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Students' Views and Attitudes Towards the Communication Code Used in Press Articles About Science

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The present research was designed to investigate the reaction of secondary school students to the communication code that the press uses in science articles: it attempts to trace which communication techniques can be of potential use in science education. The sample of the research consists of 351 secondary school students. The research instrument is a questionnaire, which attempts to trace students' preferences regarding newspaper science articles, to explore students' attitudes towards the science articles published in the press and to investigate students' reactions towards four newspaper science articles. These articles deal with different aspects of science and reflect different communication strategies. The results of the research reveal that secondary school students view the communication codes used in press science articles as being more interesting and comprehensible than those of their science textbooks. Predominantly, they do not select science articles that present their data in a scientific way (diagrams and abstract graphs). On the contrary, they do select science articles and passages in them, which use an emotional/'poetic' language with a lot of metaphors and analogies to introduce complex science concepts. It also seems that the narrative elements found in popularized science articles attract students' interest and motivate them towards further reading.

Introduction

The present article investigates the possible interaction of formal and informal learning in science education. The paper is focused on how much and in what way press science articles could interact with formal education. Specifically, this research uses press science articles as a means to reveal the communication codes that seem to be effective for students' science learning. Thus, it suggests alternative and complementary pathways to formal science education.

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While many researchers are involved in studying the learning of science through formal education, only few of them have pointed out the role played by informal sources in shaping the public's understanding of science. Nowadays, this role seems to be quite crucial, since learning in science can result from a synthesis of many different sources all around us. All informal sources that have been designed to promote the understanding of science appear in a great variety of contexts and through an increased number of media, such as television, newspapers, magazines, books, museums, planetariums, construction toys, the Internet, and so on (Collins & Bodmer, 1986; Kariotoglou & Papasotiriou, 1999; Wellington, 1991).

The way these informal sources influence students' understanding of scientific ideas has been investigated by some researchers. Sometimes, the research leads to quite opposite results regarding the effect each one of these informal sources has on students' science learning. Thus, as Gunter et al. (1998) reported in their research on how students learn about biotechnology, one third of 16-year-old to 19-year-old students reported print media as a personal source of information. On the other hand, as Jarman and McClune (2002) indicate, 'pupils were more likely to refer to television or internet than to the written word as a source of out-of-school science information'. But, despite the question of which one of these sources is the most attractive or the most powerful in the way students approach science, all of the aforementioned research underlines the fact that students gain a great deal of their overall science knowledge through non-formal sources of learning. This non-formal science knowledge comes to students either directly from informal sources or it comes to them indirectly through their teachers or through their parents, their friends and their relatives, who are influenced by these informal sources (Halkia, 2003).

The Greek science curriculum demands the quick processing of a large amount of content, leaving very little freedom to teachers to use other sources apart from the provided science textbook in their everyday practice. However, teachers' own scientific awareness can often be influenced by informal sources of scientific knowledge. As recent research has pointed out, science teachers declare that press science articles are a main source for their self-education in science issues (Halkia, 2003). They also seem to believe that press science articles are a reliable source of scientific information. That is why contemporary Greek science teachers make use of the material found in such informal sources either by designing relevant educational material based on such sources or by encouraging their students to utilize such material in their science homework. Thus, daily more and more pictures, information, data, and so on, from informal sources make their way into Greek classrooms (Halkia, 2003), as:

> science teachers are always looking for new Motivations and Demonstrations, new ways to make science real, immediate, and interesting to students. (Lemke, 1990, p. 155)

The Role of 'Press Science' in Promoting Scientific Literacy

Scholars, research centers and science educators from all over the world have repeatedly warned that the public's scientific literacy is remarkably low (Physics on Stage

Project Description, 1999, p. 2). One way of defining scientific literacy is the ability of the public to understand science reports and discussions that appear in the popular media (DeBoer, 2000). As a result of this lack of scientific literacy, many people are not able to participate in public discourse about science matters.

The significance of science knowledge coming from informal sources is that it usually deals with contemporary science issues, or with science issues that affect people's everyday lives. Maybe that is one of the main reasons why it seems more meaningful to people than the knowledge coming from formal education. This kind of knowledge contributes decisively to shaping the public's attitude towards science (Schibeci, 1989), while at the same time it also largely contributes to creating 'citizen science', a 'science which relates in reflexive ways to the concerns, interests and activities of citizens as they go about their everyday business' (Jenkins, 1999, p. 704). In many cases, it seems that formal education that deals with 'school science' is not aligned with the interests and needs of the general public. Thus, the problem faced by formal science education is that 'citizen science' often is not compatible with 'school science' (Halkia, 2003; Hutton, 1996; Wellington, 1991).

