The International JOURNAL of LEARNING

School Visits to a Research Laboratory as Non -Formal Education

Kostas Dimopoulos
Vasilis Koulaidis

VOLUME 12, NUMBER 10

COMMON GROUND

www.Learning-Journal.com

INTERNATIONAL JOURNAL OF LEARNING
http://www.Learning-Journal.com

First published in 2005/2006 in Melbourne, Australia by Common Ground Publishing Pty Ltd
www.CommonGroundPublishing.com.

ISSN: 1447-9494 (print), 1447-9540 (online)
Publisher Site: http://www.Learning-Journal.com

The INTERNATIONAL JOURNAL OF LEARNING is a peer refereed journal. Full papers submitted for publication are refereed by Associate Editors through anonymous referee processes.

Typeset in Common Ground Markup Language using CGCreator multichannel typesetting system
http://www.CommonGroundSoftware.com.

School Visits to a Research Laboratory as Non-Formal Education

Kostas Dimopoulos, University of Peloponnese, Greece
Vasilis Koulaidis, University of Peloponnese, Greece

Abstract: The objective of this paper is to evaluate the educational potentials and limitations of school visits to a research center by exploring the short-term cognitive and affective effects on students as a result of such visits. In this paper a school visit to a research laboratory is considered as a fundamentally different educational experience from the ones students usually encounter within their formal schooling. In specific the cognitive effects examined concern: a) the students' level of information about the institutional functioning of the research laboratory and b) their knowledge about some fundamental science concepts around which a large part of the visit was structured. In parallel the affective effects examined concern: a) the students' level of interest about scientific research, b) their career orientation in scientific professions, c) the image they hold about the laboratory itself and the kind of research conducted in it. The short-term effects were explored through the use of a questionnaire distributed to 825 students of the upper secondary level (17-18 years old) in a pre and post visit format. The results obtained show that the school visits have very positive effects on the students' level of information about the institutional functioning of the research center while at the affective level they contribute to a deflation of the mythological status of scientific research to its real dimensions. Finally relatively to the raising of the students' knowledge about the techno-scientific content, it could be concluded that as a result of the visit the latter seem to move from a state of full ignorance before the visit, to a state of cognitive confusion characterized by either the mixing of correct and false elements or the incompleteness of the acquired information after it. In general it is concluded that the school visits have important limitations but also offer considerable educational potentials possibly overlooked even by the science teachers organizing them.

Keywords: School visits, Research centers, Short-term effects, Non-formal science education.

Introduction

THE OBJECTIVE OF this paper is to evaluate the educational potentials and limitations of school visits to a research center by exploring the short-term cognitive and affective effects on students as a result of such visits.

Visits to research centers is one of the channels disseminating techno-scientific information to non-experts. These channels have been considerably multiplied during the last decades (Lewenstein, 2001). Other examples of such channels are mass media, science and technology museums, various non governmental organizations formed on the basis of issues with direct relevance to techno-scientific knowledge (e.g. ecological organizations, consumers' organizations), science and technology based industry and a large number of scientific institutions (e.g. universities, research centers).

The network of all these channels promotes in many cases activities of educational form (i.e. enhancement of understanding, attitude change, etc) constituting in this way a parallel to the formal educational system, non-formal educational infrastructure (Rennie et al., 2003).

The educational activities promoted though by this network, differ drastically from the corresponding ones taking place within the formal educational system. The main differences could be summarized in the non systematic and short-term nature of the former activities with respect to the latter ones. An additional differentiating feature is that the educational activities taking place outside the formal educational system are usually not formally assessed and hence non-accredited.

School visits to sites of scientific and technological interest (i.e. science and technology centers, industrial establishments, research centers) constitute typical examples of non-formal science education activities.

This study focuses on the analysis of the cognitive and affective effects of school visits to the Greek National Center for Scientific Research "Democritus" (henceforth NCSR). Taking into account that a large number of researchers consider learning as a long term process during which understanding and the formation of specific kind of attitudes is influenced by experiences form a wide variety of sources, among of which a very important one is also the non-formal learning environments, in this study we do not deal with the potentials the visit opens up for a visitor in the long term, but we are restricted in the evaluation of the short term effects only (Rogoff and Lave, 1984). These short-term effects constitute the minimum base beyond of which the students' learning outcomes could be further enhanced though ad-

ditional experiences either within the framework of formal schooling or elsewhere.

