ABSTRACT

GIOPPO, CHRISTIANE. Designing and Testing Modules on Non-Formal Education for Teacher Education Candidates: A Brazilian Experience. (Under the supervision of Dr. John Penick and Dr. Glenda Carter.)

Two modules for preparing educators to use non-formal and Informal education opportunities were developed and tested at the Federal University of Paraná, Brazil. The first module prepared teacher candidates to create and teach lessons that use informal environments such as beaches and natural areas, while the second module focused on preparing museum interns to design and teach with activities prepared specifically for non-formal settings.

The research was carried out in three steps. The first sought the perceptions of three groups of professionals about the use of non-formal/informal settings by school groups and their teachers, and asked for suggestions on designing educational modules. In the second step, the conception and development of the modules was enlightened by interview responses, research literature, and Biology Education program constraints. The third step tested both modules by having Biology Education majors, develop and pilot activities for middle and high school students, with the results observed the research as post at.

The results of testing Module I indicated that teacher candidates need a strong support system to become effective teachers. Data also showed that they needed additional instruction on preparing integrated inquiry lessons and how to use
the module as a regular and permanent addition to the curriculum. Thus, the first module was redesigned but not further tested.

Module II results indicated that museum personnel and administration became interested in designing more interactive activities and the school students who participated in the activities enjoyed being at the museum. Module II data also indicated need for revision and more study, especially regarding the use of inquiry, the implementation strategy for traditional museums, and the development of activities that are feasible for large group of museum visitors.

This study indicated that such modules are valuable and could lead to change in informal and non-formal instruction. But, the teacher candidates who design the activities need considerably more instruction on innovative teaching practices, lesson design, and the expected goals and roles of such activities.
DESIGNING AND TESTING MODULES ON NON-FORMAL EDUCATION FOR TEACHER EDUCATION CANDIDATES: A BRAZILIAN EXPERIENCE

By

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APPROVED BY:

Chairman of Advisory Committee
...There ain't no doubt in no one's mind
  That loves the finest thing around
  Whisper something soft and kind
And hey babe the sky's on fire, I'm dyin' ain't I
  Goin' to Carolina in my mind

In my mind I'm goin' to Carolina
  Can't you see the sunshine
  Can't you just feel the moonshine
Ain't it just like a friend of mine
  It hit me from behind
Yes I'm goin' to Carolina in my mind...

James Taylor (Carolina in my mind)
To my grammas Zayra Cararo Gioppo (*in memoriam*) and Aurora Simbalista Gonçalves
Two women whose strength inspired me.
BIOGRAPHY

Christiane Gioppo Marques da Cruz was born March 8, 1961 in Rio de Janeiro, Brazil. Her undergraduate degree in Biology Education (1982) was awarded from The Federal University of Paraná (UFPR). Gioppo taught middle school science for 7 years in a public school in the Curitiba area.

In 1990 she became a teacher educator for the Paraná State Educational Board traveling all over the state to do in-service science professional development. At the same time she had a part time position as non-formal educator at The Curitiba Science Park. In 1993 she became an auxiliary instructor at UFPR for the practicum internship supervision.

Between 1993 and 1994 Gioppo was awarded with two specialized degrees. In 1999 she finished a Master of Science at São Paulo University. Her thesis focused on a science textbook evaluation. While presenting the results of this study in a conference held in Argentina she was introduced to the International Council of Associations for Science Education (ICASE). Christiane then became affiliated with this association and organized the Third Latin American and Caribbean ICASE Symposium, in 1999. It was the first ICASE Symposium in Brazil, with 1,200 people from 15 countries. During this conference she was introduced to Dr. John Penick, who invited her to apply for a doctoral degree at North Carolina State University.
Christiane feels fortunate to be married to a wonderful man, Daniel, who stayed in Brazil all the time supporting her, building a new home and even helping her studies, sending reading materials. She also has a terrific kid, Mariane who generously came to the US and shared her friendship, the bedroom, and the computer (!) with her as she worked on this project.
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I am being awarded with a degree for this dissertation; however this is certainly not an individual project. Without the help, friendship, camaraderie and support of so many people this project would never be finished.

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While I will not list all the friends from Brazil I met in Raleigh, I can say however they are all incredible people whom I will never forget.

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CHAPTER I

Introduction

In the past few decades, western societies have undergone changes leading us to reformulate the way we think, act, and consequently, learn. As a result of these changes, postmodern philosophers, like Habermas (1990), agree that society has passed the moment of modernity, and we are now living in the era known as the postmodern or post-industrial era. This era is discontinuous from modernity.

Our postmodern condition is characterized by erosion of the family as a social nucleus; we have changed our perception of social and gender roles; and many social institutions (including schools) have lost their original meanings (Lyotard, 1985). Murdoch (1993) has emphasized the role of communication as an essential part of social development and change. Meanwhile, technology products that impact all social levels have become common, making some communication faster and easier, potentially leading to even more changes. Organizations have become more flexible, decentralized, and democratic while many individuals suffer increased anxiety and depression because of the fast lifestyle. Because of these processes, we are seeing changes in knowledge and learning dynamics. Knowledge is no longer a set of eternal truths and our view of learning has moved from the pure cognitive dimension to the cognitive-reflective level. Educators must now rethink many aspects of learning, schools, and schooling.
In the postmodern society, some education systems are struggling to have universal goals while others seek local goals, focused on various subcultures or groups. Inflexible systems are dying because they are not able to encompass the societal changes and new social institutions are in constant flux. The fast pace of postmodern society demands flexibility, ease of access, and a significant need or requirement for continuous life-long education. We recognize that meaning is produced by the self, rather than by others or institutions, however, in order to be efficient education must respond to the needs of people. Hence, curriculum for learning must be transportable, available not just at schools, and it must combine universal knowledge with contemporary realities. To meet these new educational demands, other institutions traditionally devoted to culture are joining the education infrastructure. Science museums are examples of such institutions that are now more focused on educating the general public.

*The New Museum*

In the modern urban scenery, museums were contemplated as temples, externally magnificent in their architecture and internally solemn repositories of knowledge (Caro, 1997). But, while society was changing, this icon was losing its old identity. In the 1970s, science museums all over the world started shifting their internal process of power from curatorial (object-based) concerns to educational (audience-based) concerns. Bitgood (1994) observed, “…exhibits with more popular appeal and effectiveness move away from the elitist, exclusive, rarefied atmosphere that collections-based exhibits seemed to have” (p. 66). However, the staff and
scientific curators who argued that accuracy and integrity could go astray did not always appreciate this change. One example was the hotly debated role of signage in art and science museums.

Signages usually written for a specialized audience were identified as a potential instrument to communicate key science concepts to the general public, keeping people in the museum longer. Falk (1997) investigated a common exhibit design assumption. By clustering conceptually related exhibits, the implicit, single overarching concept would be communicated and conceptual understanding would be developed. Using signage as a treatment for visitor conceptual development, he found that signage helped visitors to understand the exhibit cluster explicitly and that they “...demonstrated a significantly improved ability to discern and articulate the major intended messages” (p. 685). Besides this, visitors spent more time in the presence of exhibits with explicitly signed exhibits. Falk suggested that labels with headlines and sub-headlines appear to be a successful way to facilitate visitor conceptual development when they are designated and delineated for them. Labels facilitated comprehension of the exhibit, because they acted as reinforcing conceptual organizers.

As museums changed focus, their new role opened an extensive area of uncertainties. Science museum staff usually knew very little about education, as their main focus had previously been to collect and preserve. Now, with changing goals, staff attitudes toward visitors and roles needed to change, but these did not shift simultaneously, and often an elitist and condescending attitude towards visitors...
kept science on a pedestal and visitors at a distance. Bitgood (1994) reviewed visitor studies done between 1952 and 1976 and found that museum educational strategies, especially the short one hour programs and museum signage were generally ineffective. However, a few science museums began paying attention to the need to change.

Today, science museums are reinventing themselves and moving toward filling a prominent educational niche. Informal and non-formal modes of education, such as media, science centers, and science museums, are now flourishing everywhere and establishing a unique informal educational infrastructure. With their interaction with the public, this “informal infrastructure” (Luke, Camp, Dierking, & Pearce, 2001) has the potential to make powerful contributions to education. Museums, and especially media, claim they have the potential to help reshape education towards a more scientifically literate society (Chen, 1994).

To maximize their powerful potential to contribute to education, these institutions must examine their practices and outcomes. They need stronger research support. Museums and science centers, if designed and operated properly, can play an important role in supporting science literacy within communities by integrating cultural perspectives into exhibits and educational programs. In the words of Colbern and Aikenhead (1997), we must contextualize learning in a “cultural milieu”, but we know very little about how science museums can do that. We need additional research about how museums can be more effective for educational purposes.
Many gaps exist in knowledge about non-formal educational settings. We need to identify the best use of science museums as educational tools in the new postmodern era. We need research in areas to answer questions such as:

1. How can non-formal institutions provide flexible and effective education for our citizens?

2. What should be in a science museum curriculum?

3. What is the role of non-formal education and the non-formal educator?

4. How can we evaluate the educational impact of non-formal education?

5. How can we prepare teachers to deal with non-formal environs?

6. How do we prepare museum staff and formal science teachers to deal with issues of non-formal education?

7. How can we fully integrate formal and non-formal education?

A small research group on informal/non-formal education at North Carolina State University has reviewed the literature and finds little research on any of these topics. We do know that currently the apprenticeship-style teacher education is the standard for non-formal educator staff in a science museum (Tran, 2002), and the museum evaluation process for determining achievement is much more intuitive than researched-based (Suzuki, 2003).

To fill in one small gap in our knowledge, this dissertation focuses on designing a research-based modular curriculum for teaching science teachers in the southern Brazilian State of Paraná to use non-formal/ informal education settings
effectively. Such a curriculum can capitalize on the learning potential of non-formal institutions and enhance capacity to teach science.

*Paraná Society*

Paraná State encompasses many features of postmodern society. Three new specific areas of change and demand in Paraná State delineate this research: Paraná societal changes; the science methods course at Federal University of Paraná (UFPR); and, the two new museums in Curitiba, the state capital.

Recent changes in southern Brazil population demographics are bringing new demands for education. The population is getting older (IBGE, 2000b; IBGE, 2000c) and staying in school longer or even coming back to school after a long period of dropout. Consequently, illiteracy rates are being reduced (IBGE, 1999). In the last decades of the 20th century population growth rates were reduced, gradually reaching 0.93% in the 1991 census. Now, political marketing of the "good life" available in the state has attracted out-of-state, poorly qualified people seeking employment. Population growth rates due to migration have started to increase again, reaching 1.5% in the 2000 census (IBGE 2000f). At the same time the population is moving to inner city areas. Thus, urban areas are approaching 82% of the state population (IBGE, 2000).

With increased urbanization come new demands on education, especially for science and technology. Workforce issues also require curriculum adjustments. Consequently, science education, including teacher preparation and non-formal
education must respond as well. Non-formal science education can, perhaps, play a larger role in general education than it has in the past.

Science Methods Course at Federal University of Paraná

Science teacher education programs at UFPR compete for student interest with the biology baccalaureate program. The majority of students are involved in basic research very early in the baccalaureate program, and students are allowed to do both programs simultaneously, if their schedules permit. Most of these students are not interested in teaching, especially in formal schools. The licensed degree is considered by many as a spare or backup degree, allowing students to accept temporary jobs teaching while waiting for graduate school acceptance or searching for university positions.

In the new Guidelines and Basis for Education law (Lei de Diretrizes e Bases da Educação, LDB) practicum internship minimum hours have increased to 300. With this amount of time, students are now able to do part of their internships at schools and part in non-formal settings (LDB, 1996). Thus, student teachers interested in non-formal/ informal settings are now demanding out-of-school internships. (Recently, the law had an addendum to increase the internship hours to 800. This amount of hours will become required for students doing their internship in 2005 or beyond).

Even now, eight years later, the Federal University of Paraná, is still not able to fulfill this demand. Obstacles include a shortage of practicum instructors and supervisors, a lack of a well-organized practicum plan for non-formal institutions, and
our college instructors do not consider the implementation of practicum internships outside formal school settings a priority.

Recently UFPR began reviewing practicum internship priorities. Now instructors are recognizing the need to prepare teachers for non-formal settings as the demand is growing fast. This recognition is supported by research findings (Olson, Cox -Petersen, & McComas, 2001) that non-formal settings allow very rich teaching experiences and that teachers must be prepared to use non-formal settings (Griffin & Symington, 1997).

Two New Museums in the Curitiba Area

The new Museum of Art, Architecture and City Design, also called The Oscar Nyemeyer Museum opened on November 22, 2002. Designed by Oscar Niemeyer, the same architect who designed the capital, Brasilia, this museum is one of the largest in Brazil. The museum building has an area of 322,800 ft\(^2\) and occupies land of more than 335,207 ft\(^2\), and includes an exhibition area of 178,686.7 ft\(^2\). Although the topic is art, architecture and city design, this facility could support educational efforts in engineering and environment, as well as city development and its problems.

A second museum, called Science Park, is outside the city in an area that was formerly the state fairgrounds. This science center with four pavilion areas was opened in the final days of December 2002, at the end of a governor’s term (Santos, 2002, p.2). One pavilion is entirely dedicated to astronomy. Environmental issues are presented in all the pavilions. There is also an outside area with a giant state
map showing all municipal districts in geographic relief. Visitors can walk on it and perceive proportional distances.

When the new governor started his term in January 2003, one of his first orders was to close the two new museums. He argued that there was no budget or need for them. The two museums would cost a lot for the state budget. The scientific and art community as well as the local population immediately reacted to this, criticizing the Governor’s act. He then re-opened the Art museum, but argued that there was no staff prepared to assist schools in the Science Park. The Federal University of Paraná then offered to help by training eighteen students to work as docents in the Science Park. The Governor intended to re-open the Science Park in September 2003; however bureaucratic issues about transferring the property from the agricultural sector to the educational sector delayed the process until December 2003. The park was partially opened for a while but closed again shortly after it opened. It was partially opened again in the beginning of 2004, but is now assisting only school groups by appointment.

With two new museums and a few voluntary docents trained in an emergency program, there are no regular programs or courses at the museums or even in any university or college in the area to deal with science education in non-formal settings. Teachers are not prepared to use museum facilities as an educational resource. Before these museums, the city had no tradition of museum visits for school groups, and science teacher preparation programs at UFPR had never offered any kind of education for teaching in non-formal settings. Therefore, it is
important to consider informal and non-formal science education as part of the present university teacher education curriculum.

The Research Project

Postmodern society emphasizes communication, universal goals, and change in lifestyle. Paraná must meet these demands as well as the educational demands they represent. The postmodern and educational pressures combined with UFPR considerations suggest six statements or assumptions:

1. The population profile has changed, demanding new perspectives on education and teacher preparation to deal with workforce demands.

2. UFPR students see a teaching license as a spare degree rather than as a primary goal.

3. College students in the science teacher preparation courses at Federal University of Paraná who may prefer non-formal practicum internship have no alternative internships available.

4. A new education law requires college teacher preparation program adjustments, revisions, and even new curricula, to include a diversity of teaching experiences, including nonformal.

5. Most visitors in science museums and centers in Curitiba are middle school students.
6. Two new museums in the city require teacher and staff preparation. Museum administrators better understand the role of non-formal settings for educating school populations and the general public.

From these six statements and from the major issues identified earlier in the introduction, the goal of this project evolved: To develop a module to prepare pre-service teachers to use non-formal/informal settings.

To accomplish this task, input from the major stakeholders in the process was framed by the following questions.

1. What are the college instructors’ perceptions about what teachers should know in order to teach effectively in non-formal settings?

2. What are the perceptions of Science Museum/Science Center personnel about what teachers should know to teach effectively in non-formal settings?

3. What are the science teachers’ own perceptions about what they should know to teach effectively in non-formal settings?

To further inform the process, the research literature was reviewed to answer the following question.

4. What does the research literature suggest are the essential components of a module for teaching teacher candidates to effectively use non-formal settings?

These four questions focused the initial data collection and analysis process and resulted in an initial draft of a module, which was then piloted with teacher
candidates & museum interns\(^1\). The following question then guided the data collection and analysis process for the second part of this study, a pilot of the developed module.

5. What are the perceptions of teacher candidates about the effectiveness of the module for preparing them to teach in non-formal/informal settings?

\(^1\) Please refer to chapter II on the section of *Schools and Schooling in Brazil* to the definition of intern in Brazil.
CHAPTER II

Literature Review

This chapter starts describing post-modern features and their origins by depicting changes in developed societies. Then it discusses how these changes impact knowledge production and consumption revealing the rise of an “invisible infrastructure” (IRA, 1996) that is providing connections and initiatives for out-of school education in multiple contexts. Considering the boost of out-of school initiatives this review reveals some consequences for formal education and teacher preparation. The chapter then finishes with a portrayal of education in Brazil. There are four main sections. Postmodern world: Changes on character and status of knowledge, Informal and Non-formal Education, Schools and teachers in the postmodern era, Schools and schooling in Brazil.

The first section, Postmodern world: Changes on character and status of knowledge, argues that most of western society has entered in a new era, the postmodern era, where knowledge has a different status. Societal changes are described by comparisons between modern and post-modern characteristics, especially regarding knowledge production. Some features of the Enlightenment era and Modernity are compared. Then Lyotard’s (1983) description of the postindustrial and post-modern eras is posed to explain changes in knowledge production that created a different morphology (Castells, 1996) for western developed societies. The section closes arguing that the new societal morphology then requires different ways to educate outside formal school systems.
The second section, *Informal and Non-formal Education*, presents some definitions of formal, informal, and non-formal education in a chronological perspective, and then poses operational definitions for this dissertation. After that, the section discusses the multiple contexts of learning and the current trend of establishing an informal infrastructure that supports knowledge production and consumption in different settings, and values of this infrastructure for learning are posed. The section then focuses on pros and cons of alternative ways to promote learning outside formal schools such as media, science centers and science museums. The section's closing argument recognizes the value of learning in diverse settings, although it points out a need for integrating formal schooling in multiple learning contexts. In order to do that, this new demand called for a change in teacher preparation.

The third section, *Schools and teachers in the postmodern era*, discusses the discrepancy between formal schooling and societal intents. It claims that while some people have access to rich information environments, most schools are still focusing on classroom settings and teachers are still being prepared according to industrial era needs. The discrepancies among teacher preparation, school curriculum, and societal necessities are growing. While teachers and schools are focusing only on academic knowledge, society faces paradoxes such as people having overwhelming amounts of information with almost no preparation to make informed choices. Teachers no longer can rely only on their own knowledge and materials to teach science. Museums, science centers, and other places also changed, becoming more open to schools and educational goals. Thus limitations
and perspectives on teacher education and the use of non-formal settings are posed.

The fourth and final section, *Schools and schooling in Brazil*, delineates the educational system in Brazil from childhood education to the graduate level. This section informs the dissertation context. The chapter finishes with lingering questions on how to prepare teacher candidates to use non-formal resources and become more integrated to societal needs such as supporting life long learning.

*Postmodern world: Changes on character and status of knowledge*

In the last few decades, societies have experienced many changes. Developed countries’ societies are now computerized. These societies are driven by information technologies (IT) and efficiency plays a crucial role. These changes have impacted not only the economy or the way people deal with technology, but also the character and status of knowledge. Lyotard (1983) advocated that these changes redefined society entering a new era, the postmodern era.

Postmodern is a very broad expression applied to numerous disciplines. Thus before discussing the postmodern era and its societal changes, it is necessary to deconstruct the terminology and understand the main ideas of the postmodern precursor, the modern era.

Modernism is usually used to define an aesthetic movement of art, literature, and drama. Its roots may be traced all the way back to the nineteenth century. On the other hand, modernity is a different concept. Modernity is more encompassing and older than modernism. Modernity is related to the philosophical and sociological
movement to oppose “antiquity.” Its roots seem to go back to The Age of Enlightenment or even the Renaissance. The basic premises of modernity are deeply rooted in The Age of Enlightenment. Wyard (2003, n.p.) listed several features of Enlightenment:

1. Reason is the most significant and positive capacity of humans.
2. Reason enables one to break free from primitive, dogmatic, and superstitious beliefs holding one in the bonds of irrationality and ignorance.
3. In realizing the liberating potential of reason, one not only learns to think correctly, but to act correctly as well.
4. Through philosophical and scientific progress, reason can lead humanity as a whole to a state of earthly perfection.
5. Reason makes all humans equal and, therefore, deserving of equal liberty and treatment before the law.
6. Beliefs of any sort should be accepted only on the basis of reason, and not on traditional or priestly authority.
7. All human endeavors should seek to impart and develop knowledge, not feelings or character (n.p.)

Clages (2003) argued that Enlightenment ideas are almost the same as those of Humanism or of Modernism. Modernity is then ultimately related to order and rationality. The ordered society is the goal. Thus science is the primary form of knowledge because it pursues rational thinking and makes it possible to create order out of chaos.

For Lyotard (1983) pre-modern knowledge was basically narrative, a linear sequence of events in a story. Religion and myths were told to unify society by setting its rules. Stories were not always based in facts. In the modern era narratives were considered inappropriate. Local cultures or common sense were
deeply rejected as folklore or superstitions. Only science could produce truth. Thus modernity is based on notions of objectivity of knowledge. In other words, there is a real world that can be validated by an objective test revealing the truth, the objective reality. On the other hand, many things could not be explained by objective tests. The impasse was that science was not allowed to create narratives to describe scientific events. Lyotard (1983) suggested that two new mechanisms were created to legitimate science: legitimization and speculation. They are described as metanarratives.