In Greece, as well as in other countries, research on the student population, reveals that students characterize physics as one of the most difficult and less attractive subjects of secondary school programs of study (Halkia & Karanicas, 1999). But at the same time an increased interest in science matters is being manifested by the public. This is reflected in the high frequency with which science subjects are covered in the pages of newspapers and magazines (Koulaidis, 2000). Indeed, lately, newspapers have developed special insets dedicated to science, which are largely addressed to students and teachers. These science articles and insets seem to elicit a large response from their readers, as is inferred from the frequency with which they are published. This might be an indication that the press has developed a successful science communication code with the public (Lewenstein, 1992). The code in question seems to be acceptable to most people's cognitive schemata, since people are neither accustomed to, nor easily accept, the strict formalistic code of science researchers (Halkia, 2003).

Among the great variety of informal sources, it is now widely recognized that 'press science' promotes scientific literacy in society (Koulaidis, 2000). The science topics covered by the press articles seem successfully to address people's special interests. This kind of informal science education has proved to be flexible in addressing different groups of people with special interests. In that way, each citizen has the opportunity to construct a body of science knowledge adapted to his/her own needs, which will enable him/her to cope with his/her everyday problems (Jenkins, 1999). In addition to that, the science knowledge presented in the press seems to utilize a very attractive communication code, which is easily accepted by the readers. This is done either by those professionals (science researchers or specialized science journalists) who usually have a deep knowledge in a particular field of science and the ability to popularize complex science matters, providing 'educational and interpretative opportunities for the general public to better familiarize itself with science', or by those journalists who usually report science as 'news' and write about science in a superficial way (Laugksch, 2000).

The decisive role of those professionals who were able to reveal to the public the secret beauty of science, creating an overall positive attitude towards science, has been traced as recently as the 1960s. Thus, great science fiction authors (such as Isaac Asimov), as well as renowned 'popularizers' of science (such as Richard Dawkins, Paul Davies and Stephen Hawkins), are largely responsible for building the public's awareness of science, as contrasted to the rather limited contribution provided in this direction by the formal science education taught in schools (Fensham, 1999). Nowadays, professionals of this kind write popular science articles in magazines and newspapers aiming to inform the public about the latest achievements of science or to popularize complex science theories.

Differences Between 'Press Science' and 'School Science'

The two approaches of science education represented by 'press science' and by 'school science' do not follow similar routes in the process of science learning and they do not share the same aims. Press science on one hand and formal science on the other may both serve as 'intermediaries' between scientists and the public (Wellington, 1991). However, although each of these two media contributes in its own way to the public understanding of science, they are characterized by completely different methodological tools and contrasting modes of interaction with their receivers. Press science functions in a context of free choice where the receiver is personally attracted by an article and chooses to read it, while formal school science is addressed to the student in a context of compulsory requirements (Wellington, 1991). Thus, press science presents an extensive variety of attractive, but incidental scientific issues that are barely confined by rules of systematic approach and inter-article consistency, while formal school science is usually shaped around a carefully structured, strict curriculum (Halkia, 2003). In addition, press science usually adopts a narrative style to present a science story, which seems to be very effective with students, while formal science education prefers to avoid such attempts and confines itself to a formalistic code, which is usually unfriendly to students (Carson, 2002).

Lemke (1990, p. 155) argues that the curriculum begins from the needs of the practicing research scientists; it organizes, presents and teaches science from their extremely specialized viewpoint. Maybe for that reason the scientific language is 'expository' or 'analytical' most of the time. It is used to express relationships of classification, taxonomy, and logical connections among abstract or generalized terms and processes (Lemke, 1990, p. 158). It is also characterized by high levels of nominalization, technical language (Parkinson & Adendorff, 2004), interlocking definitions, special expressions, syntactic ambiguity and semantic discontinuity (Halliday, 1993, p. 71), much formalistic mathematics, and generally speaking by a formalistic style. In addition, as Martin (1993, p. 172) points out, scientific language both compacts and changes the nature of everyday words.