The need for studying school visits to a research center is based the following two reasons:

1. Despite the fact that visits to other settings of non-formal science education such as to science centers and museums have been extensively studied, school visits to research centers, according to our knowledge, have never been studied (Anderson et al., 2000; Falk and Dierking, 2000; Griffin, 1998).
2. Research centers are the only destination of school visits where students have the opportunity to come in contact with authentic conditions of techno-scientific knowledge production processes.

The school visits to science and technology museums though, are likely to be quite different in nature from the corresponding visits to research centers. For example a) the chance students have in the case of research centers to come in contact with conditions of science in the making as opposed to the settled and consolidated scientific knowledge usually encountered in science and technology museums or b) the fact that the artifacts with which the students come in contact in the science and technology museums context, unlikely to what happens in the research centers, are usually carefully designed for expository and learning purposes, are elements that could differentiate significantly the two kinds of visit experience.

Despite these potential differentiations though and also given that the visits to both types of institutions have yet many common characteristics (e.g exposure to new knowledge in brief time, curatorship, out of school activity), in this paper we will discuss our findings in the light of the relevant research findings about science and technology centers and museums. Doing so though, we are fully aware of the danger not taking into account or even underestimating the features differentiating in crucial ways the two types of visits from a pedagogical point of view.

The Structure of a Typical Visit to the NCSR

The NCRS "Democritus" covers an area of approximately 45.000m² (11.1 acres). The Center employs approximately 180 permanent researchers, 50 postdoctoral fellows, 120 PhD candidates, 300 people on contract-researchers, technicians, support personnel- and 200 persons as technical personnel.

Public and school visits to the NCSR started 35 years ago. These visits have always been addressed to students of the last grade of upper secondary school (Lyceum) (17-18 yrs old), since due to their specialized content only students of this level are considered to have the appropriate knowledge level so as to benefit from them. About four thousand students visit NCSR every year. These students constitute 80%-90% of the total number of the center's visitors.

Below we shall describe the path followed during a typical visit. Once the visitors enter the premises of NCSR a guide, welcomes them and leads them to the first station of the visit, the Institute of Nuclear and Particle Physics where they visit the TANDEM Accelerator Lab. In the beginning, the visitors enter the accelerator room where a specialist explains its function and describes how the staff ensures security against radiation. After that he shows them a blueprint of the accelerator in order to describe its interior and its function. In parallel some basic concepts and terms of nuclear physics like nuclear and sub-atomic particles and their properties as well as the principles of a nuclear accelerator's function are explained to the students. At the end of this phase the specialist explains how the Center's staff operates the accelerator from a distance (when the room is sealed) while he also presents the implications of the research done on the accelerator in the fields of technology, materials, and environment. The visitors can then ask any questions they wish.

The visitors are then guided to the Institute of Radioisotopes and Radiodiagnostic Products. There, a researcher explains the basics about these products and projects a relevant video to the students. In particular the concepts of *radioisotope* and *half life time* as well as the role of *radiomedicines* for the diagnosis and treating of various diseases and especially cancer, are exposed. All the students then discuss what they saw and the possible questions that have arisen.

The third institute visited is the Institute of Biology, where the students have the opportunity to come in contact with the Human Tissue Bank. There, another researcher explains how the tissues are stored and used, presents the social and medical usefulness of the Tissue Bank and answers to the visitors' questions. During this phase the visitors have also the opportunity to observe some tissue samples and discuss the applications of the tissue bank for reconstructive surgery.

The typical duration of a visit is about one hour and a half. If there is time after the end of the visit and before their scheduled departure, the visitors enter the auditorium of the center, where they watch a video making a general presentation of the center, its history and functions. Finally, it should be mentioned that no leaflets or other informational material is distributed.

Methodology

The objective of this study is the exploration of some of the short-effects of school visits to NCSR on students. The effects examined are distinguished as cognitive and affective ones. Specifically, as far as the cognitive effects are concerned, the following dimensions are examined:

1. Knowledge about the research center NCSR as an institution as well as the research activities carried out in it (i.e. the specialty of the scientists working in NCSR, the scientific fields in which scientific research is carried out in NCSR, the objectives of the corresponding research, the institutional functioning of NCSR)
2. Knowledge about some basic elements of techno-scientific content, presented prominently during the visit.

Furthermore, in relation to the affective effects, the following dimensions are examined:

1. Interest in scientific research
2. Interest in following a career on science and technology and
3. Image of the research center itself as well as of the scientific research conducted in it.