Metanarratives are overarching stories or theories used to legitimate science via discourse, a discourse on the importance of science to reach order and truth, called metadiscourse. Thus modern science self-legitimates by metadiscourses.

As society entered into the postindustrial age the status of knowledge also changed. Lyotard (1983) suggested that the goal of science of seeking truth changed. The metadiscourse mechanism of self-legitimization lost its status. There was a growing incredulity towards science. The goal of science became efficiency rather than truth. Efficiency is becoming the self-legitimating mechanism. Wyard (2003) described postmodernism as “highly skeptical of explanations which claim to be valid for all groups, cultures, traditions or races, and instead focuses on the relative truths of each person (n.p.).” Knowledge is then considered a “productive resource” (Scarborough, 1999). The postmodern paradox is that its own positions and principles are not beyond scrutiny.
Gibbons, Limoges, Nowotny, Swartzman, Scott and Trow (1994) delineated the new phase of knowledge production into two modes of knowledge, summarized in Table 1.

**TABLE 1:**

Modes of Knowledge

<table>
<thead>
<tr>
<th></th>
<th><strong>Mode 1</strong></th>
<th><strong>Mode 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem is defined</td>
<td>By academy</td>
<td>By uses and application</td>
</tr>
<tr>
<td>Content</td>
<td>Disciplinary/</td>
<td>Transdisciplinary/</td>
</tr>
<tr>
<td></td>
<td>Homogeneous</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Who produces</td>
<td>Usually individuals</td>
<td>Team production</td>
</tr>
<tr>
<td>Where</td>
<td>In traditional research centers</td>
<td>In diverse sites</td>
</tr>
<tr>
<td>Organization types</td>
<td>Highly Hierarchical</td>
<td>“Heterarchical”</td>
</tr>
<tr>
<td>Types of knowledge</td>
<td>Pure or applied</td>
<td>Includes skills, experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and culture</td>
</tr>
<tr>
<td>Quality Control</td>
<td>By peer review</td>
<td>Peer review</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market acceptability</td>
</tr>
</tbody>
</table>

The two modes of knowledge coexist in the postmodern era and the second mode, under the complete relativism of postmodernity, is being more and more
accepted. Scarbrough (1999) emphasized that the changes in the social context are as important as the changes in the knowledge production locus. He argued that the social context created a new environment for mode-two knowledge called the network environment. Scarbrough (1999) also argued that changes in the organization context have led to a re-definition of knowledge. In the network environment, differences in social context resulted in changes in the nature of knowledge.

Knowledge in the network environment can be said to have ‘escaped’ in four different ways:

- Freed from traditional institutional constraints
- Leaked out through the loss of specialist expertise and key personnel attendant on restructuring
- Liberated from specific locales through advances in IT [information technology] networks
- Attempts to appropriate it through conventional management control (p.6-7)

For Castells (1996, p. 469), network relationships represent “the new social morphology of our societies.” Scarbrough (1999) emphasized that the greatest aspect of network relationships was not their structure but rather their lack of structure. Knowledge has been mediated within organizations through the development of chain relationships. Such network relationships have had an equally important effect in promoting the distribution and consumption of knowledge. However, Scarbrough’s analysis was that networks are able to “empower the consumer over the producer of knowledge” (p. 7). While many viewed networks only as capturing and distributing knowledge, he emphasized network roles as able to reconstitute knowledge. The information flow and flexibility on the network allowed conditions to replace the old established disciplinary forms of knowledge with new
ways of knowing. Thus, the development of Information Technology (IT) networks among and within organizations modified the old network diagram and reconstituted its architecture, establishing a new ecology for the production and consumption of knowledge.

In summary, this ecological system of networks makes the case for broadening education outside traditional settings of formal schooling. More specifically, informal and non-formal modes of education, such as media and science museums can fulfill an important role in supporting science literacy within communities by integrating cultural perspectives into exhibits and educational programs, in other words contextualizing learning in a “cultural milieu” (Colbern & Aikenhead, 1997). The next section discusses some definitions of formal, informal and non-formal found in the literature. The section poses operational definitions for this dissertation.

**Informal and Non-formal Education**

*Defining formal, informal, non-formal, free choice, and out-of-school education*

Only a few decades ago informal or non-formal education was rarely discussed as a research area. Today there is a fast growing body of knowledge and research in this field. New developments and concepts in educational research are thriving and informal education is growing in recognition and understanding. Typical of relatively new and growing fields, definitions are not uniform, leading to a
sometimes-confusing array of terms. Falk (2001) has traced the origin of terms such as formal, informal and non-formal.

The distinctions between formal, informal, and nonformal go back nearly 50 years and were first developed by individuals working in the area of international development as a means to distinguish the kinds of educational experiences individuals in developing countries had in the absence of an established compulsory education system. (p.6)

Looking carefully to that time, two names were prominent, Ivan Illich and Paulo Freire. Born Austrian, Ivan Illich came to the United States in 1951 and worked in a Puerto Rican community in Manhattan. In 1961 he co-founded the widely known and polemical Center for Intercultural Documentation in Mexico. From the rich discussions at the center many books arose, among them Deschooling Society (1971). In this book, Illich advocated for the creation of nets of learning and support. A paragraph on the introduction may summarize his ideas about school and schooling.

Universal education through schooling is not feasible. It would be no more feasible if it were attempted by means of alternative institutions built on the style of present schools. Neither new attitudes of teachers toward their pupils nor the proliferation of educational hardware or software (in classroom or bedroom), nor finally the attempt to expand the pedagogue’s responsibility until it engulfs his pupils’ lifetimes will deliver universal education. The current search for new educational funnels must be reversed into the search for their institutional inverse: educational webs which heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring. We hope to contribute concepts needed by those who conduct such counterfoil research on education--and also to those who seek alternatives to other established service industries. (p.1)

Paulo Freire was an educational thinker who emphasized dialogue as a way to use life experience to develop consciousness that was understood as a tool to transform society. His book Pedagogy of the Oppressed (1970) reflected on the
empowerment of communities, and social change. However, these concepts created for adult community education led to the idea of informal education. Freire and Illich were together at CIDOC. In 1976, J. L. Elias wrote a useful review on their main concepts.

In the United Nations Educational Scientific and Cultural Organization (UNESCO) report: *Learning to be* (UNESCO, 1972) three learning systems, formal, informal, and non-formal were presented. Combs, Prosser and Ahmed (1973) capitalized on UNESCO’s concepts providing concise definitions:

*Formal education*: the hierarchically structured, chronologically graded ‘education system’, running from primary school through the university and including, in addition to general academic studies, a variety of specialised programmes and institutions for full-time technical and professional training.

*Informal education*: the truly lifelong process whereby every individual acquires attitudes, values, skills and knowledge from daily experience and the educative influences and resources in his or her environment – from family and neighbours, from work and play, from the market place, the library and the mass media.

*Non-formal education*: any organised educational activity outside the established formal system – whether operating separately or as an important feature of some broader activity – that is intended to serve identifiable clienteles and learning objectives. (p.8)

These distinctions in definitions mainly focused on the location of the system, not on the process.

In the mid 1970s, “informal” was borrowed by museums and environmental educators to distinguish their activities from those of school-based education (Falk, 2001). The work of Maarshalk (1988) and Crane (1994) are examples. Maarshalk (1988) used “informal education” to refer to learning that takes place outside the
classroom while Crane (1994) defined informal as voluntary and not associated with a school or curriculum.

Another term that emerged based on site and focused on environmental education was “outdoor education.” Simon Priest (1986) established a definition of outdoor education based on relationships. He stated outdoor education is “an experimental process of learning by doing, which takes place primarily through exposure of the out-of-doors. In outdoor education the emphasis for the subject of learning is placed on RELATIONSHIPS, relationships concerning people and natural resources [capitals in the original] (p.13).” His definition is founded upon six points:

1) Outdoor education is a method for learning.
2) The process of outdoor learning is experiential.
3) Learning takes place primarily in the outdoor setting, but not exclusively in it.
4) Experiential learning requires full use of the senses, involves cognitive, affective and motor domains and also includes intuition.
5) Learning is based upon interdisciplinary curriculum matter (not necessarily school based curriculum).
6) Outdoor education is a matter of relationships, relationships with natural resources as well as people and society.

Priest created a metaphor of a tree with two branches to describe outdoor education. The trunk would be outdoor education with two main branches - adventure education and environmental education. The adventure branch is mainly focused on interpersonal and intrapersonal relationships. The environmental branch is concentrated on ecosystemic and ekistic (human ecology) relationships. The experiential learning process, represented by the leaves in his metaphor, interconnects all these relationships.
Gradually, definitions of terms and different modes of education based on the setting were refocused to include the learning process. Moreover, several authors developed frameworks to aid in understanding. Ramey-Gassert, Walberg III and Walberg (1994), modified Wellington (1990), and developed a framework for informal and formal learning and added features to the previous definitions. They compared formal to informal learning across multiple components including assessment, sequence, and curriculum connections among other things (Table 2).

TABLE 2:

Ramey-Gassert et al. (1990) Comparison of Informal and Formal Learning

<table>
<thead>
<tr>
<th>Informal learning</th>
<th>Formal Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Unstructured</td>
<td>Structured</td>
</tr>
<tr>
<td>Unsequenced</td>
<td>Sequenced</td>
</tr>
<tr>
<td>Nonassessed</td>
<td>Assessed</td>
</tr>
<tr>
<td>Unevaluated</td>
<td>Evaluated</td>
</tr>
<tr>
<td>Open-ended</td>
<td>Closed-ended</td>
</tr>
<tr>
<td>Learner-led</td>
<td>Teacher-led</td>
</tr>
<tr>
<td>Learner-centered</td>
<td>Teacher-centered</td>
</tr>
<tr>
<td>Out-of-school context</td>
<td>Classroom context</td>
</tr>
<tr>
<td>Non-curriculum-based</td>
<td>Curriculum-based</td>
</tr>
<tr>
<td>Many unintended outcomes</td>
<td>Fewer unintended outcomes</td>
</tr>
<tr>
<td>Less directly measurable outcomes</td>
<td>Empirically measured outcomes</td>
</tr>
<tr>
<td>Social intercourse</td>
<td>Solitary work</td>
</tr>
<tr>
<td>Nondirected or learner directed</td>
<td>Teacher directed</td>
</tr>
</tbody>
</table>

Note: Ramey-Gassert et al. (1994) Modified from Wellington (1990, p. 248)

Heimlich (1993) also focused on the learning process. He stated:

Informal learning has often been called ‘incidental learning’ in that opportunities for learning are structured by educators, but the choice of participation is entirely on the part of the individual. ... In informal learning, the
educator or interpreter defines what will be available, disseminated or aired for the learner, which correlates to the objectives of the program. The learner then controls the means of learning through choosing to listen, choosing to read, choosing to participate in the nature walk, or reading the signs on the self-guided tour. (p.4)

On the other hand, the discipline of communities and adult literacy also developed formal, informal, and non-formal definitions. Fordham (1993), adapting Simkins (1977) developed a framework (Table 3) to differentiate formal from non-formal, comparing purposes, timing, content delivery system, and control.

**TABLE 3:**


<table>
<thead>
<tr>
<th></th>
<th>Formal</th>
<th>Non-formal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purposes</strong></td>
<td>Long-term &amp; general</td>
<td>Short-term &amp; specific</td>
</tr>
<tr>
<td></td>
<td>Credential-based</td>
<td>Non-credential-based</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Long-cycle / preparatory /</td>
<td>Short cycle / recurrent /</td>
</tr>
<tr>
<td></td>
<td>full-time</td>
<td>part-time</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Standardized / input</td>
<td>Individualized / output</td>
</tr>
<tr>
<td></td>
<td>centered</td>
<td>centered</td>
</tr>
<tr>
<td><strong>Delivery</strong></td>
<td>Academic</td>
<td>Practical</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>Entry requirements determine</td>
<td>Clientele determine entry</td>
</tr>
<tr>
<td></td>
<td>clientele</td>
<td>requirements</td>
</tr>
<tr>
<td></td>
<td>Institution-based, isolated</td>
<td>Environment-based, community</td>
</tr>
<tr>
<td></td>
<td>from environment</td>
<td>related</td>
</tr>
<tr>
<td></td>
<td>Rigidly structured, teacher-</td>
<td>Flexible, learner-centered</td>
</tr>
<tr>
<td></td>
<td>centered and resource</td>
<td>and resource saving</td>
</tr>
<tr>
<td></td>
<td>intensive</td>
<td></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>External / hierarchical</td>
<td>Self-governing / democratic</td>
</tr>
</tbody>
</table>

Note: Framework adapted by Fordham 1993 from Simkins (1977, pp12-15)

Recently Colley, Hodkinson, and Malcolm (2002) did a comprehensive study to map the concepts of formal, informal, and non-formal. Their descriptions were detailed and indicated that there is almost no learning situation in which formal or
informal components are completely lacking. They concluded that frontiers among formal, informal, and non-formal need to be understood in particular contexts to avoid over simplification of the definitions, thus it is more helpful to explore “dimensions of formality and informality, and ways in which they relate to each other” (p.1)

Lewenstein (2001), discussing public communication about science when he identified other terms connected in some fashion to the concept of informal options including

- informal science communication
- public communication of science and technology
- popularization of science
- public understanding of science
- public understanding of science and technology
- public understanding of science, engineering, and technology (p.21)

However, the author indicated free-choice learning as a term that could consolidate the informal infrastructure.

Falk (2001), working primarily with museum education, reiterated that the physical setting is just one factor that may influence learning, and that while the physical setting is important, so too is “the social context and the underlying motivation of the learner” (p.7). To capture this meaning Falk (2001) strongly advocated for the adoption of free-choice learning as an alternative term that better captured the concept and range of activities in the field than did the term informal learning. Free-choice learning identifies with learning as a social construct. Its distinctive characteristics are voluntary, nonsequential, self-paced, and free choice.
However, this term is not yet as broadly accepted as informal learning, and even national organizations that opened the doors for this mode of education still call it informal education (NSTA, 1998). Other groups such as NSF (division of elementary, secondary and informal education) that provides funds for research in informal learning, and professional educational organizations like NARST, AERA, and ICASE are also opening special interest groups to discuss informal education. In addition, journals such as *Science Education* and *Science Education International* are opening entire sections for informal research papers, or even special issues. Thus, even recognizing the discrepancies in terminology, this dissertation came back to Combs, Posner and Ahmed (1973) and Coombs and Ahmed (1974) whose definitions were mentioned previously as transitory operational definitions, for formal, informal and non-formal settings. I chose their definition because in this study the setting, the locale where learning is happening, is an important issue.

In informal learning the learner controls his/her own learning, consequently a variety of understandings is possible, inappropriate interpretations and understandings included. Thus, informal learning may occur in an informal, non-formal, or even in a formal setting. For example, a father and his kids fishing in a lake and having fun can be considered as leisure. However, if they suddenly catch a turtle, the kids may become interested in knowing why the turtle has red eyes or whether it is a female or a male. They may ask, “What does it eat?”, or “Is the turtle going to survive out of the water?” At this time, their leisure becomes an educational experience and the father would be the informal educator. Moreover, this experience could act as a springboard to other educational experiences like going to a
bookstore to find a book about turtles, or to visit a science museum to learn more about the topic.

Having glanced at the conceptual dominion of informal and non-formal settings, it is now important to address the operational definitions for informal and non-formal.

**Operational Definitions**

For the purposes of this dissertation, informal setting is used to represent any sort of setting that does not have a stated educational goal but can be used for education. For example a beach, river, or even an inner city square can be used for multiple purposes such as entertainment, education, or even marketing. A schoolteacher or other educator may use these places to plan field trips and field work related to educational goals, such as collecting samples or studying the site as a whole, but the setting itself does not have a clear educational goal.

Similarly a non-formal setting is any organized institution outside the formal education system that carries educational goals. It is characterized as learner centered, nonassessed, and voluntary. A science museum, science center, zoo, botanical garden, or even a clearly signed park trail fit within this definition. There is a clear educational goal from the institutional point of view. However, a visitor may choose to learn (or not) in this setting.

Non-formal institutions have at least two advantages over schools and school labs. First, they usually have cutting edge equipment, displays and materials
available in many major areas. Because they have more diverse visitors and staff they can prepare more elaborate exhibits to the public. Second, they have trained professionals to design and create exhibits with new information.

**Multiple Contexts**

Informal education, representing any sort of setting that does not have a stated educational goal but can be used for education, is part of a huge group of activities including a myriad of contexts. Lewestein (2001) traced the history of popularization of science in the U.S. and found roots of these activities in the 1800s. He identified four trends of scientific popularizing at that time. First, leading scientists wrote for the public mainly to persuade them about the usefulness of science, to explore philosophical issues, and to appeal for a more scientific approach to the world. Second, the technological inculcation was designed to educate the lower classes and create a work force during the industrial revolution. Third, itinerant lectures and public demonstrations were used for education and entertainment reasons. Fourth, there were museum displays of curiosities that acted mainly as entertainment for the elite population of the time.

As for the twentieth century, Lewenstein (2001) described new strands of popularization of science based upon new technologies and the nature of science. The new strands were the rise of scientific societies and disease-related associations, specialization in science and other professional activities, the
development of new forms of media, and an increase in the public interest (or concern) about scientific progress.

After World War II, the demand for scientific literacy was broadly accepted. By the 1950s, environmental issues added a new need to understand science developments and dangers, and science journalism reflected that moment by becoming more critical towards science. In the 1980s, a boom of science museums and science media reflected the renewed interest in science.

In 1996, the IRA surveyed 440 institutions of non-formal education. The results suggested that there is an “invisible infrastructure” of informal science education institutions to support science. The ten major findings on this survey were as follows.

1. Informal science education institutions serve schools on a national scale.
2. School programs are a priority.
3. School programs are funded from local resources.
4. Informal science education institutions focus on elementary schools.
5. Informal science education institutions provide many forms of support for science education.
6. Informal science education institutions serve many teachers each year.
7. Many programs provide in-depth learning experiences for teachers.
8. Many institutions offer internship and residencies.
9. Many institutions of informal science education provide pre-service activities.
10. Informal science education institutions are serving schools with large numbers of underrepresented students.
Lewenstein (2001) advocated for the existence of an informal infrastructure that works together to develop the field. He defined infrastructure, as “a pattern of connections that provide for interaction, communication and progress – connections that help each of the sources accomplish things that otherwise could not be accomplished. Infrastructure provides for new initiatives” (p. 22). To delineate this infrastructure, Lewenstein focused on producers to categorize science information available to the public. His categories included government, mass media (newspapers, magazines, radio, television), museums, community organizations, industry, non-governmental institutions (NGOs), and nonprofit foundations.

Besides Lewenstein, other authors agreed upon the need for informal infrastructure (Luke, Camp, Dierking & Pearce, 2001; Falk, 2001). An infrastructure may help clarify definitions such as formal, informal, non-formal.

Having stated the operational definitions of informal and non-formal settings, and delineated the multiple contexts in which they happen, it is now important to address the role of media as a vehicle for informal learning as well as to intensify locate science museums and science centers as non-formal institutions.

Informal and Non-formal Settings in Education

There is a consensus among researchers regarding the educational value and potential of informal and non-formal education. However, there are ongoing discussions about how to use these settings or how to measure effectiveness, learning, values, or attitudes. There is also no agreement on a research agenda or
research designs and methodology. This section discusses some research results on the value of media (informal), science museums, science centers and other nonformal settings in education.

Media

The media have a tremendous influence on public perceptions and understandings and the communication era is changing the way we see the world. Dramatic changes in technologies have brought the globalization issue closer to the most remote and isolated communities. Television has enabled mass production with national and international exposure of relevant issues. Chen (1994) identified positive and negative outcomes. Positive outcomes of the media have been identified such as “helping broaden viewers’ narrow stereotypes of science and the work of scientists and can motivate an interest in related activities” (p. 52). However, the media can also present misleading information through international programs that are void of regional and cultural differences, especially with regard to small isolated and/or unique communities. Besides this negative side, Chen (1994) emphasized that the impact of the media remains largely unexamined by systematic research efforts. Wright, Anderson, Huston, Collins, Schmitt and Linebarger (2001) have studied the learning impact on child TV-viewers. They described a series of models to analyze the effects of “TV-diet” (p.91) and indicate the gaps and deficits on the mass media research.

In a 1988 study, Millar investigated the influence of the media on public perceptions and understandings of scientific information. He reported that often the
media is left to interpret scientific discourse. For example, the public generally demands pragmatic and straightforward information from the media but when the media turn to specialized opinion on the issues to be reported it may not find simple answers translatable to the public.

In short (sic), lay perceptions of what is possible for experts to provide by way of answer or information differ from experts' own view. The suggestion that it might be impossible to produce trustworthy knowledge of what is happening, and what to do (at the necessary level of resolution down to the scale of individual lives and daily practices), appears to be far from public minds. (p. 392)

In other words, research may not always supply straightforward, undoubted yes or no answers to the public because its own nature is limited. Thus, Millar suggested that, while providing scientific information to the public it is also important to provide information on the process of scientific knowledge production (internal process of science), and the kind of information that research may reasonably provide.