On the other hand, narrative language expresses relationships of time, place, manner and action among specific, real or fictional persons and events, and seems to

be used more to deal with specific and concrete relations than does the language of theoretical science (Lemke, 1990, p. 158; Parkinson & Adendorf, 2004) and, according to Martin (1993, pp. 199–200), none of the terms used in narrative styles is defined, although their relative meaning in the text can be deduced from the time-line of the story. Narratives lack the strict formalistic code of scientific language. Many science popularizers, in their attempt to reveal the hidden beauty of our world to the public, use this genre: a 'sentimental language' (Guirand, 1989), which has many metaphors and analogies, and which is able to convey the mental enjoyment that the representations of microcosm and macrocosm cause (Feynman, 1994, Treagust 2000). But most important for learning is students' familiarity with the conventions of narrative or story-telling. Perhaps for that reason, teachers also use narratives in telling anecdotes, stories, and jokes, and sometimes to produce extended analogies (Lemke, 1990, pp. 108–109).

Analogies and metaphors are cognitive mechanisms that provide a means of understanding the structure of unfamiliar conceptual domains by setting up a simple correspondence between them (Christidou & Koulaidis, 2001b; Lemke, 1990, p. 117). These domains may refer to different thematic items, but have the same semantic relations between them. One domain should be already familiar, while the other one is the target domain, which is unfamiliar to the student — and it is this target domain that the analogy (or metaphor) aims to explain (Christidou & Koulaidis, 2001b). Students have learnt to transfer semantic relationships from the familiar thematic items and their patterns to the unfamiliar items and their patterns (Lemke, 1990, p. 117). Thus, analogies and metaphors function as tools of thought. Metaphors constitute an important explanatory tool in the case of scientific knowledge. Metaphorical language provides a useful and flexible mechanism for describing physical entities and phenomena (Christidou & Koulaidis, 2001a). People use them spontaneously in their discussions of natural phenomena, in order to structure unfamiliar knowledge domains (Christidou & Koulaidis, 2001b).

According to research conducted by Christidou et al. (2004), 'active, creative metaphors' are used by the Greek press and popularized scientific magazines in science articles. The question is whether the students feel that the presented way of writing science is more familiar to them.

The Research

The Research Questions

The present research was designed to investigate the reaction of Greek secondary education students to the communication code that the press uses in science articles: it attempts to trace which communication techniques can be of potential use in science education, as well as students' attitudes towards the science articles published in the press.

Specifically, an attempt has been made at answering the following questions:

- On what extent and why do students appreciate science articles found in the press media?
- For what reasons do students choose to read a specific article?
- Which elements of science articles attract students' attention?

The Sample

The target population is that of Greek secondary students. The sampling method used is the stratified cluster random sampling. The sample comes from 12 randomly selected secondary schools of the broader region of Athens (Attica). The schools were representative of different socioeconomic levels: the district of Athens was divided into six major regions, each representative of the socioeconomic status of their inhabitants. Within these regions one school was randomly selected, and within these schools a class of about 25 students (aged 15–17) was randomly selected.

All schools selected were secondary (high) schools for general education in which students were prepared for their entrance to universities. Upper secondary schools in Greece are either academically oriented, demanding skill in the use of language, and called 'Integrated Lyceums', or are vocationally oriented and called 'Technical Lyceums'. For that reason, the overwhelming majority of students attending 'Integrated Lyceums' are not immigrants. Greek is the first language for the majority of their student population, while the immigrants attending them do speak Greek fluently. Thus, the majority of immigrant students studying in high schools prefer to attend 'Technical Lyceums' because of the language problem. The total sample of the present research consists of 351 secondary school ('Integrated Lyceums') students.

The Instrument

The research instrument is a questionnaire consisting of four parts:

- The first part (A) collects demographic data.
- The second part (B), consisting of nine items, traces the students' habits and responses in reading press science articles (whether they read newspapers and magazines, the kind of articles they choose to read, the kind of elements that attract their attention and interest in articles etc.).
- The third part (C), consisting of three items, explores students' attitudes towards the science and technology articles that are published in the press in comparison with corresponding issues in their science textbooks (whether the knowledge presented in these articles is comprehensible, interesting, attractive, etc.).
- The fourth part (D) analyzes students' responses to an experimental treatment: four articles, published on the same day (Sunday) in Greek national broadsheet newspapers with a large circulation, have been presented to students. Students were asked to (appendix 1):

1. choose and read an article among those four newspaper science articles that refers to different aspects of science and technology and utilizes different communication techniques;
2. explain the reasons for their choice; and
3. choose the article's section (a paragraph or a picture or both) that impressed them most.