The fact that the students come in contact with the NSCR as well as with the scientific content presented during the visit for a first time, could reasonably lead to the assumption that the effects identified are attributed more to the visit itself rather than to students' prior experiences.[1] This assumption is further based on the fact that only 17.5% of the students have received any kind of relevant preparation in schools.

The aforementioned effects were explored using data gathered through a questionnaire administered to a sample of 825 students (48.9% males and 51.1% females). The sample of the participating students was selected on the basis of visit statistics of the previous year. The questionnaire was structured in two parts: part one to be answered before the visits, and part two to be completed immediately after the visit.[2]

During the survey the sample was divided into two different but equal sub-samples (A and B). This division was realised by the numbering of the questionnaires distributed to each visitors' group in ascending order, whereby the uneven questionnaires contained the questions for sub-sample A, and the questionnaires with even numbers contained the questions for sub-sample B. Both before and after the visit, each visitor received the questionnaire with the same number. This distribution ensured a high comparability between the two sub-samples. In order to understand whether the visit had any effect, we did ask all the visitors the same questions in the "before" and "after" the visit questionnaire with the exception of the questions related to the dimension of knowledge of the techno-scientific content presented, which were differentiated for both of the two sub-samples in the two parts of the study (before and after).

This approach was adopted so as to minimise the problem of a possible increase in visitors' attention during the visit for specific matters mentioned in the 'before the visit questionnaire'. Thus, for example, if in the 'before the visit questionnaire' a person belonging in the sub-sample A was asked a question about the structure of the atom in the 'after the visit questionnaire' this same person was asked to define the term 'half life time'. A person belonging in the sub-sample B was asked to answer the same two questions but in reverse order.

The data collected through the questionnaires were complemented with additional data from semi-structured interviews conducted immediately after the visit with twenty four students and ten teachers respectively.

Results

Cognitive effects I: Knowledge about the Research Center as an Institution as well as the Research Activities carried out in it

From the comparison of the students' answers before and after the visit, it can be concluded that the latter leave the visit having a fuller picture of the NCSR as well as of the kind of research activities conducted in it (see Table 1). Specifically, after the visit more students (+24.8%) know that the personnel of the center consists of scientists coming from many different specialties while the percentage of those who opt for the 'do not know' answer decreased by more than 20%. This result shows that an effect of the visit was students to understand better the multi or interdisciplinary nature of the scientific research conducted in a modern center such as the NCSR.

[1] Answering to a relevant question 98.9% of the students stated that they visit the NCSR for a first time. Besides taking into consideration the period the visit took place as well as the structure and the pacing of the National Physics Syllabus, it is reasonable to make the assumption that the students hear about the scientific issues presentated during the visit for a first time.

[2] The questionnaires were completed during October and March of 2002.

Table 1: The Scientists Working at the NCSR are:

Specialties	Before (%) Sub-sample A	After (%) Sub-sample B	Change (%)
Only physicists	4.2	1.7	-2.5
Only chemists	0.7	0.0	-0.7
Of many specialties (correct)	63.5	88.3	+24.8
Don't know	31.6	10.0	-21.6

Furthermore, after the visit considerably more visitors are in a position to correctly identify the techno-scientific fields that NCSR conducts research on. For example the percentage of visitors correctly mentioning after the visit that NCSR does not carry out research on Seismology or that it does carry out research on Informatics is almost doubled (see Table 2).

Table 2: The NCSR does not Carry Out Research on:

Field	Before (%) Sub-sample A	After (%) Sub-sample B	Change (%)
Biology	2.4	1.1	-1.3
Physics	3.9	2.2	-1.7
Seismology (correct)	31.0	61.6	+30.6
Informatics	62.7	35.1	-27.6

Concerning the students' knowledge about the objectives of the NCSR, it was found that the effects of the visit were also quite positive since 15% to 50% more students were more aware of these objectives after the visit. There seems though to exist also a problematic effect of the visit concerning this dimension. Specifically as shown from the data of Table 3. the increase of the correct answers to the first two relevant items, is accompanied by an even greater reduction of the 'DK' answers. This trend shows that as an effect of the visit a considerable proportion of the students was moved from a state of ignorance to a state of false knowledge relatively to some aspects of the center's objectives.