In a similar approach, Caro (1997) noted that differences in the interpretation of what should be included in a media program or museum exhibition reflected differences among science educators, the “science popularizer” (p. 220) (the person or group who will select and restate scientific information to a specific audience), and scientists' agendas. While science educators need to discuss general concepts of basic science, scientists do not work in basic science. On the contrary, they work in narrow fields producing sophisticated knowledge that may not respond to the public's immediate needs.
Hence, the researchers mentioned agreed upon the media’s potential to improve public understandings of science. However there is a concern about what the media should do and how effectively it can fulfill this role. Chen (1994) recommended a reconceptualization of media research to better assess the impact and effectiveness of the media contributions to the general public.

Science centers, Science museums

Besides media, museums, and other non-formal educational settings are other venues that stand to increase public understanding of science. For example, natural history museums, science museums, science centers, and nature centers are designed to provide information and educate the public. Many science museums are trying to overcome the traditional role of natural history museums as “places where to collect and preserve samples, as a depository for scientists, not for the curiosity of the crowd” (Caro, 1996, p.44). New museum missions are more democratic and inclusive than ever before, and may play a more important role if science museums take into account local/regional issues.

There is strong evidence that non-formal institutions could be meaningful learning environments (Falk & Dierking, 2002) not only due to their rich collections, but also because kids are more active in these environments (Inhelder, Sinclair, & Bovet, 1974). Falk and Dierking (2000) developed a learning model in non-formal settings that recognizes the importance of the social context in the museum experience. Besides this, exhibit designs are areas of research for science museums and science centers (Schauble & Bartlett, 1997; Borun, Massey, & Lutter,
Exhibits are being used as research tools for learning (Feher & Rice, 1985; Allen, 1997), and designers are preparing exhibits based on research results to improve learning experiences (Ramey-Gassert et al., 1994; Falk, 1997). With better exhibits the general public and students will have better opportunities to develop more meaningful understandings.

Bloom (1992) described further advantages of museum settings for learning such as their *sui generis* context as display arrangements, establishing a non-threatening environment. He also mentioned absence of time constraints that enable the public to stay in an exhibit for extended periods of time, the infinite number of times that a person could come back to review the subject, and the absence of formal evaluation. Additional advantages such as the possibility of the public to be self-paced and self-directed may increase intrinsic motivation (Csikszentmihalyi, M. & Hermanson, 1995). Non-formal institutions could be used as learning tools for anyone interested in learning, especially teachers. Hence, museums stand to make important contributions with respect to the scientific literacy of the general public. This is also true for the contributions non-formal settings can make to schools.

The increasing volume of research on media, science museums and science centers is undoubtedly bringing light to informal / non-formal education. And more than that, research is enlarging the informal field and establishing its infrastructure (Lewenstein, 2001; Luke et al., 2001). Thus, the challenge now is to understand how museums and media could be agents to promote discourse between different
cultures in a non-formal environment. There is a research gap on the role of informal / non-formal education regarding inconsistencies between public cultures and the culture of science. Martin (2001) recognized this gap and suggested a research agenda with new directions in informal education. One of the areas identified was the need for in-depth research on teacher preparation for the non-formal setting.

*Schools and teachers in the postmodern era*

Schools have a long history in western societies. They are secular institutions usually pictured as traditional places for knowledge transmission and knowledge status maintenance. Schools are then firmly based on Gibbon’s et al. (1994) mode one of knowledge production and transmission. Knowledge in this mode is centered mainly on the school site and on a teacher who is usually considered well qualified.

As the society changes, educational environments are being pushed to adapt to these changes. On one hand schools are having a hard time facing contradictions of the rapid and extensive change that is not being followed by teachers or even school systems. On the other hand, an invisible infrastructure (IRA, 1996) is growing to promote informal science learning.

Hargreaves (1996) suggested that there is a recognition that society has changed and we now live in a new era. In this era there are cultural diversity, technological complexities, and scientific uncertainties. People live in a rich information environment where changes occur in a high speed. However we have
more and more difficulties to deal with choices. Basic teaching and schooling structures were established in another time with a different set of goals; thus schools are not able to discuss post modern inconsistencies or even to face them and overcome their problems. Besides this, many teachers are still being prepared according to the needs of the industrial era where teaching was restricted to the classroom setting with students grouped by age level. In summary, society is facing paradoxes of the postmodern age while schools are still preparing citizens to live in the modern age.

Parallel to schools' anachronism, cultural and scientific knowledge produced outside traditional research centers is now being accepted. Because of this diversity of knowledge production, “in a knowledge rich age schools cannot continue to be exclusive or even necessarily the primary sites of learning. The places and modes of learning will increasingly become socially and geographically distributed” (Heath, 2001, p. 4).

Corroborating the idea of geographically distributed learning, the IRA report (1996) showed that 99% of science centers and 97% of natural history museums are supporting teachers, schools, and districts, providing more than one day field trip visits. The report mentioned that nearly one-third of all non-formal institutions offer programs that have pre-service connections. In fact, eighty-five percent of responding science centers rated their institutions' priority for school support programs "high." The survey offered evidence that institutions of informal science education are part of the infrastructure for science education. These institutions
serve more than 150,000 U.S. teachers teaching science (almost 10 percent of the total in the teaching force). Thus informal science education institutions do indeed provide infrastructure for science education, not only contributing to the teaching of science in the U.S. schools but also distributing education responsibilities to outside-of-school settings.

Limitations in Teacher Preparation for Informal/Non-formal Settings

If on one side, an informal infrastructure is growing and consolidating science education outside school settings, on the other side, the teacher preparation to deal with informal institutions is not growing at the same speed. Teachers are now facing more challenges than ever before to be prepared for all these changes.

Teacher education must adjust. It is fundamental that teacher education recognize the complexity of learning and the role other institutions play in knowledge production. In my experience with southern Brazilian teachers, they are not prepared to use non-formal institutions fully. During pre-service years, student teachers seldom have non-formal teaching experiences outside schools or education colleges. Heath (2001) described examples of teachers having a broader role, working as partners coming between diverse media and different sources of knowledge. Teacher education should then focus on guidance, mediation, and the use of knowledge in a useful way “the preparation of teachers must reflect the flexibility that the new environment will demand” (p. 6).
Based on the premises that society is changing and teacher preparation should focus on flexibility to adapt for these changes, this chapter now turns its focus on research results of current teaching practices. These practices belong to a reform movement that seeks to improve teacher preparation, professional development, and changes in science curricula.

A report from the National Research Council (NRC, 2001) on teacher education, revised from a 1998 version, mentioned that teacher preparation and professional development deserve a central place in education. The report reaffirmed some previous recommendations and included others, based on new research results on the improvement of teaching in science, mathematics, and technology areas. It pointed out that “improving the quality of science and mathematics teaching, the professionalism of teaching, and the incentives and rewards in teaching are issues that are now deemed to be critical to the national interest” (p. XI). It also mentioned that teacher education enhancement should be related to recommendations about what students should know and be able to do at various grade levels. These changes are of particular importance to science education because they affect the way teachers deal with knowledge and its different modes, and how they use out-of-school resources to teach.

Besides teacher preparation, a new science curricula movement is emerging. It recognizes a need to transform science curricula. Hurd (2001) commented on this reform movement and its main goal.

Revolutionary changes are taking place in the science within our knowledge-intensive society, and they are impacting our culture, the
economy, and the adaptability of people. We must have new criteria for the reinvention of science curricula. Traditionally, science curricula focused on inquiry and the facts and theories characteristic of a discipline, but a new view of science education is emerging. Its central theme is the utilization of science knowledge for human adaptability and welfare. In other words, students and their quality of life are the major focus of an education in the sciences.

The “standards” for the reinvented science curricula are seen as life skills: intellectual and social skills likely to increase the adaptative capacities of students and equip them for more productive lives. Examples of these skills include: (1) acquiring a literacy concept of the interaction of science and technology; (2) making decisions that recognize elements of risk; (3) recognizing the place of values, feelings, emotions, and ethics in making decisions about one’s life...life skills provide a mean of relating science and technology to everyday life. (p. 59)

In order to rethink curricula and teacher preparation it is important to redefine “science literacy for all” in the context of knowledge society. It seemed that the old definition did not include cultural aspects of literacy. Hand et al. (2003) discussed new perspectives to address literacy in science literacy. They cited the definition of science literacy of Norris and Phillips because it captured the dual meaning of literacy: “science literacy involves being fluent in the language, discourse patterns, and communication systems of science, and in the derived sense involves being knowledgeable, learned, and educated in science.” (Norris & Phillips quoted in Hand et al., 2003 p. 608). They argued that science communication - either oral or written - involves language, mathematical symbols, graphic representations, visual adjuncts, and physical gestures. In other words, it is multidimensional.

To address literacy multidimensionality the authors point out that

Language practices of the research laboratories and classrooms involve speaking, listening, writing, representing, reading, and viewing the
various signs gestures, texts and discourses related to doing science, understanding science and communicating science. These uses of language must be seen as a legitimate part of scientific literacy and must be considered in future education explorations so as to empower learning and inform instruction. In particular, researchers must consider the psychological, philosophical, linguistic, and pedagogical aspects of language in the unique context of science. (Hand et al, 2004, p. 614)

The multiple uses of language to achieve scientific literacy can be easily found in rich environs such as science museums and centers. These places are prepared to stimulate visitors’ senses with different sounds, smells, and tactile exhibits. In addition to providing a sensorial experience, some exhibits can make students reflect, think about, and review their positions about an issue. In summary, non-formal institutions are rich places to achieve science literacy. They can impact students’ intellectual and social skills, and ultimately improve science learning. Thus, in order for schools to start including current issues there are some changes that must be addressed. Teacher education must prepare teachers to regularly use non-formal settings as teaching tools, and schools need to include informal infrastructure as additional support to achieve scientific literacy. The next section presents research results and advocates for the use of non-formal settings in science learning.

Teacher Education and Informal Education

School field trips to museums, zoos, botanical gardens and aquariums are widely described as activities that enhance motivation by engaging students in
promoting learning. However, it is not enough to simply take students to these places. Excursions to informal settings need to be well prepared. Science teachers can learn how to plan and manage field trips in a science methods course. These courses can help future teachers develop skills needed and required by the National/State Certification Board. However, many college science teacher educators indicate a lack of time necessary to adequately prepare future teachers to effectively carry out field trips (Gioppo, 2002). Research has shown that inadequate teacher preparation leads to teachers over-emphasizing the use of textbooks. Yager and Penick (1983) considered that "the supremacy of the textbook is the most serious limit on science learning" (p.22). Furthermore, Yager (1983) noted "over 90% of all science teachers use a textbook 95% of the time; … the textbook becomes the course outline….". He also claimed "there is no evidence of science being taught by direct experience" (p. 578). Thus the need to understand and develop teachers’ adequate skills to use informal/outdoor education is imperative.

The UNESCO International Commission on Education for the Twenty-First Century had a meeting with a hearing session in Vancouver, in 1994. In this meeting a wide variety of topics were discussed, among them “multiculturalism, diversity in education, the relationship between formal and non-formal education, and the developments in science and the science of learning and their influence on the organization and process of education” (p.3). The meeting report addressed four main questions: “What kind of education do we want and need tomorrow? What kind of educational system, and what kinds of teachers are needed, and for what kinds of societies?”(p.4) To answer those questions the new world trends for
education and its paradoxes were discussed. One trend related to informal/non-formal education that was mentioned was

...the diminishing monopoly of schools over learning. Largely a result of development in information and communication technology, there has been a gradual but inexorable shift away from the schools as provider, storehouse and font of information and knowledge. ... children acquire, through television, radio, advertising, computer games, popular music, and so on, an increasing proportion of their information, beliefs, values, and attitudes, thus diminishing the influence and importance to them of what is taught in school (p.4).

The report also mentioned the changing role of the teacher in this new situation. It revealed that teachers, more than any other professionals, were fully aware of societal changes and the resulting pressure for schools and teacher competencies to respond appropriately. Teachers may feel the need to make the school more appealing than other media.

They [teachers] also are obliged, even to become involved in a broad range of activities that are more related to social services than to education and learning as they are generally understood, and they often feel ill-prepared to carry out these tasks (p.4).

Teachers must now expand upon their traditional roles and at the same time they have to maintain the student-teacher relationship. Because of these changes, five paradoxes and tensions that are the core of teachers’ expectations and roles were pointed out.

The first was the contrast between the fast speed of educational changes and benchmarks to sustain the processes of change. The second was the wide availability of communication and the increase of people’s isolation. The third paradox was the enhancement of educational conditions to create free time for teachers and the new administrative and evaluative demands that use almost all of
teachers’ free time. The fourth was the role of information availability on the consciousness of societal interdependence and the increase of the gap among unequipped communities. The fifth concern is related to the shift on the monopoly of education away from schools and the issue of teacher authority. If the teacher is not the only source of information any more the relationship between the teacher and what is taught is changed. However, teachers and students still see a teacher’s role as essential for learning.

The literature on teacher preparation for informal / non-formal settings revealed the claim for science educators to fulfill this demand. When researching the common uses by teachers for school activities in informal settings, Simmons (1993) found that almost half of the activities suggested by the teachers were recreation related. Thus she emphasized that “without direction, [teachers] will rely on the previous experience or stereotyped ideas of what can be accomplished in a particular setting” (p. 15).

Olson, Cox-Petersen, and McComas (2001) found that we must

...provide pre service teachers with experiences where effective field trip strategies are modeled for them, followed by the opportunity to develop and conduct a field trip with their own students while under guidance of a cooperating teacher and with support from university (p.169).

The authors reported that (after practicing effective field trip strategies) teacher candidates’ concerns shifted from simple management to focus on student learning. They found that candidates that had field trip experiences during their teacher preparation program “are more likely to take a field trip during their first
years as teachers.” Furthermore, candidates reported the master teachers’ comment that they (master teachers) "learned more about how to do field trips by watching the student teachers" (p. 169).

Studies of in-service (professional development) teachers and their visits to informal settings demonstrated the necessity to “reconsider the relegation of such visits to nonformal learning and to position the visits within the formal learning entitlement of the students” (Smith, McLaughlin, & Tunnicliffe, 1998, p.139). Their main finding was that “a zoo can be an important learning experience for students in the context of formal learning if their teachers are adequately briefed about the topic and opportunities for learning that can be found at the informal science setting.”

Dingra, Miele, MacDonald, and Powel (2001) related the results of different events for educators at the American Museum of Natural History in New York City and assessed the project impact on teacher participants and their classrooms. The authors used Vygotsky’s zone of proximal development concept and suggested that museum staff and museum artifacts mediate learning among students.

The paper described in detail different experiences and viewpoints on a collaborative model for science teacher preparation, which included museum educators, college teacher educators, and science teachers. The model was an effort to reform science education by means of integrating new approaches and practices into science teaching. These practices went beyond classroom settings to make science meaningful, inclusive, and related to students’ lives. Hence, teacher involvement was key to the success of the project. However researchers realized
that “... in the absence of effective teacher education with a focus on the power of informal science learning experiences and learning experiences in the museum context, museum-school partnership frequently end up being no more than field trips that are somewhat unconnected to the classroom curriculum” (p. 2).

Dingra et al.’s (2001) summative evaluation showed that participants’ sensory interaction with museum artifacts enhanced their learning. Teachers mentioned that the profusion of resources for teaching provided by the nonformal sites had a great value. They felt more confident to use the museum as a resource for teaching. Teachers mentioned that a methods course that used a museum as a pedagogical approach could also improve their science knowledge. Besides this, there was significant benefit on the affective domain.

Students [in-service teachers] appear to appreciate being included in the larger community of the museums ... It is my belief that the prestige of being welcomed into an internationally recognized institution such as the American Museum of Natural History helps to balance the assaults on self-image with which school teachers in low-income neighborhoods must contend on a daily basis.... Inclusion in the museum ‘family’ seems to help alleviate some of the stress. (p.11-12).

Besides using the museum as a resource for enhancing teachers’ morale, research participants mentioned their lack of preparation for field trips. “... most of the teachers in his district ... were not trained in what they or the students could do when they go to a trip. For them ‘a trip is just a day out in the field and hopefully you'll learn something’” (p.16). They also mentioned how important it is to be selective while planning the visit to avoid overwhelming students with too many different exhibits and displays.
Dingra et al. concluded that a combination of professional development with museum resources and a formal science methods course had positive results that could later be traced in classrooms. The interaction of formal and non-formal gave teachers new insights on how they could learn and use museum resources for teaching. The paper finished by recommending that teacher education programs include informal science learning experiences for teachers to make them aware of the available resources. “In order to prepare public school teachers to teach science effectively in urban settings, it is important that one of the goals of the teacher education program be to help teachers see the rich resources that exist and that are easily accessible to them for teaching purposes “(p.20).

Griffin and Symington (1997) investigated strategies used by classroom teachers before, during and after the visit to a science museum. Results indicated that teachers mainly used task-oriented strategies. They suggested that teachers often have blurred goals for their visits to a science museum. Only 50% were able to describe a goal for the museum excursion that was related to curriculum content. Less than half of the study sample were able to link the visit and the topic being studied at school, and believed that the museum was responsible for this lack of connection. Researchers suggested that as a consequence of this disconnection as well as teachers’ attitudes toward the visit, student learning would be affected. The authors designed a learning –oriented framework for planning field trips to museums.
Kisiel (2003) studied how teachers prepare and use worksheets in a museum setting. He found that museum experiences were influenced not only by the design of the worksheets, but also by how worksheets were used. These worksheets provided important information on how teachers used museums as learning environments. He noticed that many teachers used worksheets to introduce structure and to control a “potentially chaotic setting.” (p.9). Besides worksheet design and use, Kisiel (2003) found that the level of teacher or chaperone involvement with students greatly affected worksheet effectiveness. He concluded that if training in-service teachers to deal with field trips and worksheets in non-formal settings is important, it is even more beneficial and important to introduce pre-service teachers to these concepts. “Creating an effective learning experience in a museum is more than creating an effective worksheet. Teacher, student and especially the museum must all be prepared to contribute to this goal” (p.20).

Although there is no consensus on the use of worksheets in a museum setting, there is a general agreement on the advantages of field trips for learning.

Manzanal, Barreiro and Jiménez (1999) reported that students who had participated in a field trip acquired a new and deeper scheme of knowledge, and a more solid understanding than the control group. “The field trip gave the pupils concrete data, which fit in with the information that was imparted later in the course” (p. 450).

An examination of the previous literature suggests we need to understand how teachers are being prepared and how they could use informal settings to
capitalize on the field trip experience. This study could be useful to science educators who intend to teach pre-service students to use fieldwork more effectively by focusing on students' learning. Furthermore it could provide information that may assist with the reorganization of a science methods course, helping define what should be included/excluded in it.

Preparing teachers to use these resources, teaching them how to select and evaluate information, can support lifelong learning of teachers and students.

_Schools and Schooling in Brazil_

A brief description of the Brazilian Educational System and some statistics are provided to better inform the context in which the dissertation was developed. The educational system in Brazil is subdivided into five levels and a description of each follows.

_Chandhood Education (Educação Infantil)_

This level includes children from birth to six years old. It ranges from day care to kindergarten. Most of time kindergarten is offered at the same facility as primary schools.

_Grammar School (Ensino Fundamental)_

At this level, students range from seven to fourteen years old. It is divided into eight years. The first four years were called primary school (1st to 4th grades), and the final four years were called middle school (séries finais). Even if primary school is the common and well-known name among parents and the population,
they are dated on the educational documents and education boards, who use only Ensino Fundamental.

High School (Ensino médio e ensino profissionalizante)

The length is variable for college path (3 years) or technical path (4 years). The college path occurs far more often than the technical one. The main difference from the US high school system is that most of schools have only one set of courses required for all students. There are no optional courses, thus most of the time enrollment is not based on courses but on grade level. There are also no different level courses (average, honor, or AP courses). The usual scenario is a group of students enrolling on the first high school grade (9th grade) staying in the same classroom and doing the same courses during all three high school years. Most of the time the teacher changes class not students. This makes the group very strong and connected.

In the last high school year (Third year so called Terceiro ano), some students prefer changing schools and going to a preparatory test year school. These popular schools focus only on the college test. They prepare students to pass the test offering a review of all high school content. These schools do not offer lab or out of class activities, but they offer tutorial support. All of them are private schools for middle and upper classes. Each classroom is a theatre having between 150 to 300 students; all students will be competing for university seats. Since 1996 the educational law changed and high school level is now being added gradually to
the required level of education. Lower class students can now have free high school, books, and meals.

*College Level*

The college level comprises all undergraduate programs. The length may vary between three to six years, depending upon the program. The majority of courses are required in most programs. There are only a few optional courses available for each program. Enrollment is usually based on semester or annual courses.

Intern has a slightly different meaning in Portuguese, since an intern can be an undergraduate student doing required internship but it can also be a voluntary work, just to grab experience and enrich one’s resume, without any credit hours. Internships may have financial support for undergraduate students, but if it is part of their course work it can be with no funds. The same apply to graduate students, excluding former students after graduation with no connection with an educational institution.

*Graduate level*

The specializing degree is the lowest graduate level. Programs usually have a minimum of 360 hours with a monograph product at the end, most of them with a defense. Students have an advisor but the other members of the committee are known only on the defense date. MBAs are usually included on this level.

Master and doctoral programs are usually academic. Brazilian Universities do not have an educational doctorate, however they may have professional mastery.
These types of programs are now growing fast in number, but they are still not significant in science education at this point. Masters programs usually have 30-40 credit hours and Doctoral programs another 40 credit hours.