(The two last questions of part (D) are open-ended questions.)

The four articles were selected according to the following criteria:

1. The articles were circulated on the same day.
2. The articles referred to current issues.
3. The articles were published in major national broadsheet Sunday newspapers (Sunday newspapers were preferred because a lot of people read them).
4. The articles contain reliable knowledge (three of the articles were written by scientists and the fourth one was written by a journalist).
5. The articles cover diverse subjects.
6. The articles cover a wide range of difficulty in offered knowledge.
7. The articles include several teaching tools (e.g. models, metaphors, analogies etc.).
8. The articles differ in the way their writers addressed the public: using formal scientific code, with scientific terminology, graphs, and so on, or informal (popularized) scientific code, with a narrative style of writing.

The articles we are referring to are briefly the following:

(a) 'How an Earth catastrophe can be avoided, in view of a possible collision with an asteroid or a comet' (astronomy). A scientist, who often writes popular articles for the press, wrote this specific article. He adopts a communication code, characterized by common stereotypes of an outside danger threatening the earth. The article contains a lot of information simulating a possible disaster, accompanied by evocative pictures.

(b) 'The rapid change of climate and how it affects Greece' (environment). Similarly, a scientist wrote this article. The article adopts a popularized scientific code, which, however, is strictly limited to the presentation of facts and data. It contains a lot of scientific information and is accompanied by many abstract graphs.

(c) 'Robotics: In a few years time robots will replace unskilled workers' (technology). This time, a journalist signed the specific article. She adopts a journalistic presentation, containing attractive but trivial information with social references. It is accompanied by a lot of descriptive photographs.

(d) 'Strings, the music of the universe' (physics theories). An eminent scientist is the writer of this article. He attempts a conscious popularization of a difficult subject, using a lot of analogies, metaphors and scientific models. The article is accompanied by evocative pictures.

The Administration of the Questionnaire

Postgraduate students, trained to administer questionnaires, conducted the research. The completion of the questionnaire lasted 1 hour. The procedure had four stages.

- In the first stage of the research process, the questionnaire was introduced to the research subjects by telling them that its main aim was to answer a question raised within the scientific community. The question was whether press science articles affect science education or not. To obtain a clear answer, we were addressing the people qualified to know; that is, the students themselves. The selected articles were presented to students. The students had the opportunity to examine them.
- In the second stage, each student took the questionnaire and answered the quantitative questions (part A, part B, and part C of the questionnaire).
- In the third stage, each student chose the article he/she wanted to read and answered the qualitative questions D1 and D2 (appendix 1: part D of the questionnaire).
- In the fourth stage, each student took one photocopy of the pre-selected article and read it. After that, he/she chose a paragraph or a picture or both and then answered the qualitative questions D3 (appendix 1: part D of the questionnaire).

The Way Data Were Analyzed

The students' responses were collected mainly using Likert-scale items and items ranking in order of importance. The quantitative parts (part A, part B and part C) of the questionnaire were analyzed with the SPSS program. Their frequencies were mainly recorded and the possible statistical semantic differences between several subgroups were investigated. For the fourth part's responses, a content analysis was conducted.

In order to carry out the content analysis of students' answers, suitable categories for sorting responses should be identified. A panel of judges (three researchers/experts in science education) agreed on the basic 'themes' of each article's paragraphs and the characterization of the pictures as evocative, descriptive and mental.

Evocative pictures (without indispensable relation to the text) function as 'decorative' elements (Levin et al. 1987) aiming to create mental 'scenery' or 'atmosphere'. This in not necessarily a negative function, since frequently a reader on seeing a picture is being introduced to the 'atmosphere' of the subject.

Descriptive pictures represent elements of the real world that are mentioned in the text. Levin et al. (1987) argue that the function of these pictures is a representative one. There is a correspondence between the picture and the text, and they are in use where the visual dimension functions instructively (Halkia & Theodoridis, 2002).