Table 3: The Objectives of the Research done in the NCSR are to:

	Before (%) Sub-sample A		After (%) Sub-sample B		Change (%)	
Objectives	Correct	DK	Correct	DK	Correct	DK
Combine research with industry and production (True)	13.3	72.1	43.0	29.4	+29.7	-42.7
Make experiments to study new materials (True)	38.8	56.2	55.3	29.9	+16.5	-26.3
Study only nuclear fusion (False)	38.1	48.5	77.8	9.4	+39.7	-39.1
Study subjects that are relevant to the health (True)	38.6	53.9	89.1	7.0	+50.5	-46.9

Finally, in relation to the institutional functioning of the center, from the results of Table 4, it becomes evident that while more students after the visit know that the center was not founded in 1990 (+42.8%), the fact that the NCSR has collaborations with similar foreign research centers seems to be up taken by only a marginal percentage of students (+3.4%). The difference in the responses to these two questions could be possibly attributed to the different emphasis given to the corresponding aspects during the guided tour and especially during the video shown to the students at the end of the visit.

Table 4: The Institutional Functioning of the NCSR

	Before (%) Sub-sample A		After (%) Sub-sample B		Change (%)	
Statement	Correct	DK	Correct	DK	Correct	DK
The center operates since 1990 (False)	13.6	80.4	56.4	34.4	+42.8	-46.0
NCSR has collaboration with other centers all over the world (True)	53.3	45.3	56.7	39.6	+3.4	-5.7

Cognitive effects II: Knowledge about some basic Elements of Techno-Scientific Content

In order to determine how the visit affected the visitors' knowledge about some fundamentals of physics, specific open questions corresponding to basic elements of techno-scientific content, presented prominently during the visit, were posed to them both before and after the visit. In specific, the visitors were asked to provide short essay type answers about the structure of the atom, as well as about the meaning of the terms "radio medicines", "half life time" and "particle accelerator".

The answers to these questions were independently coded by two experienced physics teachers teaching in the upper secondary school for longer than ten years, as *correct* in the case that they included the majority of the points forming a model answer predefined by the teachers themselves, as *ambiguous* if they included only some of the points of the model answer, usually mixed with false points and as *false* in the case they did not include any of the points constituting the model answer.

The results show (see Table 5) that the visit does not seem to have an overall considerable influence on the visitors' knowledge about any of the four issues asked about. Specifically, the increase of the correct answers about "radio-medicine", "half-life time" as well as about "particle accelerator", i.e. for those elements of the techno-scientific content which according to the percentages of the correct answers before the visit seem to be completely unknown to the vast majority of students, is only marginal.

Table 5: Students' Knowledge about some Basic Elements of the Techno-Scientific content Presented during the Visit

	Before (%) Sub-sample A			After (%) Sub-sample B			Change (%)		
Concept	Correct	Ambig uous	DK	Correct	Ambig uous	DK	Correct	Ambig uous	DK
Structure of the atom	56.7	14.7	25.5	48.2	15.4	32.5	-8.5	+0.7	+7.0
Radio Medicines	0.0	1.4	95.7	1.5	13.0	75.3	+1.5	+11.6	-20.4
Half life time	6.8	7.6	69.2	7.5	6.3	69.7	+0.7	-1.3	+0.5
Particle accelerator	2.2	16.4	71.6	7.0	41.1	40.9	+4.8	+24.7	-30.7

Concerning though the notions of "radio-medicine" and "particle accelerator", a considerable increase of the ambiguous answers was observed, a fact meaning that students have formed at least a superficial knowledge about these.

About the more familiar prior the visit concept of the ''structure of the atom", a decrease of the correct and an increase of the "DK" answers was noted. This trend could be explained by the fact that some students, relying on the relevant incomplete model taught at school which is restricted at the level of the nucleus description (with the electrons revolving around it) gave a correct answer before the visit, while after the visit these same students produced either false or "DK" answers, possibly as a result of the confusion that caused them the description of a more detailed model of the atomic structure including some sub-atomic particles like quarks, neutrinos, gluons and W^+, W^-, Z^0 bosons at the TANDEM accelerator.

In overall, these results show that if the visit had any significant effect on the students' cognitive level, this was the latter's move form a state of ignorance to a state of cognitive confusion.

Affective effects I: Interest in Scientific Research

More students (+14.7%) express even higher levels of interest in scientific research than before the visit (their answers fall in the categories 'very strong' and 'rather strong' interest) (see Table 6). At this point it must be stressed though that this result should be cautiously accepted since part of the effect identified possibly originates not from the students' true attitudes but from their tendency to comply with a "politically correct" position, expected by their teachers, especially after the end of a visit to an institution where scientific research is the main activity.