Among the population of 25-years-old and older (85.4 million), only 5.8 million have college level, in other words only 6.8% of this population stratum. However since 1991, the number of people with college level grew 17.8%. At that time the population 25-years-old or above was 67.2 million, and 3.8 million (5.7%) had an undergraduate or graduate degree. However, from the population with a college degree, 80% are white and 20% are African descendents, Indians, and Orientals. Brazil has 5.8 million people with college degrees; from this total 4.6 are white. When comparing school level with race, numbers show that almost 10% of white people have a college degree, among African descendents and Indians the number drops to 2%. Even if the white population represents the majority of college degrees in absolute numbers, the Asian descents are the ones with the best index. According to IBGE, among Asian descendents 27% have a college degree. When considering gender, there are more women (3.1 million) than men (2.6 million) with college degrees.

Regarding schooling at other education levels, the schooling mean grew at all age levels since 1990. The biggest difference occurred among students between 18 and 19 years old. In 1992, the average for this age level was 5.9 years at school; in 1999 the average went up to 7.3 years at school.
Brazil entered the 21st century with 97% of children between 7 and 14 years old at school. However we still have 29.4% of people 15 years old or older being considered “functional illiterates” (people 15 years old or older that studied 3 years or less). This number dropped from 28.9% in 1992 to 21.8% in 1999 in the south but it is still very high.

As for students age 15 to 19, the problem of enrollment is far from solved. According to OECD (2001) 78% of students between 15 and 19 years old are at school, most of them are still on grammar school, because the high rates of distortion age/grade. School census 2001 (INEP, 2001) revealed that 53.3% of students enrolled were not in the correct grade for their age. One reason is that almost 50% of High School students work full time and study on the evening shift. High School test results for these students were way below the non-worker students. In Paraná state, the test mean results were 277.5 (intermediate level) for non-worker students and 249.2 (critic level) for worker students, the last ones have a knowledge level equivalent to what is expected of 4th grade students. The information above suggests that an action is urgent to change these features. This dissertation proposes a change on teacher preparation level

Summary

Summarizing a review of the literature we see that post-modernism characterized changes in society and the way we learn. As a consequence, formal, non-formal, and informal education are being redefined. A review of the literature on informal / non-formal education helped delineate working definitions for the
terminology used throughout the dissertation. Then, reviewing research on non-formal institutions as learning environments indicated that there is strong evidence of many advantages for learning in these places. However, there is a lack of research on how to promote science communication with formal students from different cultures in a non-formal environment. The literature on teacher preparation for informal/ non-formal education showed that research is mainly focused on professional development for in-service teachers, and we need a strong commitment from college instructors to set up a model for their students as needed. Finally some information on the Brazilian Education System and recent statistical data revealed the urgent need to change the ways Brazilian students are being taught.

The literature reviewed in this chapter showed that there are still lingering questions on how to prepare pre-service teachers to use non-formal resources to support science education. Chapter III presents the methodology used in this study to answer these questions.
CHAPTER III
Methods

The goal of this study was to develop a module for a teacher preparation program to enhance the effective use of non-formal/informal settings. To accomplish this task, the research project was carried out in three steps. In step one, I collected information by interviewing three groups of professionals: science teachers, college instructors (working with a science teaching program), and museum/ science center staff. In step two I used information from the interviews and findings from the literature on the topic to design two modules to enrich the use of non-formal/informal science education, for teachers and museum educators. In step three, the lesson plans using non-formal/informal environs were piloted by teacher candidates from the biology education program at the Federal University of Paraná in southern Brazil. Chapter III describes each step, the sample characteristics, the details for each module design, and the pilot tests. Figure 1 summarizes the method utilized during throughout this study.

Step I: Collecting Information - Interviews

To design the modules I sought the perceptions of professionals about the use of non-formal/informal settings by school groups and their teachers and asked for suggestions on designing them. Museum staff would give me the perspective of the insiders, the people who work with students and the general public while they
are in the museum. This would provide insight into the difficulties faced daily by these professionals. Science teachers would give me the perspective of the school itself, logistics and school policies that could facilitate (or not) out of school activities. The college instructors would give me the perspective of professional education regarding the needs and desires for change along with university bureaucracy to modify a course syllabus or plan an off-campus activity.

Selection of interviewees

As for the museum staff I interviewed three museum professionals from south and southeast regions of Brazil. These museums and centers were all part of university systems, thus interviewees were university employees. All three of the interviewees worked in state capitals; one was selected because he works in a large, well recognized science center, the second one was chosen because he works in Paraná state, in a small natural history museum, and the third one was chosen because he is director of a non-formal program connected to the university. Besides this, more than one person working in a science museum or center recommended the subjects to me because of their positions, their importance to the field, and their openness to education issues.

All three of these interviewees work in institutions supported by a university system. They all have graduate degrees in a science area. None had any degree in education or administration, although two were in higher administration positions. These professionals were chosen as research subjects because they worked in well-known institutions. Two of them were members of the Natural History Museum and
Science Centers Association (Associação de Centros e Museus de Ciências). Visitors to these institutions come from well beyond the local community level.

Figure 1: The research method flowchart.
As for college instructors, I interviewed three subjects, in Paraná State. They all had majors in science, graduate degrees in education, and work at a College of Education. One has a Ph.D. in Education. The second one is a doctoral student in science education and the third one is a master instructor in science education. Instructors from Paraná were preferred not only because of their knowledge of Paraná universities public, but also because they have experience teaching in pre-service teacher programs. Thus they know the daily needs of teacher candidates, in-service science teachers, and middle/high school students. These subjects were also available and willing to participate in the research interview.

Three science teachers were chosen based on the recommendations made by college instructors and museum personnel during their interviews. They provided the names of teachers who were doing high-level activities inside or outside the classroom. Two of the teachers selected also attended the science teacher conference held in South Brazil in July 2002. Two are Paraná State Public School System employees and work with middle and high school levels. The third one is a doctoral student in science education. His dissertation topic was on a program developed in a science center.

*Interview structure and analysis*

A topical interview of the type selected for use in this study was defined by Glesne (1999) as “an interview in search of opinions, perceptions, and attitudes toward some topic. This would be a form of topical interviewing that focuses more
on a program, issue, or process than on people’s lives,” (p.69). It was planned with
three major questions:

1- What are the difficulties of doing an out-of-school activity?

2- If you were helping design a course for teacher candidates what topics
would you include to help them effectively use informal/non-formal
settings?

3- Based on your experience visiting / working at an informal/non-formal
facility, what should an intern learn to be able to effectively teach in these
places?

The analysis of interviews was based on constant comparisons of data
(Schwandt,1997) or as summarized by Schram (2003):

... constant comparison means that the researcher looks at indicators
or incidents from the data (actions, events, perspectives) for similarities and
differences. From this the analyst identifies underlying uniformities in the
indicators and constructs a preliminary category or concept. These
categories are compared with each other and with additional indicators from
the data to further define the concept. (p.75)

In this dissertation, transcriptions of interviews were made and categories
arose from the data. From constant comparisons, categories were merged and
refined, and then a table was constructed listing the categories of responses given
by the interviewees. Interview responses and emergent categories were compared
with the literature on the topic “bringing together prior theoretical commitments with
emergent and evolving analytical schemes” (Schram, 2003, p.74). Using this
comparison, two modules for the use of non-formal settings were designed.
**Step II: Designing the Modules.**

Interview responses and the research literature enlightened the conception of two modules. They were designed to be tested on the Biology Education Program at Federal University of Paraná. I focused on the existing courses of the program trying to implement these modules with minimum changes on the course syllabus. The main goal was to use the existing structure and change the perspective by linking isolated courses and instructors with a common project. Each module had a portion for candidates to pilot with their students. In this portion, each module was piloted twice, one with school students and the other one with peer teacher candidates. Module designs are described in the results chapter.

The first module was designed to teach science teacher candidates to effectively use informal science education. At the beginning I designed this module to be used at the Science Park, in Curitiba. However, because of the delays opening the facility (see chapter 1), I rearranged the module to be used in an informal field trip for middle/high school students. The second module was designed for museum interns to effectively use non-formal institutions to teach science. The design was established to meet the needs of the Natural History Museum at UFPR and the needs of schoolteachers while visiting a natural history museum, and to try to discover ways that museum interns could improve the school excursion visits.

Module II was designed as an internship activity in the Biology Education program. The students were also teacher candidates from the same program as the students on module I. However they were doing a required internship that is usually
done during the last semester, called 8th period (senior year). This internship is related to education but not restricted to school settings. Students are allowed to do their internship in non-formal or informal settings, at the university as teaching assistants, or in any kind of activity related to education in general. The module was born when two teacher candidates working as museum interns came to me because they heard I was studying non-formal education. They asked me to supervise them and help them develop a small research project for their internship. This module would be much smaller than the first module because I needed to design it for one semester course, thus interns would address able to address only museum immediate needs.

*Step III: Modules application*

*Module I*

We started with a group of forty-seven Biology Education program teacher candidates enrolled in a science methods course that I taught, during the 2003 Fall semester (April to August). It is important to point out that the regular fall semester at UFPR goes from mid-February to the end of June. However in 2003, the university was still making up classes from a huge strike that happened in 2002 and took more than 90 school days, so the beginning of the regular fall semester was delayed.
During the course, candidates were invited to apply for a two-week summer workshop in the U.S., offered by NCSU and Sci-link\textsuperscript{2}. For this extra-activity candidates were chosen based on completion of Basic Geology and Invertebrates courses. They were required to be proficient in English and have financial support to pay for their own trip. Five candidates along with two college instructors from UFPR were selected to participate. Sci-link / NCSU provided financial support for food and housing.

During the first summer workshop week the group learned about Mapping Our School Site (MOSS project), using Geographic Information System (GIS) and Arc View software. The focus was on profiling a school site and learning how to input data on the software. In the second week, the group was at Grandfather Mountain learning about the mountain environment and its geological features. At the end of the week candidates were asked to develop a lesson plan to discuss a science topic at school. At this point UFPR instructors met and brainstormed lesson plan topics to be researched in the field. They checked possibilities, listed materials, and references. Then UFPR instructors and candidates sat together. The same brainstorm strategy was used to discuss and decide on topics. Topic selection was based on feasibility of implementation in Brazil and elsewhere, since the idea was to have international connections, and relevancy for the South Brazil school curriculum. Topics should be doable when tested in a real school environment, and the lessons

\textsuperscript{2} Sci-link is part of the Department of Mathematics, Science and Technology Education on the College of Education at North Carolina State University. It works mainly with in-service education programs and it is well known among N. C. science teachers because of Grandfather Mountain workshops that bring people from all over the United States to study North Carolina mountain environments.
should include a fieldwork activity related to a follow up lab activity. Candidates designed five lesson plans to use informal settings to teach science.

Module I- Pilot 1 with High School Students.

After returning to Brazil we searched for schools that would be interested in implementing the lessons. The option for public schools was related to a “pay back” for studying in a public university, since in Brazil public universities are totally free of fees and tuitions. So candidates that are supported by public universities should be offering public schools some kind of help and support. Three schools were chosen according to the lesson topics or needs. Then a small research project was designed to test the lessons. Each project is described separately for context comprehension.

*Project Structure*

Four out of five projects followed a similar structure. High school students

- Filled out questions adapted from a socioeconomic questionnaire used by the government to test high school students (ENEM test).
- Answered a pre-test on the topic with open-ended questions.
- Discussed contents related to the project and planned the field trip (pre-trip).
- Carried out a half-day field trip.
- Engaged in a follow up activity: animals, plants, and fungus identification (according to the project). Input data on spreadsheets. Created graphics with data collected. Analyzed data and drew conclusions.
• Answered a post-test.

In the other project, high school students:

• Filled out selected questions from a socioeconomic questionnaire used by the government to test high school students (ENEM test).
• Answered a pre-test on the topic with open-ended questions.
• Discussed contents related to the project and built rain collectors.
• Collected rain in different places.
• Entered data on spreadsheets. Entered data on a map. Created graphics with data collected. Analyzed data and made conclusions.
• Answered a post-test.

Characterizing projects and schools.

A description of each project content, students involved and schools characterization follows:

School 1

After reflecting upon the public schools’ poor financial conditions without regular transportation for students, candidates and I decided that there would be a better chance for the project to succeed if we chose a school at the coast instead of choosing a school in Curitiba and then trying to find an activity bus to travel to the coast. Thus we contacted one school for both projects, 1.5 hours away from
Curitiba, at Paraná’s coast. The principal immediately accepted our offer and was very excited with the opportunity because they had never had contact with any university project before. The night shift\(^3\) was chosen mainly because teacher candidates could have regular classes during the day, travel to the coast and work on the project during the evening once a week, and the next day go back to Curitiba for regular classes. Fortunately, the biology teacher for the evening shift was also a part time Ph.D. student from the UFPR Marine Studies Center working at school during the evening to pay for her studies. On the other hand the school was a very poor one, the science lab had no computers for students and no science equipment. There was only a sink, tables, and two microscopes. The school had no photocopy machine to prepare the activities. All the materials for the fieldwork were brought from Curitiba, either borrowed from the university or given by a private company that supported this project. The school had 280 high school students on morning and evening shifts. Twenty-two students participated in both projects; most were full time workers and came to school during the evening. The socioeconomic questionnaire revealed that the majority of students’ parents were illiterate or had finished only 4\(^{th}\) grade. Seventeen out of 22 family incomes were between US$ 300-350 per month. Most students were Year One (comparable to 10\(^{th}\) grade) girls with a mean age of 17 years old. Two projects were implemented at this site.

*Project 1: Beach Sand and Beach Profile.*

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\(^3\) It was mentioned on chapter II, under *school and schooling in Brazil*, that most public schools have three shifts a day. Morning, afternoon and evening shifts. Evening shifts are usually preferred by worker students.
The project’s main goal was to design a profile of the sand beach and relate it to the sand grain size. In order to do that, students needed to understand waves, beach formation, and its relation to weather conditions. Then the candidates prepared a lesson to introduce the topic of waves, beach formation, and differences on coast profiles. They also discussed the field trip with the class. After that they went on a four-hour field trip to the beach during low tide. While at the beach they collectively decided where to draw a beach transect\(^4\). They measured highs with two different instruments; one using pipe and water, and the other using a regular topographic instrument. After that they measured 10 different points from the dune to the water and dug 50 x 50 x 50 cm holes. They put the topsoil sand into a plastic bag, measured the height of the tide, and came back to the university lab at the coast. At the lab the sand was dried for 24 hours and grain size was measured. With the data they created a beach profile from the dunes to the water and included sand grain size in each point.

*Project 2: Animal Distribution Along the Beach.*

The second project was similar to the first one. However, after digging the sand, students sieved and washed the sand searching for small invertebrates. Because projects were similar, candidates worked together with the same group of students, moving them around to participate in both activities. From the 40 students invited to participate, there were only 22 at the second field trip trial, possibly because of weather conditions (three field trips to the beach were necessary).

\(^4\) A beach transect is a line that starts on the low tide point and finishes on the dunes or beyond, thus it cuts the beach perpendicularly.
because of bad weather) or, since it was on a Saturday morning, and some students worked on Saturdays.

_School 2:_

The school chosen for Project 3 is on a limestone site, in the Curitiba area, one hour from Curitiba City limits. The school is in Colombo town; it is the major school of the city and receives all students from rural areas of the county. The teacher candidate had 69 morning shift students of the Year One (10th grade). Most of them (45) were sixteen years old girls. A socioeconomic questionnaire revealed that family income was between US$ 300-350 per month for the majority (43), however 11 families would have incomes of US$ 460 per month or above. There were 28 parents who had attended school only until 4th grade. As for the science laboratory there was some equipment but no computers. The school had a photocopy machine for students and teachers were allowed to use it for a small cost.

_Project 3: Acid Rain in Karst (Limestone) Topography_

The third project was analyzing the effect of acid rain on limestone topography. The main idea is that limestone geology is favorable to create caverns. Thus if there is acid rain with this topography, caverns will be endangered. The topics discussed were rain formation, acid rain and pH. Because the project was weather dependent, the teacher candidate proposed the construction of rain collectors. Then students could collect rain anywhere in the county. Recycled beverage containers were used to build rain collectors and filters. Students could
take them home and collect rain whenever it happened. On the day after the rain, students brought rain collectors back to school to test pH. A map of the region and zip codes were used to locate each collector, even the ones in rural areas. Rain was collected and measured during a period of 15 days. Tables and graphs were prepared to analyze the results. The group planned a cavern excursion, but because of the weather they could not make it.

School 3

As projects 4 & 5 needed a preserved natural area with high quality water, which would be very difficult to find close to a school, we chose a school that had its own activity bus (most of them do not have their own buses for students’ transportation or activities). Although it is being a public school, it has federal financial support, being a much richer school than the average public school. The bus allowed flexibility to plan the field activity. The school had 800 students in middle and high school levels together. There were 300 high school students studying during the morning. Lab classes, sports, or extra-classes were always during the afternoon and students were not required to participate. For this activity candidates had one initial contact with the teacher, explaining the project and the activity. They collectively decided on the grade level that should be invited to participate. Students from Years One and Two (corresponding to 10th and 11th grades) were invited. Twenty-three students showed up, all from 11th grade. A socioeconomic questionnaire revealed that 55% of parents had a college degree. Family income was US$ 2000 per month or above, and all students of the sample
intended to have a college degree. The activity was proposed for three afternoons, one each week. The school had a good lab with all necessary materials, including identification keys. The teacher has a Master of Science degree in education and he was very interested in strengthening the partnership with the university.

*Project 4: Searching for Macro-Invertebrates in a Creek*

This project’s main goal was to analyze what kinds of macro-invertebrates could be found in a creek. This teacher candidate chose a wild natural area 1.25 hours from Curitiba. The candidate worked with Year Two (11th grade) students. They discussed creeks and invertebrates in a 50-minute session. The next activity was to carry on a four-hour field trip in a spring water area to collect and separate macro-invertebrates. The class following the field trip was in the lab to identify the animals and input data on a spreadsheet. At the end of the activity, they related macro-invertebrates with water quality, identifying animals that indicated pollution and the ones that are resistant to polluted water.

*Project 5: Life in a Dead Log.*

The project’s aim was to find three dead logs from natural areas in different stages of decomposition and check what kind of life would be there, then compare the three levels of decomposition in terms of diversity of life (animals, plants and fungus). Because this project was supposed to search for dead logs in natural areas, the teacher candidate worked with the same students of project four. By using the same bus and students, both activities could be done on the same day.
Informal Meetings

Candidates and I discussed problems and expectations on different occasions all during the project application process. However, at the end of each project, when they had pre-and posttests to compare we arranged a meeting and had a more contextual discussion on each part of the pilot. We talked about their impressions of the schools, the teachers, and their lesson plans. Candidates evaluated their lesson plans by comparing their expectations before to the implementation to what really happened. What was good and what went wrong? Meetings were usually very informal conversations between candidates working in the same school and me. Sometimes, while I was at school visiting them and checking their progress, the teacher would also sit with us either to have input on the next step or to give suggestions on the improvement of their lessons. I took notes on candidates’ main complaints and what they liked the most, their expectations and so on. Information collected during these meetings was analyzed in terms of what to change and what to keep in the module. In addition, this information determined the changes for the second pilot.

Module I – Pilot II with Science Methods Course Students

We decided to re-test the projects to check teacher candidates’ reactions to an off-campus field trip in the course. The design was tested again during the 2003 spring semester (September 2003-February 2004) science methods course. To avoid confusion this group will be called the methods course students. Teacher
candidates who developed and implemented the projects will still be called teacher candidates. During the spring semester, the science methods course had a group of 47 students, most of them females in the Biology Education program, junior year (called the 6th period).

Before the pilot, methods course students had participated in a small excursion to a science center in Curitiba, and developed a three-phase excursion lesson plan for a school. At that point in the course, methods students had not had lessons on doing laboratory or field trip activities.

Candidates first presented all five projects piloted at the schools, discussing the strengths and problems as well as students’ reactions. Then we collectively discussed the idea of modeling one of the projects with the group. Candidates and methods course students decided to use the project on animal distribution on the beach. The school at the coast offered its campus for students to sleep there. The biology teacher from the school, who participated in the previous pilot, offered to come and teach about animal competition on a rocky coast. The group left Curitiba on Friday at 6:00 p.m. and came back on Saturday at 8:00 p.m.

On Friday evening, the methods course students were introduced to the teacher who discussed her activity on the rocky coast. Saturday morning we went to an area that had a sandy beach and a rocky coast formation close to each other. Half of the group was on the rocky coast, counting animals and analyzing measures. The other half was with the candidates digging sand and profiling the beach. This pilot was different from the previous pilot in that candidates had to go to the field
three times in order to have a good collection and they decided to start digging from the beach to the dune area, to avoid losing some points when the tide was rising. They also decided to dig 20 x 20 x 20 cm holes on one side of the transect and 50 x 50 x 50 cm holes on the other side of the transect. Then, methods students would have a parameter to compare and decide about the better method to collect animals on a sand beach. These changes were based on results from the previous pilot.