Mental pictures, organize the information and direct the recipient either with the assistance of visual elements/symbols (chronic codes, shading, small arrows and dots, vectors, etc.) or with the assistance of symbolic representations of a phenomenon

(graphs, conceptual maps, charts, diagrams, circuits, tables, model simultations, graphical representations, etc.), toward a comprehension of the way a particular phenomenon occurs. Thus, they help students to create a solid cognitive structure of the subject under study.

The paragraphs of each article were numbered. That makes it possible to trace the basic 'themes' included in them, to which individual students respond. Thus, the basic 'themes' were listed and each student choice was checked.

The quantitative parts of the questionnaire helped the researchers to select general data about students' habits and attitudes toward science. The fourth part (part D), the qualitative part of the questionnaire, is the most important for the researchers, because it detects the elements of an article that attract students' interest. For that reason, the results of parts A, B and C are presented in brief.

Results

The main results of the research are the following.

Part A of the Questionnaire: Demographic data

- The gender of participant students: in the sample there are 167 boys (47.6%) and 184 girls (52.4%).
- The age of the participant students: 15–17 years old.
- The school district: districts of different socioeconomic status.

Part B of the Questionnaire: Do students read science articles?

- Most students do not read newspapers regularly (every day, 16.5%; every Sunday, 25.1%; rarely, 40.7%; and never, 17.7%), but the great majority of them read magazines (91.5%). They choose to read magazines, which cover a wide variety of subjects and topics and are accompanied by many impressive photographs. Thus, in the list of 10 magazines, which include science subjects, exclusively or partially, 59.5% of students prefers to read (first) youth magazines, 38.5% of them (second) the 'National Geographic' (Greek translation), while only 7.7% of them read (seventh) the 'Physical World' (Edition of the Union of Greek Physicists for students).
- For boys, science is one of the most favored subjects they choose to read (second among nine), while for girls is one of the least favored subjects (seventh among nine). The first preference for boys is sports, while for girls it is cultural and social events.
- Most students are mainly attracted by a science article's title and its accompanying pictures.
- Between the very many science areas covered by the press, students seem to prefer those connected with contemporary technological discoveries and computers. They are also attracted by the subjects referring to cosmology and astronomy.

Part C of the Questionnaire: Press science or school science?

Students believe that the science issues met in press articles, in comparison with the corresponding ones found in their science textbooks:

- contain more interesting and attractive information (agree, 68.9%; disagree, 6.3%);
- are more comprehensible (agree, 51.3%; disagree, 21.9%); and
- contain more contemporary knowledge (agree, 66.1%; disagree, 9.1%).

The high percentage (~25%) of students who chose not to answer is probably due to the fact that these students do not read press science articles regularly.

Part D of the Questionnaire: Which press science article and why?

The content analysis of students' responses to the fourth part of the questionnaire (concerning their choice and reading of the specific newspaper science articles) revealed the following.

Which science article do students choose to read?. The sample students chose to read the science articles as presented in Table 1.

One first remark about the distributions in Table 1 shows that students do not prefer to read articles written in a scientific language, such as 'The rapid change of climate …' (with diagrams, graphs, conceptual maps), despite the fact that the specific article refers to phenomena affecting people's lives (environment). The majority of students prefer to read articles that present provocative ('How an earth catastrophe …', or 'Robotics: In few years time …') scientific issues in a popularized manner with a lot of narrative elements. It seems that the articles they like most resemble the issues found in science fiction. Perhaps that is the reason why they prefer to read articles written mainly by journalists or by scientists who simulate (mimic) the way journalists present the facts. In a similar research addressed to teachers the results were quite opposite: teachers prefer to read articles written primarily by scientists. Particularly, the majority of the secondary school science teachers prefer to read articles that either use a scientific language and refer to phenomena affecting people's lives (environment) or present a complex theory in a simple manner (physics theory) (Halkia, 2003).

Table 1. Gender differences in choosing science articles

Students	Astronomy: 'How an Earth catastrophe …'	Environment: 'The rapid change of climate …'	Technology: 'Robotics: In a few years time …'	Physics theory: 'Strings, the music of the universe'
Boys	44%	7%	32%	14%
Girls	51%	8%	18%	15%

Content analysis on the open-ended questions revealed no significant differences between boys and girls. Therefore, for reasons of conciseness, these answers (tables 2 and 3) are being reported as representing one single group of students (adding boys and girls together). In the following, only answers that elicited frequencies higher than 8% are reported.