Table 6: Level of Interest in Scientific Research

Level	Before (%) Sub-sample A	After (%) Sub-sample B	Change (%)
Very strong	16.8	23.2	+6.4
Rather strong	40.9	49.2	+8.3
Rather weak	33.4	23.5	-9.9
Very weak	8.9	4.0	-4.9

Affective effects II: Interest in Following a Career on Science and Technology

In contrast to the results obtained for the effects of the visit relatively to the interest in scientific research, the answers for the interest the visit generated for students to follow a scientific or technological career show that the visit did not have any considerable such effect (see Table 7).

Table 7: Would you like to become a Scientist?

Statement	Before (%) Sub-sample A	After (%) Sub-sample B	Change (%)
No, I wouldn't like to become a scientist	45.2	45.6	+0.4
Yes, I think I would like to become a scientist, but not a physicist	39.8	41.1	+1.3
Yes, I think I would like to become a scientist, and in particular a physicist	15.1	13.2	-1.9

This result could be due mainly to two reasons. The first is that the visitors being students of the last grade of upper secondary school, who have already made their career choices, are very unlikely to reconsider these choices under the influence of such an isolated event like a school visit. The second reason has to do with the fact that students had very few chances to interact with scientists working in the NCSR and so they had equally few chances to change their representations about scientific work.

Affective effects: Image of the Research Center itself as well as of the Scientific Research Conducted in it

In order to estimate the changes in the image the students hold of the research center itself as well as of the scientific research conducted in it, they were asked to assess these two dimensions before and after the visit, using six seven-pointed Likert type scales each corresponding to different kind of characteristics. The minimum (-3) and maximum values (+3) of these scales correspond to a negatively and positively charged adjective respectively, describing in each case one aspect of the image of the center or of the research done in it (see Figure 1). The image that the students hold either of the center or the research done in it in overall or for each specific aspect of these two dimensions, is determined by the mean of the students' ratings in all six of the scales or in each specific scale.

Based on the students' ratings before and after the visit, it can be concluded that they did not particularly alter their overall positive image about the research center held even before the visit (mean-before= 1.18, mean-after=1.20). There were though two specific characteristics of the center for which the visit seemed to have significant effect (see fig.1).

The first concerns the impact of the center which after the end of the visit were found to be regarded as more beneficial for society than before the visit ($t = 4.37$, $df = 673.1$, $p < 0.001$). This finding may be explained by the very frequent references of the guides, especially at the Institute of Radioisotopes and Radiodiagnostic Products and the Human Tissue Bank, to the beneficial social results of the research

conducted in the NCSR, especially in the fields of health and environment.

The second characteristic for which there was a statistically significant change is related to the safety of the center. Specifically, the students tend to consider the center as more risky after the visit ($t = -3.00$, $df = 667.8$, $p<0.01$), but not at alarmingly high levels (mean-after= +0.52). This effect could be attributed to the emphasis given during the presentation to the students to the security measures taken while the TANDEM accelerator is in operation.