On Saturday afternoon, we went back to the school campus, identified animals, input data on spreadsheets, analyzed data, and created graphics with data collected. Then we discussed the field trip and lab connections, field trip logistics, and safety precautions. At the end of the afternoon, after hours of analyzing data, we asked methods students for their perceptions on the activity and its use in a school. We also asked for input on the improvement of the activity and the difficulties we could have when trying it with a school class. The teacher coordinated the activity and I recorded notes. The methods students were together in the lab and talked openly. Although they were tired after the intensive two-day trip, they talked for about half an hour. They even mentioned the importance of the field trip modeling for the college level. Students’ suggestions and complaints were later analyzed collectively with the candidates and teacher in terms of the viability of this activity in the methods course and what should be changed for next field trip with methods students. It was clear that the activity was not to be discarded.

*Module II*
To implement the module for teacher candidates working as museum interns, we chose the Natural History Museum at Federal University of Paraná because its facility is inside campus. Most of the museum visitors are middle and high school students, and most interns are enrolled in the biology education program at the Federal University of Paraná, while working as museum interns and teacher candidates.

The museum choice brought advantages and disadvantages. The advantage is that interns had a twofold role there. They were working in the museum and assisting schools that were coming as visitors, yet they were teacher candidates in the biology program. Thus as interns the candidates would have the perspective of insiders, persons who assist students and teachers when they come to the museum. They know whether the teacher planned the visit. They even know if the teacher came to visit the museum in advance. They know all the exhibits and the difficulty level or interesting things to talk about for each one of them. The model they would be planning, designing and testing a small activity connected to an exhibit.

As teacher candidates the interns were doing their practicum internships, so they could have the perspective of outsiders, the prospective teachers who came to visit the facility. They could bring students to participate in one-shot short educational programs. With these two roles the participant interns had a unique opportunity to be familiar with both sides, understanding the work of each side so they could attach greater value to the non-formal institution as a resource for science education.
The disadvantage was that the museum is in the Biology Institute and, even recognizing the effort and hard work of museum personnel, we also know that museum exhibits and design need continual improvement to be congruent to its main public, middle and high school students. Thus there was a paradoxical situation that riddled us while developing Module II. The idea then was to create a strategy to hear all people involved and then develop a proposal without creating unnecessary disagreement. A different approach was to add to, or expand on museum staff members’ ideas, not to superficially criticize their work. To avoid developing a module based on pointless issues, the first step was to talk to different professionals involved in museum education programs. The next section describes museum immediate needs that helped focus the design of activities.

The Museum and Museum Needs

The Natural History Museum at UFPR is a traditional museum with stuffed animals and collections behind glass. There are a few terrariums and aquariums with live animals and plants. There are no discovery rooms or alternative materials for children or adolescents. It has a very small space inside the Biology Institute. Thus it is not possible to have a large group of school visitors all at once. When a school excursion arrives, students are divided into two groups. The first group goes inside while the second waits outside until the first group is half way through. Students outside usually wait for a half-hour. During this time they may be staying in line, but they can also be walking around or checking the department rooms. Thus the museum is always receiving complaints of misbehavior. Because of this
situation, the museum director specially asked for activities that could keep students together in an area annex of the museum doing activities to get them interested in the exhibition.

**Design of the Activities**

Two museum interns designed a series of games related to Arthropods, to be played in the annex during the waiting time. These activities were organized as small stations, so students could be moving from one activity to another. Five stations were prepared.

- **Modeling a spider with clay.** In this activity students received clay and a picture of a spider. They would model the spider using the clay. Then a list of points is given to check how it compares to the model.

- **Two Puzzles.** Two puzzles of microscopic arthropods were given for students to set up, and then students would guess what these animals were and where they lived.

- **Crossword.** Students were given a box of insects and a crossword puzzle. The box has different species of insects of the same family linked with a number. Students write the common names on the crossword and find the final puzzle word.

- **Memory game.** A memory game was prepared relating animals with their common environment. Half of the game pieces have animals and the other half their habitats. Students match the animal with its habitat.
Testing activities

These activities were tested with two different groups. The first group was comprised of two classes of 6th grade students (12 years old), who had studied arthropods at school. The activity was going to be a review for the test. They played all the games for about 50 minutes.

The second group was comprised of teacher candidates from the UFPR pedagogy program (primary school teachers). Half of the group played the games before the visit and the other half after the visit. To determine the success of these activities, data were collected on the impressions of the visitors (6th grade students) about the activities and the role of interns in keeping visitors interested in the exhibits while waiting to go inside. Interns collected written and oral impressions just after they finished playing the games. A small questionnaire asked primary teacher candidates, what they liked the most, what they disliked, if the activity what would be useful for primary school students and what they would change in the activities. To review the activities, interns listed written and oral impressions and suggestions. Questionnaires were read and all the suggestions listed. The list was circulated to the museum personnel and some suggestions were made that were beyond the scope of this study. The suggestions regarding the activities were reviewed in terms of what could be improved on the activities and on the strategy.
CHAPTER IV

Results

Introduction

The research question, “What should be considered when designing a pre-service teacher educational module to prepare teachers to use non-formal settings?” guided this dissertation. Three approaches were applied to answer this question. First, interviews were conducted with three different groups of professionals: museum staff, college instructors, and science teachers. These responses and a review of research on informal /non-formal education including multiple contexts of learning as well as the need to change teacher preparation to integrate the multiple contexts with formal schooling in Brazil informed the development of two modules. Finally each module was piloted twice. The module for teacher candidates was piloted with science methods course students who in turn piloted out-of-school activities with high school students and another group of teacher candidates. The second module for teacher candidates working as interns at a natural history museum was piloted with middle school students and a group of pre-service primary teachers. This chapter presents the results of the three approaches. First, I present the results of the interviews, including a table that summarizes interview categories, then some excerpts to illustrate each category. Second, I present the modules’ design and provide a rationale for each design aspect. Third, I present results of the piloted activities.
Interview Results

During July 2002 and March 2003, a total of nine subjects from Brazil were interviewed on their perceptions about the use of non-formal settings to teach science. Three interviewees were connected to non-formal institutions and programs, three interviewees were College of Education faculty members from Paraná state universities, and three interviewees were public school science teachers. The purpose of the interviews was to provide insights about what teachers should know to effectively teach in non-formal settings. The interviews were transcribed, and then major ideas were summarized and translated into English. From the interviewees’ answers eleven categories emerged. Table 4 lists the types of responses in each category. The rows include the eleven categories; the columns list the three types of professionals interviewed. If the topic was mentioned in a positive manner an X was added, but if the answer was a criticism an O was included. Blank spaces indicate that that interviewee did not mention the topic. The findings listed on the table are further explained in the following section.

Interviews excerpts

Three major questions were posed during the interview: What are the difficulties with doing an out-of-school activity? If you were helping design a course for teacher candidates what topics would you include to help them effectively use informal/non-formal settings? Based on your experience visiting/working at an informal/non-formal facility, what should an intern learn to effectively teach in these places?
TABLE 4:

Interviews responses on eleven categories

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Museum/Center Staff</th>
<th>Faculty Members</th>
<th>Science Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1  2  3</td>
<td>1  2  3</td>
<td>1  2  3</td>
</tr>
<tr>
<td>01</td>
<td>Teacher attitude to go/ while out</td>
<td>O OX O</td>
<td>O OX O</td>
<td>OX X X</td>
</tr>
<tr>
<td>02</td>
<td>Transportation</td>
<td>O</td>
<td>O O O</td>
<td>O X</td>
</tr>
<tr>
<td>03</td>
<td>School resources</td>
<td>O O O O X</td>
<td>O O O O</td>
<td>O X</td>
</tr>
<tr>
<td>04</td>
<td>Administration/Peer support for out-of-campus activities</td>
<td>O</td>
<td>O X</td>
<td>O OX O O</td>
</tr>
<tr>
<td>05</td>
<td>Positive benefits of off campus experiences</td>
<td>X OX X X X</td>
<td>X X X O</td>
<td>O X</td>
</tr>
<tr>
<td>06</td>
<td>Exhibit set-up/ overflow</td>
<td>O O O X</td>
<td>O O O O</td>
<td>O X</td>
</tr>
<tr>
<td>07</td>
<td>Non-formal programs</td>
<td>X X X X</td>
<td>X X X X O</td>
<td>O X</td>
</tr>
<tr>
<td>08</td>
<td>Faculty attitudes towards non-formal education</td>
<td>O</td>
<td>O O O O</td>
<td>O</td>
</tr>
<tr>
<td>09</td>
<td>Candidates need to learn more about non-formal education approaches</td>
<td>X X OX X X X O X O</td>
<td>X X X O</td>
<td>O X</td>
</tr>
<tr>
<td>10</td>
<td>Teacher previous visit is an issue.</td>
<td>O O</td>
<td>X X X</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>Non-formal program need an evaluation/education plan</td>
<td>O O</td>
<td>O O O O</td>
<td>O</td>
</tr>
</tbody>
</table>

X positive responses (pros)
O Negative responses (cons)
Interviewee responses were related to their experiences. An explanation of each category follows and includes excerpts that were translated to exemplify the types of answers for that category.

**Category 1: Teacher Attitudes Toward Off-campus Activities.**

Eight out of nine interviewees mentioned teacher attitudes. This category includes references to teachers’ behaviors when they were at an informal setting or when planning to go off campus. All answered based on their own experiences but from the perspectives of their current positions. The following excerpt from a non-formal professional, similar to the responses from the other non-formal professionals, describes three types of teacher behaviors observed at the museum.

Non-formal 2: We can point out three types of teacher attitudes seen in teachers who bring students to the museum. There are a high number of teachers that come to the museum thinking that they are having a day off. Some teachers come to the museum and leave the entire responsibility to the intern. These teachers will not stay inside. They will go out to smoke or have a coffee. Then there are teachers who are very conscientious and prepare the entire visit, and then students will be working, taking notes, asking questions. These teachers use the museum as a teaching tool. There are teachers who are afraid of students’ questions or afraid of showing their lack of knowledge on the topic. These teachers will not participate in the presentation, but they have a different reason. We could say that most teachers have some difficulty with the museum exhibit content.

Faculty members were concerned about the preparation of teachers to use the museum and the teachers’ views of their roles in the museum setting as demonstrated by this response.

Faculty 3: Looking at the school reality and perceiving a little of what happens when the teacher leaves the class I suppose that is essential that the activity should not be a free time for the teacher, in which the teacher takes the
students and someone else becomes responsible. The activity should be structured in a way that the teacher defines the structure and goals for this activity, criteria to evaluate his plan when he comes back, and what were the gains from the trip.

Teachers’ responses offered some additional insights into teachers’ uses of informal settings. When asked about off-campus activities, one teacher suggested that some teachers would always find an excuse not to use informal settings.

Teacher 1: Usually teachers that are always complaining have a common profile. They are the ones who will always say I can’t, I don’t have time, it is too difficult, and my salary is not enough for this. I suppose that this [teaching] should be a life project for people. Otherwise why do they want their teaching certificate?

The other two teacher interviewees described how visits to informal settings should be implemented.

Teacher 2: There are many ways to do a visit. We may study the topic first, and then prepare questions and go, or we can go first. One difficulty is to adjust classroom content with what you are going to see. One should be very conscious that you are not “burning time,” or going because it is beautiful. So the first question should be, “Is it related to the topic?”

Teacher 3: I usually like to connect what I am teaching with their lives, theory and practice. Nowadays a teacher has to be like a showman, we have to use different methods to teach… I discuss with them about the activity, explain my objective, and then I prepare all the material for us to go. Sometimes I ask people from the community to come and talk to them about the topic first, because we could have parents that know the topic and they would help.
Category 2: Transportation

Five out of nine interviewees mentioned transportation as an issue when planning off-campus activities. For all of them transportation was a serious variable related to the success of the activity.

Non-formal 2: The biggest difficulty for teachers to come here is the transportation. Sometimes the teacher cancels the visit because the bus did not arrive on time, or did not even show up at school. Other times interns are in the middle of an explanation and the teacher is very anxious to leave because of an unforeseen schedule change.

One faculty member indicated that she experienced the same issues when arranging off-campus experiences for her students.

Faculty 2: I would like to go off-campus more often but then I face all sorts of difficulties, bus, and candidates’ schedules. They are very busy; it [the off-campus activity] could take place on Monday afternoon during the class.

Another faculty member identified the frustrations expressed by candidates regarding off-campus trips.

Faculty 3: Regarding going off-campus, candidates came to me for some advice. The schools did not want students off-campus because they have to provide buses, they have to collect parents’ permission and there is still a risk of accidents. There are many arguments that the school uses to avoid out-of-campus activities.

In contrast, two science teachers mentioned how they were positive about planning off-campus trips even if they had to overcome transportation difficulties. They showed they did not give up the idea of leaving campus.

Teacher 2: We have planned a visit to an oil plant but are having a lot of difficulties for student transportation because it is 93 miles away. . .
municipality does not allow using their buses for this type of trip and students cannot afford to pay by themselves. I tried three times and I could not get there until now, however I am not going to give up. I am going to get there somehow.

Teacher 3: When I go off-campus, I take two groups with me [80 students]; I rent a bus and put everybody in the bus. I am surprised that they are not against paying the rental. They do not complain, just the opposite, they even like it because they are going somewhere.

Category 3: School Resources

Three out of nine interviewees mentioned the lack of resources at school as an issue with off-campus trips. Two of the interviewees cited this factor in the context of the contribution of non-formal sites.

Non-formal 1: Our contribution to schools is usually related to the lack of school resources. Teachers do few experiments inside class because they do not have the materials, their schools do not have labs or adequate tables, and so on. Then we developed one optics kit with simple experiments. It can be used in grammar or high school. It was also connected with a series of courses for teachers that we offered, and then at the same time we were testing and improving it. Now we have two other kits for human sciences and Indigenous/African culture. Both are related to the newest and most popular exhibit that we ever had here; it is about African culture in Brazil.

Faculty 1: A long time ago I used to do science clubs. . . . These clubs worked with simple experiments, drama and field trips. We created a science clubroom at the college. This room still exists and is working. Students come here and have access to lab materials and activities that they would never have at school.

One teacher related the lack of resources and teacher preparation courses. He suggested that the practicum and methods course are preparing teachers for
ideal schools and these teachers will not be able to work in schools with scarce resources.

Teacher 1: I was always mad at the teacher candidates when they came to my school because they would say, “Today we are going to have a lab,” because this was to fulfill practicum requirements. Then after finishing with the practicum they would disappear. It was good to have everything handy, however when they left, the school continued to be lacking resources. This was an unfair situation for me because it seemed that I was a bad teacher since I was not doing fancy stuff like the candidates. Furthermore this approach means that the university is preparing a teacher for an ideal situation, and that real school is only for us to read in papers and books. So the university is preparing a teacher for what kind of reality?

Category 4: Administration/Peer Support for Out-of-campus Activities.

Five out of nine interviewees mentioned problems with school administration or peer support to do off campus activities.

Non-formal 2: One difficulty to come to the museum that teachers report is the difficulty of their own school administrators seeing the trip as a day off, not as an additional education activity. Another difficulty is to deal with the teachers’ own peers to adjust school schedule for the visit. Some teachers will come in a hurry and will say that they have only an hour and a half or two hours because nobody would change schedules for them to use the day.

The following excerpt criticizes the methods course’s lack of contact to school. While in the methods course, candidates were excited to be developing lesson plans; however when they went to practicum internship, they realized plans were not feasible.

Faculty 2: When candidates finished the methods course they did a very positive evaluation, saying that the course was the closest one that they had in terms of learning how to teach science. They liked developing class plans and a practicum-teaching project. However, the following semester, after finishing practicum they said that the practicum-teaching project developed in methods course was impracticable. They had problems with administration
support for an off-campus activity and also management. They felt overwhelmed and unprepared to teach. One even said she realized it was very difficult to be a teacher.

Two teachers had different opinions on administration support. One had all the support necessary from the principal but not from his fellow teachers. The other one had no support at all, neither from the administrator nor from fellow teachers who had agreed on sharing project responsibilities but in fact did not.

Teacher 2: I generally have no problem at all to go off-campus. I have the principal’s support to do that. I suppose I am lucky because with all the principals with whom I worked, I had no problems at all. However sometimes I have problems with other teachers. Some teachers are very strict with their schedules and if I need to change anything to go out with my high school students then I have problems.

Teacher 3: I feel that principals should be more supportive of teachers’ projects. . . For example, to come to this conference I had no financial support, nothing! I had to pay the tickets on my own. So I developed a project with students, I am bringing the school’s name to this booth but even that was not enough to have financial support. The other thing is, that it is very hard to convince teachers from other areas to share the tasks. We have an interdisciplinary project but they do not want to share hard work.


Five out of nine interviewees commented on the effects of off-campus activities on students’ attitudes either during a non-formal/ informal visit or program or after the visit.

Non-formal 1: We have a project to assist homeless children. This project started because half a dozen homeless were living nearby and they were usually coming here to see the exhibits. The computers were the biggest attraction for them. Most of them were illiterate. So we started this project to help them make use of the computers and learn to read and write. It was a huge success. Now we have a regular program with a thousand kids per year. Thus I am convinced that a science center can contribute to the society!
Non-formal 2: When the teacher comes here with no notion about what we can offer, students will come totally unprepared to go through an exhibit . . . . On the other hand, we have teachers who prepare very well and students come, hear the interns explanation, take notes, and sometimes they come back with parents to do a school project, or ask for fliers and posters.

Faculty 2: After going to the slum and being shocked with what I saw there, I did a project about dengue disease. Then students noticed the littering on the streets and on people’s properties. We designed a campaign to clear the litter. Students were collecting litter all over the slum and we also collected signatures and sent them to the mayor. So these activities are fabulous because they involve much more then just the content. School content, in fact, became small when facing real problems.

In the next excerpt, the teacher emphasizes how motivated students were after participating in a project in the science center. The teacher suggested that students developed strong intrinsic motivation.

Teacher 1: Students that finished the program at the center usually like to come back and continue. They have a sense of ownership. Some would say, ‘The center is mine, too!’

Teacher 3: After going off-campus they started to pay more attention in class. I am trying to connect the contents with their own lives, chemistry for their daily lives. I felt that the student drop out rates lowered, . . . After going off-campus with my students we felt much more connected. We developed rapport. I realized that they trusted me as a professional and also on the personal level, because sometimes a student comes and tells me personal stuff. I think that they even like chemistry more than before!

The following excerpt reiterates the importance of the pre-field trip visit. In this case the teacher visited the site first and planned the visit based on what she saw. She talked about indicators that the trip was a success.
Teacher 3: I was teaching a topic when I had this idea to go to a factory of cleaning products. Then I went there first, I visited the factory, I knew the raw material and from the visit I prepared the students’ trip. There they learnt about the topic and enjoyed visiting the place. It was cool to watch their excited faces viewing chemistry as a profession.

**Category 6: Exhibit Set-up/Overflow**

In this category there are comments on the size of the institution versus the public it receives and the role of the interns with the exhibits. All three non-formal educators indicated the huge demand but inadequate resources for addressing the demand.

Non-formal 1: One of the problems that we have is that our museum is too small for the city size, so if we do not pay attention we easily can overflow. Because we are connected to the university and our budget is only 1/1000 of the university monies there is no way to grow. However a city this size should have a bigger museum. We are trying to go to an area of 7,532,000 ft² but this is not an easy deal. There are lots of politics involved and this is very slow. So it is very difficult to manage the public. That is why we have the so-called flux intern. These interns will take care of the public; they are core to the smooth public flow. Besides this it is a cultural issue in Brazil to be assisted by an intern in a museum. Interns in training are now peer coached. We also have some materials to train the intern but there is still a long way to go to finish the material.

Non-formal 3: Our program is a very small one. It only works two days a week, however we already received 3,000 students last year. This year we have all the days booked until the end of the year. As we have many students, the interns will explain while students are in front of the equipment or experiment. One problem is the limited interaction between students and interns. It is a superficial explanation and no discussion. The exhibit was set up to be like this, so students would come, get a piece of information, and go. We now know that we may need to improve this idea.
**Category 7: Non-formal Programs.**

Non-formal programs refer to the regular short or long-term programs museums and centers offer to schools and the general public. Interns usually act as docents or mentors for these programs. Interviewees mentioned interns' role and involvement with students in these programs.

Non-formal 1: We have many different programs. For each one we have interns that are undergraduate students at the university and a graduate student to coordinate the program and the group of interns. Here sometimes we will have special trainings for the interns like invited guests who come to talk about special topics. I try to connect the program with a graduate student who will research that. We are now piloting a program based on the Leon Letterman program with teachers and schools in Chicago.

Two faculty members mentioned interns' passion for and deep involvement with non-formal programs that are not in a one shot exhibit format.

Faculty 1: It is interesting to see interns' reactions towards teaching. In the science club, they would never call themselves teachers. They would say they are doing scientific divulgation or popularization of science. However, the differences between interns and candidates at the end of the semester were huge. Interns were very happy; some of them even changed their minds about teaching and were more open to the idea of becoming a teacher. On the other hand, teacher candidates were very much disappointed about what they saw and dealt with at school.

Faculty 2: Because of the strike, practicum students would go to school during summer holidays. So I am redirecting them to a children's institution for the practicum internship. I already had a previous experience down there. I had a group of candidates working on a gardening project. ... The work is much more flexible. It looks like a science club [candidates have a sort of intern role because the non-formal character of the activity]. In my previous experience candidates were passionate doing the activity. They were so involved that they even missed classes and a test to go there and finish the project. Next semester I also intend to have a group working with visually impaired people.
One teacher mentioned the differences between interns who develop projects with students and interns who merely present the exhibits. The deeper contact interns have with students the better, because students build rapport with interns and come back to the center.