Why do students choose each particular science article?. The common reasons for the students' choice, as they emerge from their answers, are presented in Table 2.

Reading the aforementioned data (Table 2), some interesting points came out. First, students are attracted by the thrilling element of a coming danger, which threatens people's lives. Second, they are attracted by the article's title and subject, which is consistent with Jarman and McClune's (2002) point of view that 'articles eye-catching headlines piqued pupils interest'. Furthermore, the present research indicates that the articles' illustration strongly affects students' choice. Third, an interesting point that comes out is that some students choose to read a press science article for their self-education. In addition, some students choose to read articles relating to their interests, which mainly include issues related to technology.

What part of the articles, do they personally like most?. The content analysis of each suggested paragraph or passage that the students personally liked reveals some common features, which are presented in table 3.

These data (Table 3) reveal that primarily the students appreciate the use of 'didactic tools' (analogies, metaphors and simulations) found in the particular science articles, which enable them to understand the underlying science concepts presented in the text. They are also strongly attracted by the pictures (mostly evocative) accompanying the specific articles, while it seems that the element of danger motivates their interest and makes the article's content meaningful to them. In addition, they appear to be quite impressed by the scientists' activities, which these articles represent.

Comments

Press science articles have been recognized as a prime medium for the continued science education of non-scientists (Korpan et al., 1997; Phillips & Norris, 1999). In

Table 2. Reasons for choosing an article

	Reason	%
1	Fear/concern about coming *danger* (collision of earth with a meteorite/ comet, rapid change of climate, robots replace human beings)	48.8
2	Article with fascinating title – subtitle (*key phrase*)	34
3	*Subject* (Interesting — up to date)	33
4	Article *illustration* (mostly evocative pictures)	27.4
5	For their personal reading and *self-education*	14
6	Attitude towards *technology* (mostly positive)	8.3

Table 3. Parts of articles liked most

	Part of the article that I personally like most	%
1	Didactic tools: use of *analogies*, *metaphors*, *simulations* for space–time, strings, greenhouse effect, earth's possible disasters (26.8%).	36.9
2	Article *illustration:* (a) evocative pictures (23.2%) (b) descriptive pictures (10.7%) (c) mental pictures: conceptual maps and/or graphs (1.8%)	35.7
3	Data confirming high probability of coming *danger* for human life, or society's structure, due to: (a) the earth's collision with a comet or a meteorite (17.2%), (b) the degradation of natural resources (7.1%), (c) human beings' replacement by robots (9.2%)	33.6
4	Scientists' views and activities: (a) views for the inner structure of matter (b) prediction and prevention of coming dangers (c) construction of robots which replace human beings	25.9
5	Technological issues (social and philosophical dimensions)	11.3
6	Scientific *models* (weather prediction, greenhouse effect, atomic structure)	9.8

this work it is shown that press science articles could be of value in formal education as well.

First, this research shows that Greek students are in contact somehow with the press (newspapers or magazines). A large proportion of students claim to be regular readers of newspapers (42%), while the great majority of them (91.5%) declare themselves to be regular readers of magazines. Of course, we should point out that these magazines are not exclusively focused on science. They are all youth magazines, which either cover a wide range of topics or specialize in subjects like computers, science fiction, and so on. But, all of them almost always include some popularized issues on science. The reason for the students' preference for these kinds of magazines might be that the kind of subjects presented in them and the communication code used in the chosen articles are adapted to the interests and needs of young people. At the same time, we should stress that many students declare that they regularly read, or perhaps at least glance at, Sunday newspapers.

It is important to point out that while there is a great discrepancy (part B of the questionnaire) between boys and girls in the kind of subjects they choose to read in the press (the boys prefer sports and science, and the girls prefer cultural and social issues), there is no statistically significant difference in the way they both choose between the suggested press science articles and in the way they answer the relevant questions (last part of the questionnaire). At this point perhaps we should stress the fact that students, apart from their overall differences (different gender, different socioeconomic status), seem to respond similarly to questions connected with education. Thus, they have similar behavior when they express their feelings towards their science textbooks in comparison with science articles found in the press, and

when they choose passages (in different articles) that use similar tools to present or to clarify complex science subjects. A further research might reveal possible marginal differences between subgroups with different socioeconomic status.