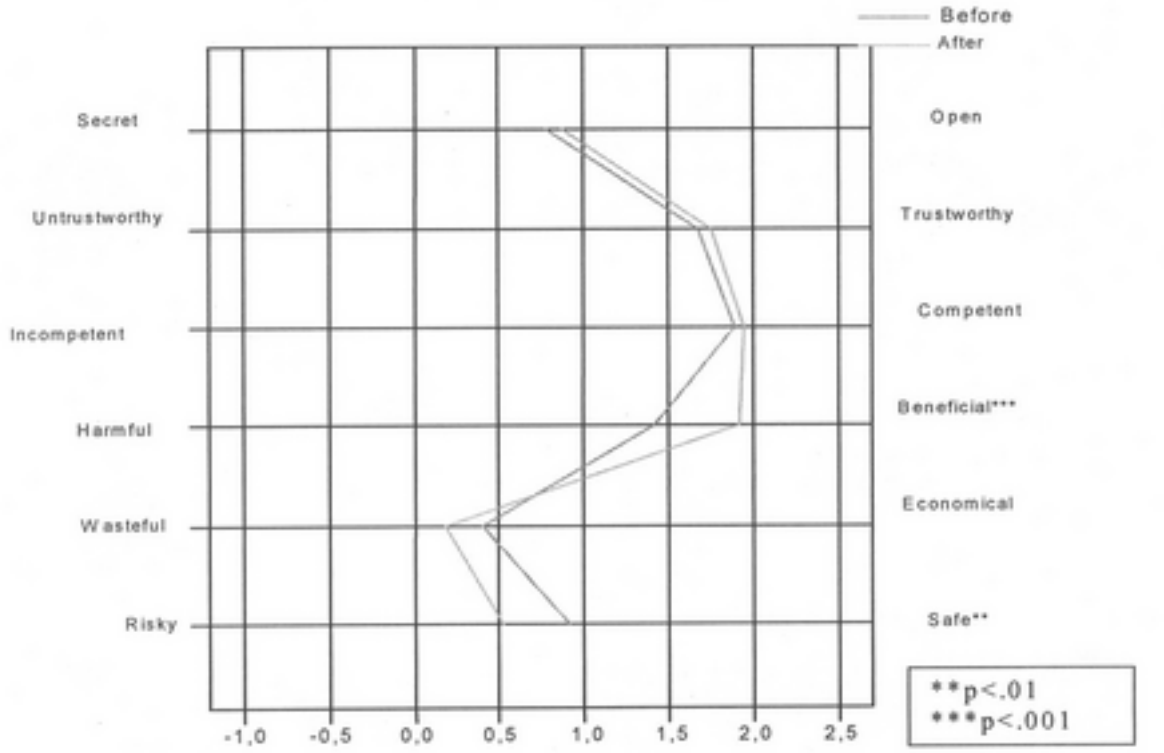

Figure 1: The Effect of the Visit on Students' Image of the Research Center

In contrast though to the effects concerning the overall image of the center, the overall image of the research conducted in it, is significantly more negative after the visit ($t = -3.35$, $df = 708.0$, $p<0.001$) (see Fig.2). This trend is mainly due to the following shifts: the students after the visit tend to regard the research done in the center as less up to date ($t = -4.36$, $df = 651.8$, $p < 0.001$), more poor ($t = 4.42$, $df = 613.6$, $p < 0.001$) and less exciting ($t = 7.88$, $df = 648.5$, $p < 0.001$). The only shift towards a positive direction is that students after the visit consider the research done in the center as more economical with respect to the amount of resources required for its conduction ($t = 3.75$, $df = 612.0$, $p < 0.001$).