Teacher 1: Program interns are very different from exhibit interns. For the exhibit, the intern is just presenting the knowledge like a showman; the program intern will really be worried about knowledge construction. In the program, the intern has a deeper contact with the student, they even have to contact their parents to be sure that the student has permission to come and will come. Interns have to know why the student chose to do such a project. They build a rapport with the student so the student will come back and count on us for other issues later on.

Category 8: Faculty attitudes towards non-formal education.

In this category, comments on faculty attitudes towards non-formal education in the methods course for teacher/intern candidates were revealed. Three different perspectives arose. First was a recognition that education is considered a less important issue compared to hard sciences.

Non-formal 3: As for my colleagues, my students, and me one important thing is to recognize the importance of the methods course, because this is a thing that we physicists have difficulty recognizing. We have a natural arrogance towards education. I think that we do not have good examples.

Second, faculty may lack confidence towards teaching about non-formal issues.

Faculty 1: Here we do not work in non-formal institutions; I feel incompetent to do that for multiple reasons. I remember that I went to the Natural History Museum with some students to learn about school excursions but this was a sporadic, ephemeral activity. On the other hand if interns learn at the museum it would be incorporated into their repertoire. Then when they
become professionals they would consider these spaces differently than what they are doing now.

Third, the practicum internships may be extended to school programs at non-formal institutions.

Teacher 1: A science center could be a very good alternative for practicum. It could be equivalent to the practicum but at a non-formal institution. How to do that? I suppose that special programs for students would make interns understand that these places are educational, too. Otherwise teachers and candidates realize that only when they visit the places and observe the possibilities it offers for learning.

Category 9: Candidates Need to Learn More about Non-formal Approaches.

In this category, suggestions to approach non-formal education are presented. Each interviewee had a different perspective on how teacher candidates should learn about non-formal education, but all agreed that candidates should have some sort of training or deeper information on the topic. Suggestions ranged from an entire course on the topic at the undergraduate level, and even issues on the affective domain (such as exciting students to participate in non-formal activities).

Non-formal 1: In fact we created a course at the university [name] to train interns called “Popularization of Natural Sciences.” It is under the [name] department, it was inspired by another museum [name]. They have a three-semester course program for a complete intern training. We are still piloting our one-semester course. We prepared a syllabus with general topics on popularization of science, and then we should have a portion to deal with daily issues at the center followed by a methods portion on how to teach in science centers and museums. We accomplished the first and second portions where participants visited different sites and research labs. They discussed different ways to popularize science. Unfortunately the course is finishing and we could not get to the teaching portion of the course. We kept discussing more general issues. They are also important; however we did not do what we were supposed to.
Non-formal 3: I see the methods course in the same way that I see a course on mechanics or on chemistry. There is no connection to the real life. It is only another course in the program. I have the impression that none of my colleagues ever considered that non-formal education could be included on a syllabus for the methods course. ... I suppose we are now reaching a point [talking about the exhibit] that we need to put information together. We need an attitude change . . . . We need good examples.

One interviewee mentioned the need to change school calendar to have more participation. If his proposal works it would affect school requirements, and teacher preparation, as a consequence.

Non-formal 2: We sent a proposal to the National School Board. We are suggesting that the school calendar should include some time for required visits to museums, science museums, centers, cultural centers, technology centers, art centers. I am discussing this in a national level because we need to create the infrastructure and flexibility for teachers to come. They should not be subjected to stringent restrictions.

The excerpt that follows gives suggestions on how to use a methods course to integrate culture and biology while discussing non-formal settings. She suggested more than an approach to deal with non-formal, she included historical and sociological aspects of the setting itself to be discussed with teacher candidates. Then with this global perspective candidates might adopt an interdisciplinary approach.

Faculty 1: It is important to start discussing these issues now. I think that things have changed and now we could be planning a course with an interdisciplinary perspective. We could visit different places and choose a few to include in the course. Then while visiting we could make a list of interconnected topics that we may see there. After that we could find people who are specialists on the topic area. For example, we have a park in downtown that was created in the 1900s. So we could contact architects to
discuss how the city was before and why they chose this place to create a park. How was the park at the beginning? Then we could invite someone from the park to discuss why he or she took most of the animals' cages away, why the bird cages are still there, and so on. With that we could have a different perspective from the strict biology. We could see other professional perspectives and discuss the park in a more interdisciplinary, integrated approach.

The following two excerpts mention teachers' points of view on candidates' preparation. The first excerpt (teacher two) highlights the importance of good experiences during pre-service college years. The second excerpt (teacher three) suggests that the instructor should listen carefully to candidates' interests and objectives and then plan off-campus activities based on candidates' needs.

Teacher 2: I feel that a bad experience during the practicum may turn a teacher off. So it is important to have good experiences for them to repeat that. If an off-campus activity could be modeled for the candidate, or if they can learn not to leave the kids by themselves in a site, or if they can see the visit as part of a class topic then they would probably repeat that afterwards.

Teacher 3: The first thing that an instructor could do is to excite them about the topic, then discuss instructor objectives. Then the instructor could check if they have the same objectives, or what is different, and then plan a visit. There is no other way to teach. If candidates are not interested, if they do not have the same objectives then the instructor can be loosing time, because an undergraduate student is not a child anymore, he/she has a goal in his/her life, so instead of inserting information the instructor should extract information from them.

*Category 10: Teacher Previous Visit is an Issue.*

This category presents comments on the value of a previous visit to the fieldtrip site and some problems when such a visit does not occur.
Non-formal 2: When we book school visits we suggest the teacher to come previously to the museum, visit the exhibits, stay for a while and then come with the students. However we know that most of the teachers will not make a prior visit, so students come thinking that this is just a day off. There is a scientific and cultural knowledge that should be discussed during a visit. This is all lost when the visit is not prepared.

One faculty mentioned the practicum internship and that candidates were required to visit the neighborhood, knowing what it has to offer. The interviewee believed that this practice would facilitate the use of nearby facilities to do off-campus activities and diminish the transportation problems.

Faculty 2: One important thing to discuss on the practicum is to know what the neighborhood can offer to a school. Candidates always go to a school that is not in their neighborhood and they do not know anything about it. If there is a center, a small museum, a river or something that they could use. If we consider that transportation is very difficult, sometimes you can use a very close-by site, then it is very important to know previously. I usually ask them to search about the neighborhood during their first days of practicum internship, so they can be aware of the possibilities.

Faculty 3: The teacher should establish goals for the visit. Many times what I see is an enthusiastic approach because doing a visit is cool but there is no connection of what is going on in the class. For example, last year one candidate followed the teacher during a visit to a cavern. They prepared everything but they did not visit the place in advance. At the site they realized that it was not possible for everyone to go inside at the same time, the number of people inside was very restricted, then. People were going in as small groups, but there were not enough adults to be with each group. Besides this they visited a limestone mine. They could get in but there was no guide available. In summary, the visit was a mess and neither the teacher nor the candidate could do anything to fix that since they did not visit the place previously.
Category 11: Non-formal Programs Need an Evaluation/Education Plan

Only three interviewees commented on this category, however all remarks were negative. Comments were focused on the need to improve or create an evaluation plan for the non-formal institution. Two out of the three commentaries are cited below.

Non-formal 3: There was never a systematic evaluation for the visits. We also have never checked what is happening at schools after the visit. The only evidence that we have is that the booking is getting greater every day. Small numbers visited this exhibit initially but the number of visitors is growing fast. So we now feel the need to have more control of the variables.

Teacher 1: The center lacks an educational project. … There is an annual report that includes visitors’ statistical information, but that is all. Besides this we usually do not do anything with that. I suppose this is not just here, other institutions would do the same. This is related to our culture about museums and centers. That is a problem! On the other hand, some would argue that the main role of the center is not to be an addendum of the formal system, thus there is no point to work with school goals. My opinion is a little different. I suppose that if a student or a group of students go to a center to learn more about a topic, the educational role is evident, isn’t it? So, if we want to use the non-formal structure it has to give conditions for the student to go out differently from when he came.

Summary

This section provides insights from each group of interviewees, summarized according to the research question. It is important to mention that there was some overlapping on responses and category topics but the distinctions emerged from the subjects’ experiences with non-formal education.
1. **What are the college instructors’ perceptions about what teachers should know in order to teach effectively in non-formal settings?**

College instructors’ responses centered around four themes: (1) benefits of off-campus activities, (2) topics that should be included in the instructional module, (3) integrating the modules into existing methods courses, and (4) instructors’ concerns about using off-campus experiences.

This group had positive perceptions about the value of non-formal education for students, candidates, and teachers. Instructors recognize the relevance of alternative settings to teach science, and to add on to candidates’ teaching repertoire, increasing the possibility of the experience being repeated. Non-formal education has the potential to build rapport between teachers and students, excite students about science and turn candidates on to teaching. All these findings are comparable with previous non-formal education research such as Smith, McLaughlin, and Tunnicliffe (1998) and Olson, Cox Petersen, and McComas, (2001).

The findings of Griffin and Symington (1997) were corroborated by instructors who identified a previous visit to the site to learn about the setting and its resources as mandatory preparation before any field trip. Other responses were supported by research: visit outcomes should include the establishment of clear goals connected to class topics, and the off-campus visit plan should include a student observation.
checklist, a topic selected for observation, some drawings for students to do, and a wrap up discussion at the site.

Instructors revealed their own contradictions, first indicating that they believed non-formal teacher preparation was very important, then indicating the difficulties of integrating instruction using non-formal settings into existing methods courses. They admitted that instruction on the topic usually occurred only if the schedule permitted. Thus, candidates were almost never prepared to use non-formal institutions. As a result candidates did not see a need to participate in off-campus activities as part of their methods course; they preferred relying on previous experience as students. Nonetheless, during practicum internships candidates felt overwhelmed, unprepared, disappointed, and uncertain about their future career. They referred to methods courses as far from school reality.

Inclusion of a topic on the use of non-formal settings in methods syllabi was suggested. Instructors recommended that experiences at the site should model the ones offered to students, so that they would have a comfort zone to reproduce them. This result is similar to the findings and recommendations of Gioppo (2002). Proposals for changing methods courses ranged from management to philosophical issues. Each interviewee had an innovative suggestion. One suggested that candidates should learn how to deal with the school administration's lack of support. Another suggested the inclusion of an interdisciplinary approach to discuss the setting from different perspectives such as environmental, sociological, cultural, and scientific. There was also a proposal for including extensive philosophical
background to connect the chosen method to the theoretical background it represents.

College instructors pointed out that they do not model the off-campus activities. In other words, they rarely take the candidates out of class. Instructors were extremely critical about their own attitudes toward non-formal education and revealed both their openness to change this perspective as well as the need for them to learn more about how to do it.

2. What are the Science Museum/Science Center staff members’ perceptions about what teachers should know to teach effectively in non-formal settings?

Non-formal institution personnel discussed their perceptions on four topics related to the use of museum settings: 1) teachers’ roles, 2) interns, 3) the methods course, and 4) the educational role of non-formal settings.

It was interesting to notice the differences in perception of teacher and intern preparation. Teachers perceived that neither school administrators nor colleagues support a teacher’s effort to use off-campus experiences. They revealed that the lack of support initiates a chain of consequences that reduce drastically the quality of experience in a non-formal setting. For museum personnel, the chain starts when the task of preparing an off-campus activity falls solely on one teacher. Adding to this chain was the difficulty most teachers demonstrate with the exhibit content. Thus lack of site information and lack of content knowledge restricted planning to
only management issues. As a consequence, during the visit teachers relinquished responsibility for instruction to museum interns. Sometimes interns overcame the lack of teacher/student preparation and motivated students to learn. However, if students were not prepared for the visit, it was more likely that they would mess around and not be willing to learn. When this happened, the administrators’ fear of a museum trip being only a day off for the teacher became reality and the experience was worthless.

In summary, personnel had a clear view about school administration and teacher preparation problems and they were very critical of them all. For example, in category ten, “teacher previous visit is an issue,” faculty mentioned positive perspectives while museum personnel cited only negative statements in the same category.

On the other hand museum personnel did not see intern preparation and support on the same level. Interns were perceived as core people to the sites. They are able to organize visitors’ flow. Furthermore when the exhibit was not interactive, the public counted on interns to explain it. Thus the public was accustomed to having assistance to understand science issues.

Even considering interns as essential to the institution, interns’ preparation or education was not perceived as an essential. Knowing the science should be enough for the work they do. Thus one emphasized that interns already know the content. Intern preparation was perceived in a non-academic perspective. Suggestions for preparing interns ranged from peer coaching to short-term training
with specialist support. In fact a non-formal mentioned a semester-long undergraduate course, the topic was the popularization of science, though. Learning educational context, how students learn, or class management was not mentioned. Personnel argued that intern interaction with the public varies according to the type of internship. Program interns have more training and interaction with school students while exhibit interns have superficial training and tenuous interaction avoiding longer discussions with school groups. One believed the program interns’ main role was to keep the public flowing.

In summary, the need for teacher preparation and support to use non-formal settings was mentioned by museum personnel many times in different aspects. However, even considering interns as core people to non-formal settings, personnel basically took intern education for granted. Peer coaching and science knowledge (from their college background) were considered almost enough to interns, since their contact with students was superficial.

The role of the non-formal institution was also mentioned. Personnel suggested that excursions to non-formal settings should be used on a regular basis by schools, inserted on the educational board school calendar, and required for all schools. Another suggestion was to use non-formal settings as a way to overcome the lack of resources and laboratory activities faced by schools.

Although museum personnel were positive about the role of museums in education, they also saw their own weaknesses, mentioning exhibit set-up/overflow and the need for an evaluation plan for non-formal programs.
3. What are the teachers’ perceptions about what teachers should know to teach effectively in non-formal settings?

Teachers’ perceptions revolved around six main issues. They discussed (1) the instructor’s role in teacher preparation, (2) planning the visit, (3) the issue of administration support, (4) effects on students, (5) intern preparation, and (6) teacher preparation.

Instructors’ roles were perceived as key for keeping methods courses connected to reality. Candidates who do not learn how to deal with lack of resources during the practicum may have difficulty adjusting when they start teaching. Teachers with temporary access to additional resources provided by the candidates felt that the removal of resources upon the candidate’s departure cast aspersions on their abilities as teachers.

Teachers emphasized that it was difficult to adjust classroom topics to a non-formal setting. Thus to plan a visit teachers should have clear science learning objectives instead of loose goals such as “have a glance at the museum” “or enjoy the day.” The visit goal should also determine if an off-campus activity should occur before or after topic instruction.

School administrative support was an issue that frequently emerged from the conversations. It was pointed out that the administration might be supportive if they understood the activity goals. However, even with understanding, administrators
were not likely to take a role in planning the activity and neither were peer teachers. In addition, middle or high school schedules were difficult to coordinate, as are other issues like transportation. Teachers interviewed suggested that off-campus activities change students’ attitudes toward science.

Program interns and exhibit interns were perceived differently. While program interns were building rapport, having deeper and longer contact with students, and encouraging participation and interaction, exhibit interns had more superficial interactions since they presented the exhibit like showmen.

Teachers suggested deeper statistical analysis of non-formal settings attendance reports to improve education. They felt that if non-formal institutions grab data on attendance, they could develop an education plan as they fulfill an education role even if museum/center personnel do not agree with that. Teachers even suggested that personnel responsible for intern training should have an education background to deal effectively with both science and education.

It was proposed that there is a connection between student attitudes during non-formal programs and teachers’ excitement about the program. Teachers’ excitement could affect non-formal programs dropout rates. Thus teachers who were positive and enthusiastic about non-formal institutions have had students working more actively on program activities. As a consequence program drop out rates were low.

\(^5\) Some museums and science centers have after school programs through out the year. These programs are totally voluntary for students.
Teachers indicated that candidates should have an active role in off-campus activities. Instructors should ask for candidates’ input on what should be done and also on how to do activities. Teachers advised that a bad experience during practicum could turn off a candidate for a teaching career. Thus an off-campus activity should be modeled during the methods course so that a bad experience with an off-campus activity would not be likely during the practicum. Teachers perceived that candidates could do their practicum internship at the museums and science centers so they could have deeper contact with the setting and observe other learning possibilities.

All teachers interviewed had a statement related to category one “Teacher attitude to go/while out.” While teachers had a more positive view of their attitudes, the other professionals’ perceptions of teachers’ attitudes were largely negative about teachers’ behaviors during off campus activities.

Summary

The interview results above and the literature review were filtered by the Biology Education program constraints and as a result, to design the modules I considered the following:

- Biology Education majors should have a twofold perspective in their preparation: the outsider and the insider.
- The outsider is the perspective of a teacher who comes to a non-formal or informal setting for an activity. In this dissertation teacher candidates
represent this view, and a field trip to an informal setting is part of the module design.

• The insider is the person who works as educator in the museum in a short-term program or as exhibit guide. In this dissertation museum interns represent this view, and a school excursion to a museum is part of the module design.

• Thus two modules should be designed for students in the same program.
  
  o Module I for teacher candidates carrying out a field trip to an informal setting.
  
  o Module II for museum interns preparing a small exhibit and receiving school excursions in a museum.

• Module I should:
  
  o Have an overarching project that integrates two courses: these courses should be designed so that Biology Education majors can:
    
    ß Learn about inquiry lessons, informal/ non-formal approaches, and design lesson plans in one course.
    
    ß Test their lesson plans in a research approach in the other course.
    
    ß Provide sufficient reflection time for candidates to construct learning about their teaching experiences.
o Bond teacher candidates, teachers and college faculty members to create a net of support and camaraderie to exchange experiences.

o Include a rationale for the need for off-campus activities.

o Excite candidates about the need to change the traditional mode based on lectures to an inquiry based approach.

o Include time to model each and every activity for teacher candidates.

o Allot time for candidates to design their own lesson plans that include a field trip to an informal setting.

o Require that off-campus lesson plans should include: inquiry approach and pre-visit, visit and post-visit steps.

• Module II should:

  o Allow time for interns to interact with museum personnel and teachers before designing activities.

  o Understand museum and school needs before designing activities.

  o Promote the design of feasible activities that excite school students who come to the museum in a school excursion.

  o Promote the design activities that have a hands-on approach.

  o Analyze the activities in a research approach.
Module Design

Two modules were designed using the analysis of interview response, and the literature on the topic. The first module was designed for teacher candidates. It included two courses and a summer workshop. The second module was designed for museum interns doing the required internship of the program. Both modules were designed for use in the Biology Education program at UFPR. The following sections describe the modules’ design and the results after testing the modules. Modules one and two had a pilot portion for teacher candidates’ application. Each pilot was tested twice. Candidate’s, students, and interns’ impressions are discussed.

Module I for teacher candidates

Timeline for Module one is presented in figure 2.

The basic design for module one, for teacher candidates was planned as shown on figure 3.

Phase I: In the 90-hour methods course

An overview of Phase One as illustrated on the left side of figure 3 is described. A detailed explanation of each activity as it was implemented follows.

Phase One was implemented as part of a 90-hour methods course and had two steps: step one was a 12-hour rationale for the need to improve science education in Brazil and step two was a 16-hour modeling of three activities with teacher candidates and a inquiry lesson design. It is important to notice that the 12-
hour rationale was not added to the hours used on the methods course because these hours already existed on the previous version of this course before the study. The readings and use of the time allotted is different though. Each step is described in detail.

Step one: Rationale

During phase I, a two-week (12 hours out of 90 hours course) theoretical basis and rationale for including out of class/off campus activities in the curriculum
was provided. The decision to allot 12 hours to this part of phase one was a practical one, based on a balance between the total hours of the course (90 hours/semester or 6 hours/week during 15 weeks) and the other topics covered in the course syllabi. It is important to know that in the biology education program teacher candidates have only this one 90-hour methods course for science and biology.

Figure 3: Three-phase design of Module I for Teacher Candidates as planned (draft 1)

The methods course is usually planned and taught in three steps. The first one is a theoretical background, a rationale for exploring techniques other than the
usual lecture. The second step is an instrumental one, many different teaching techniques are discussed so that candidates build a repertoire and have a microteaching experience. In the third step they go to school to observe classes and teachers and begin to develop a plan for the practicum internship. The main differences between what happens regularly in the methods course and the module one approach is 1) activities were modeled for teacher candidates rather than just discussed and 2) candidates were required to develop an inquiry lesson that would use different strategies in different classes. During the following semester teacher candidates had an educational research methods class where they learned about educational research and carried out a small research project.

During the fall semester 2003, candidates had a two-week rationale (12 hours) in the previous design of the course. However, for this module new references and discussions were added. This first phase was divided into four topics. The first topic was a brief summary of the recent history of science education in Brazil and its correlation to societal changes. For this module, changes on modes of knowledge (Gibbons et al., 1994), issues on modern and postmodern societies (Lyotard, 1983), and the new role and value of non-formal settings for science education (Caro, 1996, Schauble and Bartlett, 1997) were blended into the topics. The overarching objective of the class was to put changes in science education in a context that would provide a rationale for hands-on activities to enhance learning.

The second topic reviewed resulted in assessing education levels and quality in Brazil compared to international assessments. Reports discussed teacher
preparation, teachers’ salaries, numbers of hours worked per week, numbers of
shifts, school curricula, and student assessment. They also briefly addressed
science laboratory and technology resources (INEP, 2001, INEP 2002, INEP 2004,
OECD, 2001). In addition to this research, interview results showed that the lack of
school resources and transportation were constraints to science education, thus a
depiction of local school resources was added for this module.

