from the results in this study to claim that the greater the knowledge about the human body and health students express, the less they believe in pseudo-scientific statements or non-scientific explanations. This is also true when it comes to the correlation between the numbers of science courses the students have attended and their opinions about pseudo-scientific statements. Only when those students who have attended three or more science courses were compared to those who did not was there a significant correlation.

Miller's (1987) and Sagan's (1995) claim that science education may function as a protection or a cure against superstition and pseudo-scientific beliefs appears to be simplified. The results, instead, support the contention made by Shermer (2003), who points to the lack of correlation between students' science knowledge and scepticism about pseudo-science. But an important question related to these results is how it is possible to be a rather successful student in the science classroom and at the same time express a high confidence in pseudo-scientific and non-science explanations. Is there not an incompatible contradiction in these two different epistemological explanations of the world? Or is it possible to hold parallel conceptions and explanation models in different contexts or discourses, such as schools and different youth sub-cultures? It is, of course, not possible to answer these questions in this study; nevertheless, the analysis has made these questions explicit.

One attempt to address this type of reasoning has been to conduct a cluster analysis. The results from this analysis indicate, for example, that it is possible for students (cluster D) to score very high on the knowledge test and simultaneously express a rather high confidence in pseudo-scientific explanations. In this cluster, girls in the theoretical alignments who have attended three or more science courses are over represented. But it is also possible for students to express a critical or even a negative view about pseudo-scientific statements and at the same time score low or very low on the knowledge test. In this cluster (F), students who have attended only the compulsory science course are over represented. Another interesting cluster is cluster A, which contains students that express the highest confidence in pseudo-scientific statements, but at the same time score above the mean value on the knowledge test. The existence of this cluster is confirmed by the assertion of Ryan et al. (2004) and Walker, Hoekstra, & Vogl (2002) and again raises the question if science education today actually succeeds in developing a critical and scientific understanding. To be able to answer this question and the questions about the existence of students' parallel conceptions, further research in the field is needed.

The results in this study indicate that it is possible to be a rather successful student in the science classroom and at the same time maintain a high confidence in pseudo-scientific and non-science explanations. Therefore, a possible implication of the results is to recommend that science educators discuss pseudo-scientific issues in relation to science with their students henceforth. This study, in addition to Shermer's (2003), points to the lack of correlation between students' science knowledge and scepticism towards pseudo-science and non-science statements. This implies that if students were to examine pseudo-scientific explanation models, as opposed to ignoring them, such an approach would likely provide possibilities to enhance their critical thinking and would create opportunities to explore and develop an understanding of the nature of science.

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