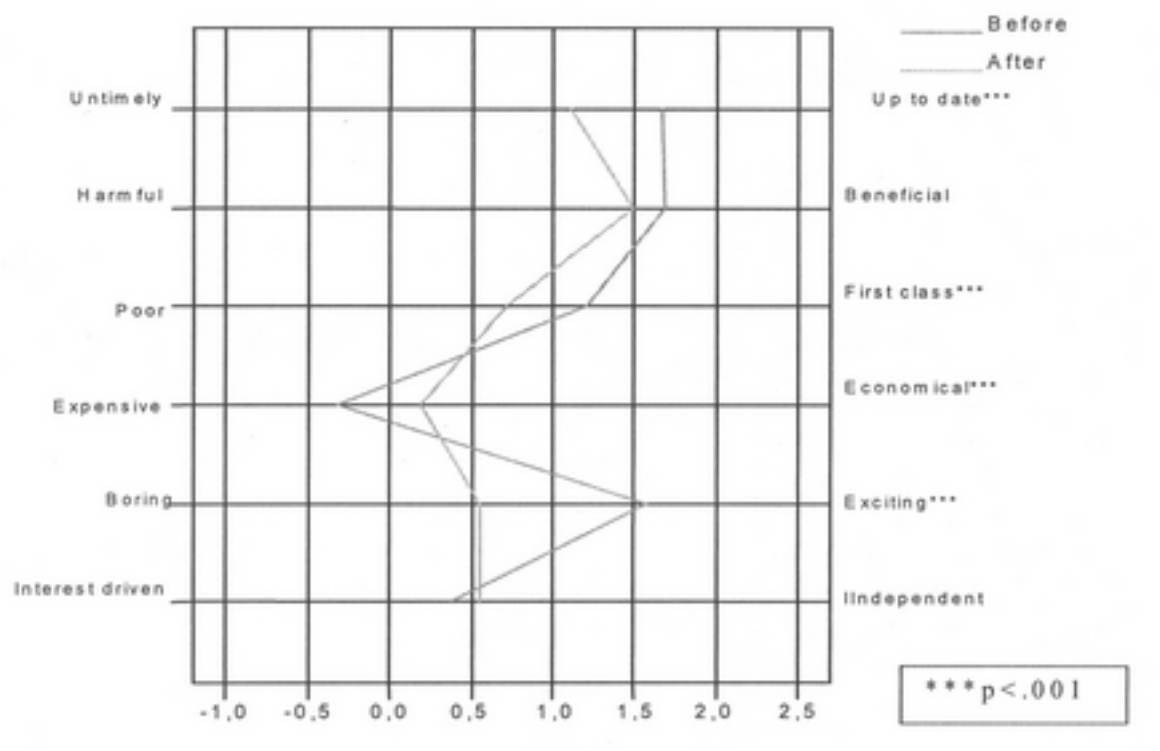

Figure 2: The Effect of the Visit on Students' Image about the Research done in the Center

All four of the aforementioned shifts converge in the direction of deflating the image of the research done in the center. This deflation simply reflects the subjective impression students form and it does not necessarily correspond to the quality of the scientific work done in the center. This effect might originate from the high expectations the students have coming to the center. Specifically, the students before the visit have as one of their most important expectations to come in contact with the conditions of the scientific research.[3] Their only relevant prior experience is through sources such as science fiction movies or mass media, where the scientific research is usually presented as up to date, first class, exciting and of course expensive (Dubeck, Moshier and Boss, 1994). The students' disappointment, according to their answers in the semi-structured interviews conducted after the visit, seems to have been further intensified by the lack of any chance to see scientific activities *in actu* during the visit.

Conclusions: The Educational Potential and the Limitations of the Visit

The results of this study could form a first empirical basis for the evaluation of the educational potential and the corresponding limitations of a school visit to research institutions.

Summarizing then the results of this study, we could say that the experience of the visit seems to have quite important effects on students both at affective and cognitive level. These effects are mostly related to aspects of the functioning of the NCSR, as well as some elements of the techno-scientific content presented during the visit. Furthermore the visit seems to have some considerable effects with regards to the image of the center and the research conducted in it.

On the contrary no particular effects were observed in more structural and independent from the context of the visit dimensions, like the students' general level of interest in scientific research or their prospects for following a scientific or technological career. Thus, a first conclusion that could be drawn is that the visit effects, as possibly expected, are far more significant for issues explicitly stressed during the visit rather than for issues only indirectly addressed during it.

Furthermore, in relation to the specific effects, the following trends were identified. Firstly, on the cognitive level a very significant effect of the visit was found to be the promotion of a quite clear picture about the institutional functioning of the specific research center. This effect becomes even more important if considered that this picture can act as a model for all the modern research centers. Since though this dimension is not particularly emphasized within

[3] It is characteristic that students, answering a relative question in the before the visit questionnaire, opted for their contact with real scientific research as their most important expectation from the visit among a list of ten alternatives.

the formal educational system while it is widely recognized as a significant aspect for raising the level of scientific literacy of people and also as one of the main objectives of a large number of science education courses, this particular effect is considered as very important (AAAS, 1993; Fensham, 1997).

Relatively to the raising of the students' level of knowledge about the techno-scientific content, it could be concluded that as a result of the visit the latter seem to move from a state of full ignorance before the visit, to a state of cognitive confusion characterized by either the mixing of correct and false elements or the incompleteness of the acquired information after it. The superficiality of the information acquired about elements of techno-scientific content is quite in agreement with the corresponding findings of similar studies conducted in the contexts of science centers and museums (Cox-Petersen et al, 2003; Anderson and Cook Roe, 1993). At this point, it should be though stressed that if the quasi-correct information acquired during the visit will not be further processed after the visit in school, it is very likely to be crystallized and form the basis for the development of false conceptual models (misconceptions).

Furthermore, the most significant effects of the visit on the affective level seem mainly to concern the change of the students' image about the research center as an institution as well as even more radically about the research carried out in it. Effects on the affective level have been also identified by other similar studies concerning school visits to science museums and centers (Rennie & Williams, 2002; Cox-Petersen et al, 2003). Specifically, the change in the image of the research center is basically related to its functioning aspects that had the most emphatic mentioning during the visit (i.e. safety and social utility of the center).

In relation to the image of the scientific research conducted in the center, it seems that the most important effect is its deflation in comparison to media originating stereotypical images corresponding only to the kind of scientific work usually taking place in mega projects of strategic research. Thus, the visit can be considered to have ambiguous effects on the affective level, since on the one side it is likely to reduce students' enthusiasm and excitement for scientific research but on the other it is equally likely to help them form a more realistic picture about it.