The third topic was Brazilian Science Education Standards (Parâmetros
Curriculares Nacionais – PCN). As reported in the interview results section, all
interviewees pointed out the need for candidates to learn more about non-formal
education approaches. However, Brazilian standards do not address teacher
preparation. Thus, for this module the U.S. standards for teacher preparation
(NSTA, 2003), and part of the U.S. National Science Education Standards (NSES)
(National Research Council [NRC], 1996) were included. Using NSTA and NSES
standards, candidates were able to view what would be expected from them as
professionals in a myriad of situations, even if these expectations were not written.
To conclude, a brief explanation on inquiry lesson plans were presented.

The fourth topic was related to textbook supremacy (Yager & Penick, 1983) in
class, the textbook’s social role using genre theory (Miller, 1984, Bazerman, 1994,
Eco, 1980) and research results about science textbooks in Brazil (Bizzo, 1996).
From this research, teachers’ fears about their lack of knowledge while in a
museum/center exhibits contents were suggested. Thus for this module, the wrap
up discussion on textbook dependency ranged from Hargreaves’ (1996)
perspectives on the relationship between teachers’ teaching styles to modern and post modern issues. A recommendation for candidates to count on external resources and specialized help to teach science and increase the quality of classes was made.

After providing a rationale for the need to improve science education and teacher preparation in Brazil, we started the instrumental step of the course.

**Step two: Modeling**

During the second step of phase one a school excursion to a non-formal setting, a field trip, and a laboratory class were modeled (Reiman & Thies-Sprinthall, 1998; Olson, Cox-Petersen & McComas, 2001) for candidates. Phase one finished with the design of an inquiry lesson.

School excursion to a non-formal setting

The first activity in the second step was a four-hour class on school excursions to non-formal settings. The objective was to identify main issues and needs to plan a school excursion. Class preparation was to read class material on the topic. During the class an excursion to a museum or other non-formal facility would be modeled for the candidates.

The excursion plan took into consideration interview results, which pointed out the need for teachers to visit the site prior to bringing students to the site. One interviewee also pointed out a possible relationship between teacher plans (or lack of) and students’ attitudes in science museums and centers. Thus, class material on
excursions to non-formal settings translated and summarized (Griffin & Symington, 1997) research results on museum excursions. It also summarized Csikszentmihalyi and Hermanson (1995), Smith, McLaughlin, and Tunnicliffe (1998) and Simmons (1993) research on motivation. Results of novelty effect were summarized from Falk, Martin, and Balling (1978), Genaro (1981), and Kubota and Ostald (1991). A three-phase plan - pre-visit, visit and post-visit - were recommended as well as three stages of the visit phase: group activity, gathering, and exploring on your own.

Then a visit to the Natural History Museum in the university was carried out. The modeled activity did not follow the best practices as suggested by research, though. Instead it was a typical visit to the museum as experienced by school groups. The goal was for the candidates to experience the usual intern guidance at the museum as a “shock treatment,” since guided visits usually present many different contents and are exhausting. Then candidates’ perceptions and feelings about the excursion were discussed and plans based on research results were proposed. Even if research provided no evidence for the effectiveness of this approach I decided to use it mainly because the Natural History Museum is inside the biology institute. Thus coming from the College of Education I was the only “outsider” in the process. Instead of telling them that the lecture approach was exhaustive and worthless, I wanted them to feel it and reflect on the students’ experience. From that we could discuss positive and negative aspects of the experience and what could be done to change it. I told them that lecture approach would provide too much information and little time to explore and observe, they could easily disagree because this is the regular practice in many courses of their
program. In other words it would be much more difficult to engage them in the discussion and analysis.

Field trip activity

The second activity of step two was a field trip. The main objective was to recognize strengths and weaknesses of school field trips. The activity previous to the class was to read class materials on the topic. During the class a field trip (using an activity bus) would be modeled for the candidates.

Interview results indicated that a well planned excursion or field trip can change students’ attitudes toward science. Bixler, Carlisle, Hammitt and Floyd (1994), and Bixler and Floyd (1999) pointed out that, students’ fears and distaste for certain types of animals and dirt were important factors to be considered when planning a field trip. Thus class materials translated and summarized Leary (1996), Farmer and Wott (1995), and Falk, Martin and Balling’s (1978) research results on field trips, and the effect of fear and disgust factors. Field trip tips were also included. The class materials suggested a three-phase plan - pre-visit, visit and post-visit. During the field trip, three stages should be incorporated, the activity, gathering, and explore on your own.

Laboratory activity

The fourth activity of step two involved the use of the laboratory. The main objective was to recognize that a laboratory class goes beyond demonstration and
fieldwork and lab activities should be linked to promote learning. Again, a reading assignment preceded the class discussion on the topic. During the class a lab activity that connected fieldwork and lab work, analyzing table and graphic data would be modeled for the candidates.

The subjects interviewed at the beginning of this project pointed out that the lack of school resources was a pervasive problem. Thus class materials tried to address resources by providing references such as Rao (1968), UNESCO (2003), and Science Teacher Center (1972) on alternative materials and lab activities with low cost materials. Class materials suggested that candidates should design plans to integrate field work and lab activities (Lab write site, n.d.). Candidates would go to the field not only to enjoy some time out of class but to observe, collect and gather data. Then the lab would be the follow up activity of the fieldwork where students would identify, interpret, analyze and synthesize data.

Designing inquiry lesson plans

To evaluate the effectiveness of these activities, teacher candidates would be asked to design a feasible inquiry lesson plan. It would include either a field trip or school excursion with a follow up activity in the lab. To design the lesson plans candidates would be strongly encouraged to have the assistance of a science instructor on the chosen content to avoid conceptual problems. The lesson plan would be tested during the Educational Research Course. The design of an integrated lesson plan completed phase one of the module.
Phase II: Summer Workshop (optional)

The second phase (middle portion of figure 3) included two optional summer workshops. Each one was a full-time, weeklong workshop created to enhance the experience of the field trip and fieldwork, and provided in depth focus on the lesson plan design. A brief description of the workshops is followed by a more detailed explanation.

Learning how to use Geographic Information System (GIS) was the main goal of the first week. GIS enhanced the meaning of the fieldwork and strongly connected it to the use of maps and mapping. During the second week candidates designed new inquiry lesson plans or enhanced their previous projects.

These workshops were planned by Sci-Link for in-service teachers and fit in with the research goals to include non-formal settings in teacher preparation. Besides this, research interviews showed that instructors’ attitudes towards non-formal education were weak and superficial, and there is a lack of administration and peer support. Thus the workshop design per se was not changed. But instead was expanded to include a mix of teacher candidates, teachers and faculty. Interested US teachers made application to be in the workshop. Teacher candidates and college instructors came from Brazil. The goal was to create a comfort zone (Gioppo, 2002) in terms of self-confidence to plan and carry out field trips, then develop rapport between college instructors and teacher candidates, and finally to
create a network of support (peer support) for non-formal activities by sharing suggestions and lesson plans.

Phase III: The 60-hour Educational Research Course

The third phase (right portion of figure 3) was designed to be included in a regular educational research course. During this course candidates have had information on research design and reliable instruments. Then they design and carry out a small educational research project.

The course syllabus of the Educational Research course was not changed for this pilot. However, a proposal for continuity and in-depth analysis was discussed with the instructors and candidates. Candidates not participating in this pilot would start from scratch and design an educational research project while the pilot group would design a research project to test the lesson plans that they designed previously.

Results for module I

The module was tested during the fall and spring semesters (April 2003 to February 2004) at the Federal University of Paraná, in Curitiba. Forty-seven teacher candidates from the biology education program who had enrolled in the methods course also participated in the first part of the pilot (Fall semester, April to August 2003).
Following the design of the module, a visit to a non-formal setting, a field trip, and laboratory classes were modeled for the candidates. Then candidates working in pairs designed lesson plans. The following sections describe each component of the module as implemented.

**Phase I - Science Methods Course Results**

*Excursion to a non-formal setting*

The first activity of the second step, an excursion to a non-formal setting, was arranged with the Natural History Museum inside the University because some candidates (10) had never visited the museum despite its location inside the Biology Institute building. Candidates were divided into three groups for the visit. While the first group was in the museum, the other two groups were waiting for their turn outside. A museum intern came by to entertain the group by talking about turtles and frogs that were in the terrarium outside the museum.

The main focus of the visit was not on the museum content itself but on intern experiences guiding school groups. An intern guided us through each exhibit on the same track and spent the same amount of time that she does with student groups. She talked about her experiences while guiding student groups and their teachers, mentioning recurrent problems with teacher and student attitudes while at the museum. She also described questions that students frequently asked.

After the visit, candidates commented on their impressions about it. They found the visit exhausting. The group that was outside did not like waiting to go
inside. There was no place to sit, and nothing to do. When an intern came to talk about the terrarium most candidates could not see what was going on. These candidates were already tired when they got in. The group that left the museum first was not as tired. However, they were not willing to stand by and wait for the others, so they walked around, went to the cafeteria and then came back. Candidates also found the visit sort of boring because the intern talked about many different subjects and some exhibits were mainly focused on posters. Candidates found the signage was far too difficult even for them to understand.

After hearing all the complaints about the visit, we discussed what we could do differently and how that type of guided visit could be better explored. Candidates then came up with some suggestions like “I would prefer coming and explaining myself and not having a guide” or “I suppose a teacher could tell the guide what topic she is teaching, then they could have a focused visit.” As for the candidates waiting outside, a candidate suggested “I would bring something for them to play while waiting outside,” and other mentioned “I would check other things that this group could do at the site, too and then switch them on the activities.” Most suggestions were related to management and the focus was what to do differently to focus on learning. After the candidates’ comments, research results on museum excursions were presented to support their non-formal visit design plan.

*Field trip activity*
A faculty member from the Biology Institute planned the field trip. He selected an activity that could be done in an urban forest area inside campus. The instructor came prior to the field trip, explained the activity, and handed out a list of required materials, clothing and instructions for the activity. During the fieldwork, candidates were divided into ten groups of three to four people, and assigned to a 10 X 10 meter grid area to plot and measure tree heights. It took them four hours to learn how to plot the grid, to measure tree heights, to fill out their grids on ground cover description and to plot the trees. Students also collected tree leaves. At the end of the activity, each group had prepared a sketch.

One interesting observation was on candidates’ attitudes during fieldwork. Although the candidates were juniors in the biology program, most of them were not excited about the fieldwork. Half of the group showed up late for the class and most of them had some sort of difficulty working on the field activity. For example, they did not know how to plot the area. Some were not familiar with the grid and three groups could not measure the tree heights at all. More than 15 students did not even come dressed for a fieldwork activity. Only three out of ten groups worked smoothly and in these three groups students had had intern experiences with a field activity or worked on field activities during the previous summer.

A discussion about the activity itself and field trip comments was held during the next class session. Since most students had difficulties measuring tree heights, they suggested the instructor should demonstrate how to do it prior to the fieldwork.
Some complained about the list of required materials and came up with a list of alternative, inexpensive materials.

Some comments on field trip contents were, “I learned how to measure a tree height in a different way, it was good to have another perspective on that,” “Never came to my mind that I would learn how to measure a tree in this course,” “I liked the activity because it has not only botany of forest contents but also mapping, preparing the tables, and even collecting data for statistical analysis.”

Field trip strategy comments were, “It is a good strategy I learned a lot,” “It is interesting but has a lot of preparation behind it,” “I saw both of you [instructors] walking around all the time and checking with us, so it is clear that we need help when doing that with a huge group,” “It is the first time that I ever heard about a field trip in the methods course.”

**Laboratory activity**

The laboratory activity was related to the field trip. Candidates took their sketches and leaves to the lab. The first task was to compare ground cover on various grids. Then candidates used leaves and other tree characteristics to identify and tabulate the diversity of trees on the entire site, not only on their group grids. A final collective result was discussed.

After the activity candidates discussed the laboratory work. Some comments caught my attention because it was the first time that a lab class was being modeled for candidates during methods course. Comments included, “It seems that lab work
became easier,” “This work requires a bigger preparation,” “It was good but I need more experience to do that.”

**Evaluation**

To evaluate the impact of the activities on class plan designs, candidates were divided into pairs and asked to develop an inquiry lesson plan using field trips or school excursions to a non-formal setting. They were told that the follow up activity should be laboratory work. Most of the candidates (30) designed disconnected lesson plans. Ten out of 47 designed fieldwork while the others included excursions to non-formal settings. The lab activity was on the same topic, but not as a follow up activity. There were no demonstration activities; however, the material would be prepared in advance for the students to observe biological features. One example of this type of planning was on the topic of flowers. The candidates planned a visit to the botanic garden to observe flower diversity followed by a laboratory class to dissect a flower. Another plan was related to health education and the topic was how to prevent broken bones. The plan included a visit to the anatomy museum to observe different bones followed by a lab class to observe the inside part of a cow bone and bone cells. There were no connections between class plans and the design of graphs, statistical analysis or discussion. There were just isolated activities.

Candidates’ comments were, “Going to a museum is much easier than going to a field trip,” “I don’t think I can do a field trip on my practicum internship. Teachers
would never allow me to do that,” “How can I plan a field trip if I do not know if I will have help. I cannot do that by myself.”

Phase II - Summer Workshop Results

Five candidates from the methods course along with three faculty members were selected to travel to North Carolina and to participate in the summer workshop. During the first week they mainly learned about Arc View software and using it to map a site inside the NCSU campus. The candidates were much faster doing the tasks and learning the software than the in-service teachers or even the college instructors. One interesting observation was the camaraderie among candidates, teachers, and college instructors. Candidates often helped teachers and college instructors to figure out some part of the software or helped finish a task.

During the second week, the group from Brazil (candidates and college instructors) went to Banner Elk, in the mountains of North Carolina where they met other teachers. The focus here was mostly related to fieldwork and lesson plan design. Faculty and candidates were very excited to be learning about a different environment and observing animals and plants that are not common in Brazil, like oak trees and salamanders. However, candidates were overwhelmed with lesson plan preparation even if the topics were discussed with college instructors, and instructors were there to help them. Candidates and faculty kept a diary during the second week. Some comments from their diaries were, “I am overwhelmed with all the work, designing a lesson plan at the computer lab is really exhausting,” “I hope
all this work pays off because we have been working hard. I learned a lot, though, “The best part for me was to know all these people from different parts of the world. It is a shame to realize how far behind we are in science education in Brazil. I hope I can help change something,” “This is the best experience that I ever had in my life.”

Phase II was well integrated and candidates had in-depth information on designing inquiry lessons. As a result their plans were not only feasible but also creative, including more fieldwork than they had done on the first phase. At the end of this phase candidates were ready to test their lessons (phase III).

*Phase III on Educational Research Methods Course Results: piloting lesson plans*

*Module I Pilot I: With High school students*

Lesson plan implementations were done during the spring semester, in the Educational Research course. Another instructor taught the course, however, the five students from the summer workshop in the U. S. were followed and supervised by me.

School 1: Beach sand and beach profile and animal distribution along the beach project.

The pilot for two of the projects was done at the same school with the same students, so results were collected together. Field trips were done on Saturdays, since students were from the evening shift and worked full time during the day.
Candidates needed to plan three field trips, because during the first one there was a storm and temperatures changed fast. It was raining and the beach disappeared under the water. Only five students where there, they dug 20 X 20X 20 cm holes but very few animals were found, since it was one week after the storm. Winds brought too much sand to the beach. There were 22 students on this activity; however, they were very disappointed not to find animals. The third field trip had only ten students. Candidates decided to dig deeper and started digging out 50 X 50 X 50 cm holes.

Students who were not doing the fieldwork went to the laboratory class. They were surprised to see all the animals that were collected at this time. Each group took some animals and identified them. Collectively, candidates and students profiled the beach and designed a table showing what animals were found in each role. Then they related these findings to sand grain size.

At the end students commented about the activity. Some comments were, “I was born here and I never looked at the beach as I looked on this project,” “I always saw these little animals at the beach but I never thought that they could live in a special zone of the beach, I always though about the beach and its animals as only one thing.” Other candidates’ comments were, “I was very surprised to see how poor the school was and that all students work full time, thus I was little afraid of not having anyone on the field trip, but we had students showing up three times!” “Students were so sad when they could not find anything [second field trip] that we had to do it again a third time, we could not just finish like that,” “Developing the
project was exhaustive and expensive, we had to go to the beach every week after my own classes and spend my money to do that but I want to continue and do a second pilot on my practicum.”

School 2: Acid rain in karst (limestone) topography.

For this pilot the candidate went to a school, built rain collectors and taught students how to measure pH. Then, after the rain, students had 24 hours to bring material back to test it. The candidate came back to check students’ measures. Students had difficulties understanding how to use the equipment and measures taken were not correct and could not be used to profile rain pH in the area. On the other hand, students were inspired by the project and brought water from their wells, from their taps, and from a stream and wanted to test it.

Students’ comments on the project were, “What if it rains on Saturday? School does not open on Sundays and we need to measure! We have to find a way to do that,” “I come to school by bus and I will bring the rain water but I do not want any water to be lost, otherwise my measure can be wrong,” “I usually come to school on foot, what if rains when I am coming with my collector. It may distort my measure and I don’t want that!”

Candidate’s comments were, “It was hard to go there because I do not have a car and it takes more than one hour just to reach the school. However, it was very exciting to see that students really wanted to participate in the project and they were worried about the measures and its precision. It makes me feel that I have more
responsibility on the success of the project. I would like to try again and fix the problems that I had on the first trial.”

School 3: Searching for macro-invertebrates in a creek and Finding Life in a dead log.

Both pilots required a trip to a natural area. The first struggle was to find a natural area near Curitiba that would have a preserved forest and creek. Candidates tried different areas but they were not preserved enough to fulfill project requirements. Then, the second struggle was to find a public school with transportation that would allow students to spend a school day out.

After finding the school, candidates piloted the project with voluntary students. On the first activity there were 27 students, but on the field trip only 23 showed up. At the end of the project students’ comments were: “This is cool, I do want to be a biology major, I hope you guys talk a little bit about the program,” “It was cold but I wanted to go in the water anyway so I took my shoes off and got in,” “I would never imagine to find so many animals in a clean water,” “I found it interesting to know that these little creatures may be used as water pollution indicators,” “At the forest we should pay attention only to the living features on a log, however I also brought other things that I would like to investigate,” “I found a log full of little mushrooms. I never saw a thing like that before; it was awesome,” “We found a tree so tall that the entire group fit in between two roots. We all squeezed and took a picture. I would like to show it to the ones who did not come.”
Candidates’ impressions about the project included, “We did that with voluntary students and they came and spent three entire afternoons with us. What would happen if we tried with the entire class during school hours? We have to convince the teacher to try that next year!” “Next time I am going to try more than one spot and rotate students to go into the water, the comparison will be better. Can we continue developing the project?” “I already know what I want to change on the project. I will write it down immediately for another try”.

At the end of the piloting (Phase III) candidates were motivated with their projects and wanted to improve their activities, thus a second pilot of the module was added. Results of the second pilot are described below.

Module I Pilot II with methods course students

In this pilot the candidates who participated in the school pilot tried one of their projects with their peers from a different year. Teacher candidates were now in their senior year while methods course students were in their junior year.

The first activity was a power point presentation of all projects and results with students. Then, candidates set up a field trip and all the associated activities for their peers. The chosen project was Animal distribution along the beach. The spot was a sand beach close to a rocky coast on an island at the Paraná coast.

At the end of the activities some impressions from methods students participating in the project were, “I have to say that I was not excited about this at all but I liked it very much,” “We worked hard, under the rain, carrying all the heavy
stuff across the island, I would never imagine to see a methods instructor doing such a thing,” “This was the best field work that I did during my entire program and amazingly it was not planned by a biology professor, it was coordinated by a methods instructor, instead. I will certainly never forget that,” “I would suggest that next time we could stay two nights to do all the stuff; it is hard to keep up with all things sleeping at the coast only one night. In other words: we wanted more,” “Every teacher and every student should do a trip like that, then their teaching would be much different.”

**Module II: for Museum Interns**

Module II was designed for teacher candidates working as museum interns to effectively use non-formal institutions to teach science. During the interviews interns were perceived by museum personnel and teachers as core people to the site, especially when exhibits were not interactive. In their perceptions interns know the content and are able to overcome teachers’ lack of preparation for the site visit; they can organize visitors’ flow and explain overly detailed signage. However, there was no agreement among interviewees on intern education: science background only, peer-coaching, or short-term college courses were all suggested in the interviews.

In Module II the main goal was to develop a few activities that could be used by the museum after the pilot. Activities were designed to integrate school curriculum with museum exhibits, and they also should give interns insight into
designing exhibits based on school and museum needs. However there was a non-revealed intention. Since the museum is a very small one, the curator usually designs the exhibits. I wanted to use the pilot as a springboard to motivate a creation of a hands-on exhibit or room where visitors could come and play. In order to do that I would supervise interns while they were preparing and testing a few activities. These activities might inspire other personnel to develop a whole a series of activities or even a discovery room. Furthermore the module development would integrate design and research, to avoid intuitive only designs for education activities as it might happen in museums and centers that do not do research in education.