The present research supports the fact that press science articles could be of use as educational material. This is supported by the findings (part C of the questionnaire) that reveal that students appreciate the information found in newspaper science articles, and they believe that they are much more attractive, interesting and comprehensible than the corresponding content of their science textbooks. This finding in conjunction with the choices they made in the last part of the questionnaire leads to the conclusion that the communication code used in science articles seems to be very appealing to students, as other researchers have also pointed out (Koulaidis, 2000). Thus, students seem to choose passages from the articles that use an emotional/'poetic' language with a lot of metaphors and analogies to introduce difficult scientific concepts; for example, they highly appreciate the narrative elements of a popularized article. In an analogous research conducted with teachers, it was found that they prefer science articles that promote their self-education. Furthermore, in the content analysis of their answers that followed, the basic 'themes' emerging were mentally demanding. On the other hand, teachers recognize that for their students the narrative style of science 'stories' and the teaching tools used (metaphors, analogies, models, etc.) catch their interest and facilitate their understanding (Halkia, 2003).

The appeal of the narrative elements in science articles seems to reflect a deep psychological need of students, as other researchers have also pointed out (Carson, 2002). From earliest times, man has felt the need to listen to stories, which give shape to his fears. This is strengthened even more by the pictures illustrating these stories — and, as the research shows, pictures accompanying press science articles seem to play a decisive role in effecting student interest. Thus, they are very much impressed and attracted by the evocative pictures that support the narrative elements of a science article and not by pictures representing conceptual maps and abstract graphs that demand mental discipline from students to be read. In addition, it seems that the students are very much attracted by issues, which ideologically refer to 'Hollywood' stereotypes of the 'outside' danger.

Students seem to discriminate between the 'normal' (Lemke, 1990, p. 136) presentation of science in textbooks used in formal education on the one hand, and the charming science 'stories' presented in the press on the other. Maybe, that is why they behave differently from their teachers in the kind of press science articles they choose to read (Halkia, 2003). Thus, the thrilling elements of adventure and of fear of the unknown seem to be decisive points in their choice.

These findings may suggest the directions for further research about the structure of science textbooks in formal education. A 'hypertext' form of science textbooks, where occasional press science articles of current concern could be the trigger for motivating students' and teachers' interest for science matters, could be designed. This could lead them to further search and conscious study of the underlying subject matter, according to their personal abilities and interests.

Press science, either through teachers or through students, crosses the borders of formal education and intervenes in the educational process (Halkia, 2003; Halkia et al., 2001). The use of press science articles in science classrooms helps students to understand public discourse about science, as well as to develop several communication skills (Hand, 1999). In addition, such articles can be used as educational material (Halkia, 2003). Thus, we strongly share Wellington's (1991) argument that, if press science is used carefully and critically, it can help and be supportive to formal education. In that respect, university scholars too have to seek their own role and consider their responsibility in popularizing science since, through their intervention, science knowledge comes back to the science classrooms (Dunwoody, 1992; Thomas & Durant, 1987).

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Appendix 1: Part D of the questionnaire

D. The following articles were published in newspapers 'To Vima' and 'Eleutherotipia' on 24-Sempteber 2000. (Presented below are the title and author of the article and a sub heading projected in the article, considered as representative of its content).

1. Title: 'How an Earth catastrophe can be avoided', H.Varvoglis.
Subheading: 'Scientists know that the danger of collision with an asteroid or a comet is possible'.
2. Title: 'The rapid change of climate', Sp. Rapsomanikis.
Subheading: 'International data and how they affect Greece'
3. Title: 'The Proletariat of ….. laboratories', Valia Kaimaki.
Subheading: 'In a few years time robots will replace unskilled workers'
4. Title: ' Strings, the music of the universe', G. Grammatikakis.
Subheading: 'Strings are the building materials for the language of matter and energy in the universe, as letters are the building materials of written discourse'

D1.	Choose which of the above articles you would read first. Please write down its title …… ……	D1I__I

D2.	Please write down the reason / reasons for choosing the specific article	D2I__I

D3.	By which part of the article are you most impressed? Please write the number/s of the paragraph/s (and underline passages in them) and/or the number/s of the picture/s you have chosen	D3I__I