At this point we would like to raise a concern about the generalizability of our findings. This is related to the extent the planning and the organization of the visit studied here, i.e. the conditions that according to the relevant literature seem to determine the visit effects, are typical of the conditions existing in other non-formal science education institutions (Martin, 2004; Anderson, Lucas and Ginns, 2003). Drawing on the findings of the research literature on school visits to science museums and centers, thus running the risk to downplay the elements that differentiate the corresponding learning experiences, we could say that the visit studied here is a quite representative case of a school visit to non-formal educational settings characterized by linear and of strictly guided nature, outdated model of piecemeal transmission of isolated decontextualized facts from the expert guides to the passive visitors and also by lack of students' exposure to authentic experiences of real research practices (Cox-Petersen, 2003; Neresini, 2004).

In conclusion, we could say that the effects of the visit are found to be much richer than what was expected from science teachers who answering to a relevant question before the visit, mentioned that simply increasing their students' interest in science and technology was their most important motivation. In other words, a school visit such as the one studied in this paper, has some potentials but also limitations for learning. The realisation of these potentials and limitations on the part of science educators can result in such visits to become educational activities not on an ad hoc basis but fully integrated to the formal educational system.

References

American Association for the Advancement of Science (AAAS). *Benchmarks for Science Literacy, Project 2061+*. New York: Oxford University Press, 1993.

Anderson, D., K.B. Lucas, I.S.Ginns, and L.D. Dierking. "Development of knowledge about electricity and magnetism during a visit to a science museum and related post activities." *Science Education* 71(2000): 658-679.

Anderson, D., B.K. Lucas, and I.S. Ginns. "Theoretical Perspectives on Learning in an Informal Setting." *Journal of Research in Science Teaching* 40(2003): 177-199.

Anderson, P., and B. Cook Roe. *Museums Impact and Evaluation Study*. Chicago: Museum of Science and Industry, 1993.

Cox-Petersen, A.M., D. Marsh, J. Kisiel, and L.M. Melber. "Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history." *Journal of Research in Science Teaching* 40(2003): 200-218.

Dubeck, L.W, S.E. Moshier, and J.E. Boss. *Fantastic Voyages: Learning Science Through Science Fiction Films*. New York: American Institute of Physics, 1994.

Falk J.H., and L.D.Dierking. *Learning from museums: visitors experiences and the making of meaning*. Walnut Creek (CA): Altamira Press, 2000.

Fensham, P. “School Science and its Problems with Scientific Literacy.” In *Science Today* ed. R. Levinson and J. Thomas. London: Routledge, 1997.
Griffin, J. “Finding evidence of learning in museum settings.” In *Communicating Science: Contexts and Channels*, ed. Eileen Scanlon, Elizabeth Wwhitelegg and Simeon Yates. London: Routledge, 1998.
Lewenstein, B. “Who Produces Science Information for the Public?” In *Free Choice Science Education: How We Learn Science Outside of School*, ed. John Falk. New York: Teachers College Press, 2001.
Martin, M. L. “An Emerging Research Framework for Studying Informal Learning and Schools.” *Science Education* 88 S1 (2004): 571-582.
Neresini, F., F. Forno, M. Kalfass, H.P. Peters, K. Dimopoulos, L. Arnellou, and M. De Pasquale-Jacobsson. “Inside The Big Black Box : Analysing Visits to Physics Laboratories”. Final Report on behalf of the European Commision, Brussels, 2004.
Rennie, L.J., E. Feher, L.D. Dierking, and J.H.Falk. “Toward an agenda for advancing research on science learning in out-of-school settings.” *Journal of Research in Science Teaching* 40(2003): 112-120.
Renie, J.L., and F.G. Williams. “Science Centers and Scientific Literacy: Promoting a Relationship with Science.” *Science Education* 86 (2002): 706-726.
Rogoff, B., and J. Lave. *Everyday cognition: Its development in social contexts*. Cambridge, M.A: Harvard University Press, 1984.

About the Authors

Dr. Kostas Dimopoulos
University of Peloponnese, Greece
Prof. Vasilis Koulaidis
University of Peloponnese, Greece

THE INTERNATIONAL JOURNAL OF LEARNING

SCOPE AND CONCERNS
Visit: http://www.Learning-Journal.com

SUBMISSION GUIDELINES
Visit: http://www.Learning-Journal.com

INQUIRIES
Email: cg-support@commongroundpublishing.com