To design the activities, three issues pointed out by research were considered. First was the need of balancing education and entertainment in the activities. Interviews suggested that museum should be fun, an exploratory diversion. However this is a huge issue in museum research as mentioned by Shortland (1987), “when education and entertainment are brought together under the same roof, education will be the loser” (p. 213). Thus we tried to bring equilibrium to the activities.

The second issue was related to the integration of culture in the science exhibit and research (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003) also mentions the docents' key role as cultural mediators: “in docent-led tours of museums the docent can be regarded as a social (and often cultural) mediating factor in the visit. In this view a mediated school field trip is also an object of study”
Thus, knowing that at the university museum interns lead school tours, we expected them also to lead the activities.

The third issue was the lack of museum exhibit design or, even worse, the lack of teaching experience. Neither the interns nor I had design experience and the college student interns also had a lack of teaching experience. This lack of experience could result in the same type of exhibition that the museum already had. The difficulties in the design process of a non-traditional exhibit at the London Science Museum were described by Macdonald (2002). She mentioned that even with new ideas and a different philosophical perspective the final product was not as different as designers had expected and the lack of design experience played a role in that. Thus three interviews were included on the planning process to hear about people’s interest and needs.

To develop the module we had three meetings directly or indirectly involved with the design. I first met with the interns. They talked about the ideas and what was expected for them in their internship project. We then brainstormed about many different possibilities for developing a small research project and we arranged another meeting.

The second meeting was with interns, the museum director, and me. The museum director shared his perspective about the interns’ work and his expectations somehow refocused our intentions. He suggested that activities could be used either in the museum while students were waiting to go inside or as part of a museum kit. The museum has a program called “Museum goes to school”
(Museu vai à Escola). In this program museum personnel go to towns and small villages that do not have access to any science museum and they spend a whole day or shift there presenting museum materials and small traveling exhibits to kids. Thus activities should be developed to be used in both situations.

The third meeting was with the interns, the science teacher, and me. The teacher and school have been chosen earlier when one intern did her practicum activities there. The intern had contact with the teacher in advance and she agreed to have her 6th grade students as our test subjects. The intern wanted to develop an activities only about insects, however the teacher suggested working with all arthropods because this would work as a review for the students. Besides this they could compare and contrast arthropod groups.

After the three meetings, we started planning the activities. Interns worked with the games, I was editing the material for clarity, helping with establishing games rules, and designing the implementation step with “stations.” In these stations students would be divided into groups, and each group would come to a table with a game on it. They would have time to play, and then rotate.

Interns then piloted the activities with two groups of 6th grade students. After the pilot, interns evaluated the activities. They rearranged them and piloted again with primary school teacher candidates from UFPR. The timeline for Module II is presented in figure 4.

The basic design for Module II is showed on figure 5. In the following section, results of the two pilot tests are presented.
Results for Module II

Module II Pilot I for Museum Interns

The second module was piloted twice. The first pilot took place in the annex room of the Natural History museum at UFPR. The annex room has glass all across the front. The room faces an inside corridor where many college students are crossing and there is also a photocopy service close by. Thus the area is always hectic and noisy. The room itself has ceramic tiles on the floor and brick walls, all the chairs have iron legs and any movement is heard and emphasized by an echo.

Figure 4: Module II timeline: from July 2002 to August 2003.
For the first trial the class had 35 6th grade students. Students were moving around the room. They were very active and noisy doing the activities and this was bothersome for the teacher. Every time they got up to move to another table the teacher complained.

Students found a memory game and crossword puzzle more difficult than the puzzles, asking more questions of the interns and needing more help to play them. The clay activity was not difficult but it was time consuming, so when one group was finished the others were still working. The activity that they liked the most was the clay. When they checked their modeling, there was always something to fix. The activity as a whole used more time than planned, so if students had a tight schedule, they would miss part of the presentation inside.

In the second class of 6th graders the teacher wanted the students to remain seated and the games to move around the tables. The interns, the teacher and myself helped to move the activities from group to group. At this time, students were a little slower than the first group; this class was more quiet and settled than was the first class. On the other hand, there was much more work for the interns and they could not do it by themselves. The interns brought in an extra puzzle for them to solve, if the memory game was finished earlier than expected. On both trials the groups did not finish all the activities at the same time. Pieces and parts of the games were on the floor after each round, and interns had to check all that before delivering the activity to another group.
Module II: Design and Implementation

Interns' ideas on their internship project

Museum needs and interacts (museum staff)

School needs and interacts (science teachers)

Activities Design

Pilot I Middle school students

Pilot II Primary School teacher candidates

Test

Informed

Evaluate

Re-test

Figure 5: Module II for Museum interns.

At the end of the activities, the teacher suggested that the interns needed more help, preferably one intern for each game, then they could also help students playing, and the noise level would be lowered.

Interns were at first overwhelmed, then relieved and exhausted. However, they enjoyed the activity. Some comments were, “It is too much, they ask a lot and want us all the time. We have to think about a way to let them do without losing the games pieces,” “I hope all the insects can still be used, otherwise we will not be able to do this activity for much longer, we need more people here, while they are playing, then it will be fun,” “I know what I can do to change the puzzles, I was
thinking about that during the class and I already have another idea. I will do that right away.”

Module II Pilot II for primary teacher candidates

For the second trial, a group of 30 pre-service primary teacher candidates tested the activities. They came to the museum during the evening, when interns were waiting for them after hours. There was no transportation to come to the museum, so the instructor invited two groups (70 candidates) to come by themselves during a class period. However, less than half of the group showed up. The group was subdivided into two. The first one went inside the exhibition hall and the second one to the annex room. The first group played the games and afterwards filled out a small questionnaire on their perceptions about the activities. The second group was late leaving the exhibition hall so they started playing and when the time ended they made few oral comments and left. This group did not fill out the questionnaires.

Only 15 teacher candidates filled out the questionnaires. Questionnaires and oral comments focused on the question, “What did you like the most?”, primary teacher candidates said that it was the clay activity because students could see and double-check their errors while modeling a spider. They also liked seeing live animals in the museum and the plaster models of sea animals. They found it interesting to have an annex room for students who were waiting to go in, however, it was tiring when the group finished looking at the exhibit and then went to the annex. As for the question, “What did you dislike?” teacher candidates mentioned...
that because stations were not synchronized (using the same amount of time) some students would be waiting to play and it could be confusing with a big group. They also mentioned the rush of passing from one exhibit to the next and all the details of each exhibit. Students would be tired before the midway point. The second group felt they had not enjoyed the activity as much as the first group did. A candidate said, “This room is nice; it is a shame to come here tired. The exhibition presentation should be shorter and focused, then we can enjoy it better.”

The third question was “would the activity would be useful for primary school students?” Teacher candidates found the material sort a little difficult for primary school, and mentioned that a teacher would not be able to use it unless the content was discussed previously in the class. However, they mentioned that they teach all the games’ contents and it would be a matter of small adjustments for primary students’ level. Some activities like the clay or puzzle would not need adjustment. As for the last question “What would you change on the activities?”, teacher candidates again mentioned they would like the activities to be synchronized for school groups, they would like to see more hands-on activities like the clay and less activities with small pieces that they would have to be checking all the time. They would also like to see more interdisciplinary activities connecting biology with reading, writing, and math, so they could come back to the class and review museum activities as regular activities.
CHAPTER V
Discussion

As society changes its needs are also changing. Knowledge and learning dynamics are different and aspects of teacher preparation programs have to be re-thought to fulfill new demands. The number, types, and quality of exhibits and educational programs in non-formal/informal settings are rapidly evolving and these locales are consolidating as an “informal infrastructure” (IRA, 1996) for science education. Hence we need to prepare teachers to appropriately use these sites to teach science. This is a new demand on teacher preparation programs.

To be able to count on multiple facilities for equipment, expertise, and teaching materials would be a great help for underserved schools and teachers, especially in developing countries like Brazil that has many other education demands to fulfill. One such facility could support different educational systems from the same area, which means a few dozen schools and potentially thousands of students, at general levels. If teachers better understand informal science education, they could use these places and enhance the quality of teaching and learning, representing a significant change in the quality of science classes. This study developed and tested a module to prepare pre-service teachers to use non-formal settings as one way to bring about these changes.
Interviews

The first step in module development was to interview three types of professionals, providing insights into what teachers should know to effectively teach in non-formal settings. The responses from each of the three types of professionals had a different focus. Museum staff focused on general administration issues and policies related to schools and museums. Understanding informal education from the perspective of museum/center staff may boost the relationship between formal and non-formal institutions and even arouse interest in a more academic preparation for science museum educators, since there is no currently program in Paraná for that. Previous research has shown that museums need to improve their intuitive evaluation processes (Suzuki, 2003) and overcome apprenticeship-style teacher education (Tran, 2002). Thus, even if there is much research on museums themselves, we still need research focused on museum educators teaching in museum settings.

As for university faculty members, their focus was on the suggestions of what one could do to expand teacher candidates’ experiences in non-formal settings. However, all of them admitted they do very little with teacher education and some felt incompetent to do that. What stood out most was the realization that these interviewees also used many of the same justifications used by schoolteachers to not go off-campus. Research is needed to further investigate college instructors who regularly go off-campus with science teacher candidates. It is crucial to understand instructors’ perceptions about non-formal institutions and what they
believe their role is in preparing teacher candidates to teach in these settings. Research (Dingra, Miele, MacDonald, & Powel, 2001) has shown that it is core for teachers to have these experiences during pre-service years. Thus, if instructors do not see a need to model (Reiman & Thies-Sprinthall, 1998) off-campus activities with their student teachers, it is likely that when these candidates become teachers they might not feel confident to go to these settings (Olson, Cox-Petersen, & McComas, 2001). We need to pay attention to the needed instructor skills and course standards that will foster such experiences.

Science teachers were enthusiastic about off-campus activities, saying they would overcome each and every problem and do whatever was necessary to go where they planned. This position reaffirmed the research results of Smith, McLaughlin, and Tunnicliffe (1998) and Gioppo (2002). In the interviews, museum staff and college instructors’ answers focused on the lack of planning and preparation of teachers for museum visits while teachers focused on their effort and hard work to overcome lack of support and all sorts of other difficulties to accomplish their plans.

It was clear that teachers work in far from ideal situations and this would be reflected in their class plans to go to non-formal settings. However these teacher interviewees had strong motivation to take students out of the classroom. Developing this determination in pre-service teachers may be the first step. To do this I could suggest three things, first, a practicum supervisor has to be very careful choosing teachers that are not disenchanted about teaching, instead teacher
candidates should be learning with teachers that are excited and want to experience and develop new ideas. Second, practicum should be a two-way road for candidates and teachers. In other words, the candidate is going to use the school for the internship, however, because schools have a huge gap in quality and infrastructure, candidates should be able to provide some resources, preparing small collections, creating terrariums, or collecting low cost experiments that could be feasible in that school, perhaps if candidate feel that he/she has some responsibility on raising the quality of education in that school, he will be active working to do that. Third the biology education program offer school activities and internship only in the last year (senior year), but this is not at all enough for one to know, and understand the complex situation of Brazilian schools, much less to get connected to the school and their students. Thus my suggestion would be to include school experience in other courses all over the program. That could give candidates different perspectives about the school, teacher and students, as for example, when candidates have Educational Psychology, they could go to the school and observe students and learn about some issues; when they are studying Educational Laws, they could go to school and investigate a related issue in the school curriculum, when they are studying learning theories, they could observe kids from different levels, and so on. Then candidates would be much more prepared to lead activities and effectively engage students, because they have a better preparation grounded on previous experience. Perhaps after that, some might need more instruction on planning and relating off-campus activities to learning specific topics. Longitudinal studies could investigate in-service training for off-campus activities for both pre-
service and in-service teachers and their reflections on teaching and student learning.

Interview responses from all professional categories studied reflected the positive benefits of off-campus experiences for students (see category 5 on table 4) as well as the positive effects of non-formal programs for interns (see category 7 “non-formal programs” and “how these activities transformed and enriched students’ experiences with the world” (Pugh, 2004, p. 182; Csikszentmihalyi & Hermanson, 1995). Furthermore, they mentioned how the impact of the museum/center visit transformed kids who in return transformed the center programs, too. Three powerful examples of this two-way road were: (a) the excerpt of museum staff one on category five, mentioning homeless illiterate kids interested in the museum and in return, the museum created a special program for them; (b) the excerpt of faculty member two on category five, telling of an experience in a slum and how students came back from the field trip to create an anti-litter campaign and collected litter in the slum neighborhood; (c) the excerpt of teacher three on category five, suggesting that drop-out rates lowered after off-campus activities because students saw a meaning for their studies.

Most comments on categories two, three, and four, "Transportation," "School resources," and "Administration/Peer Support" revealed the importance and meaning of these real issues on organizing off-campus activities, even if interviewees recognized students’ interests and engagement. Somehow schools seem to be focusing on peripheral things, leaving learning on a bizarre and
shallower level. The recognition that non-formal institutions have a strong role in students’ motivation and engagement with science requires a shift in focus on the part of school administrators and fellow teachers to have a responsibility of strongly supporting out-of-school activities. One suggestion could be to use the university grounds during teacher preparation to ensure that all candidates have some experience in non-formal/informal programs. Learning how to develop or present an exhibit for the general public may give candidates an idea of the importance of out-of-school resources for education. Another possibility would be creating an interdisciplinary activity using non-formal/informal resources. Then different teachers would use the institution (for example, a museum) to develop different activities. If all of them need to go for different reasons, they may share the preparation and management responsibilities in a fair way. Nevertheless, this discrepancy needs to be addressed by future research including school administrators, school personnel, and teachers.

After addressing the main points of the interviews I now move to the modules. The following sections address modules I and II and the activities piloted in each module. In module I five lesson plans were tested in pilot I and one lesson plan in pilot II. In module II a group of activities were piloted twice.

Module I

In module I, phase one, modeling the off-campus activities provided examples and suggestions for including these types of activities in candidates’ lesson plans. However, candidates’ plans were still not well-connected; thus they seemed unable
to overcome the traditional disconnected perspectives for lesson plan design. It seems that more time and deeper discussion are needed on inquiry lessons during step one of the activity. These discussions need to have a logical sequence as in a learning cycle style, where candidates would be growing in understanding how to develop connected lesson plan designs. The rationale and modeling inquiry lessons also seems worthwhile to give students examples of activities that use non-formal/informal settings as a resource on inquiry lessons. The off-campus activity *per se*, even if it was modeled for students, was not enough to overcome designs grounded on a traditional view of biology ontogeny and phylogeny classifications. More research is needed on the role of modeling off-campus activities to achieve inquiry lesson plan design. It seems that the connection between these two approaches would be fruitful for both, especially if researchers focus on teachers with a lecture based approach.

Still on phase one, step two, candidates commented that it was easier to go to a museum than to go on a field trip. Thus, candidates planned more museum excursions than field trips. To understand these results, one hypothesis may be described by figure six. Phase I showed that the amount of work on inquiry lesson plans was underestimated since it was included only in one class among the 12 hours developing a rationale as part of step one. Besides this, after the development of the module we realized that activities did not grow from the inquiry project, perhaps because they were presented in isolation. Thus, candidates who participated only in phase one could not overcome the traditional perspective of isolated lessons and found it easier to either plan isolated activities or to plan visits
to non-formal settings to get expert support. In other words, this phase alone was not enough to overcome the traditional lesson plan design. However, a small sample had the opportunity to participate in the optional phase two. The following section describes results that evidence changes in lesson plan designs by candidates who participated in this second phase.

Figure 6: Module I (draft 2) for Teacher Candidates as implemented.

Even though phase two was optional, it was crucial for those students who participated as it was the turning point where students got into off-campus and inquiry design. More research with bigger samples is needed on the workshop
design, connecting international students, off-campus activities, technology, teachers, instructors, and candidates, and inquiry lesson plan design, especially for candidates from a developing country like Brazil. The workshop (phase II) put college instructors, teachers and candidates all together and was core for developing activities that were feasible and at the same time simple and focused on learning. Learning the technology was key to putting everybody on the same level without constraints. All subjects were equally willing to participate (learning and teaching), with each group leading in a different portion, for example, while designing fieldwork. Thus instructors were better able to tell what would be better, then while designing the lesson plan, teachers would be leading to tell what is best for a classroom, the international experience at the same time put all the group focusing in one task and added a flavor as people where planning an activities feasible in different contexts, thus they had to learn about different places and environments and hear about education in other countries. This experience was very rich for teacher candidates and instructors from Brazil, but we do not know if it would be the same for teacher candidates from other countries, or even for Brazilian candidates doing the same kind of workshop in Brazil, so these alternatives should be tested and compared to better evaluate the impact of international experiences on teacher preparation. Regular exchange programs and long term longitudinal research with teacher are two types of research that could evaluate in depth this impact.

On the other hand we also must consider an alternative option since phase two is not feasible every semester with all students. It would be unreal to plan any
module that considers an international trip as required. It seems that the methods course should focus on the link between off-campus and inquiry designs to expect some sort of candidate response ahead of the program, during practicum internship or educational research methods classes. One possible way is for a college instructor in the methods course to model an entire unit that uses inquiry and non-formal institutions together, and then ask candidates to develop another one, then candidates would have the experience, the model and the support while creating their own. Besides this, a longitudinal research is again a good approach to follow the candidates on different educational courses and constantly monitor for strengths and weaknesses of the program.

We already know that the second phase of module one caused far more impact on teacher candidates than phase one. A possible explanation, described by figure six, might be that this phase was much more integrated than the first one. As a consequence there was a crucial change in the lesson plan design. Candidates who participated in the summer workshop had an opportunity to work in depth with inquiry designs and activities, thus creating plans where the activities were instruments that helped the inquiry, not the opposite. In other words, the focus was not on the activity itself but on the inquiry and how to plan it. Thus candidates could prepare more integrated plans and were motivated to continue working with these plans on phase three.

Figure six shows that there was a change from the design (figure three phase III) to the implementation. Candidates were not satisfied with the results and wanted
to try the activity again with a few changes. They were offered the opportunity to
work with their peer candidates on the activity and all of the candidates who
participated on phase two promptly accepted. They were motivated to present the
work they had done. It seemed that their motivation produced a change in phase
three design which was the inclusion of a second pilot.

The two-semester design was the first experience connecting two courses in
the department of practicum teaching (College of Education at UFPR). The two
instructors met and discussed possible connections and how to use the projects
developed from the previous course transforming them into research projects and
testing (pilot) during the following course. This connection seems to have worked
much better for candidates and instructors than isolated courses would have
worked; of course this is now conjecture and research should be developed to study
advantages of such an approach. When students started the educational research
methods, they had their activities ready to research after their first semester
development. In other words, to research or test an existing project (pre-designed)
in just one semester was a much easier task than starting from scratch or trying to
develop a research project with no experience in schools, classrooms or teaching.
Thus, based on the results of this study, a new design is being proposed for testing.
Figure seven summarizes this.

In this design there are only two phases. Phase one happens in the science
methods course and phase two in the educational research methods class. Phase
one now has three steps. Steps one and two are on the left side of figure seven.
Step one with 12 hours of rationale did not change. Step two starts with a four-hour class on inquiry lessons. The suggestion is to model an inquiry lesson for teacher candidates. Concomitantly candidates would search out for feasible topics according to the Brazilian National Standards (PCN). Then teacher candidates and the science methods instructor would brainstorm a list of possible inquiries. Discipline specialists who would help focus the question could check the candidates’ ideas. With that, candidates would develop a draft plan for an inquiry lesson.

Figure 7: Module I revisited (final version) for Teacher Candidates.
Step three of phase one comprises the middle portion of figure seven. This step starts with a modeled activity for fieldwork. In this module review fieldwork comes before a school excursion to non-formal settings. The reason for that is that during module one application most candidates found it easier to plan for excursions than for fieldwork. When fieldwork was modeled most candidates had already planned school excursions and did not include fieldwork in their plans. In module I a school excursion to a non-formal setting has been modeled first. Thus to motivate more candidates to include fieldwork I rearranged the order and a new trial must be conducted to investigate if this works better.

The lab activity did not change; it still comes after the fieldwork. The school excursion to a non-formal setting would be modeled in an outside science museum or science center where there is less or no bias to evaluate the setting, thus the “shock treatment” mentioned in the rationale of the first design would not be necessary. In other words, in the first design we proposed that candidates should have the same treatment as their students when visiting the Natural History Museum, so they could understand how tiring and worthless it was to have a lot of lecturing in each exhibit.

To finish the third step candidates would complete the unit design including other class plans. Again candidates would be advised to ask for specialist support to avoid concept inaccuracy. Before having the final design, students would check with science teachers and hear their impressions on the topic, methodology, number of classes for the activity, and feasibility. We are suggesting that teachers should be
asked to give their opinions only when candidates have an entire profile of the unit because we learned from interviews (category two, faculty three excerpt and category four) that fellow teachers and school administrators usually make off-school activities sort of difficult. Thus it is better to have an entire plan first and then ask for teachers' and schools' opinions. If they see a need, a reason for going out, and an entire plan already developed, they may agree with that. Otherwise it may be too difficult for candidates to plan if they come first to the teachers and are discouraged from planning these types of activities. After talking to teachers about lesson plans, students then finish their unit design.

In the previous version of module one (figures three and six), technology was included only in the optional portion of the summer workshop. It was really impressive and amazing how candidates liked learning that. However in Paraná state we still have to work with many difficulties regarding technology access. Teacher candidates in the biology education program do not have another course to work with technology issues, so the suggestion is to include at least two occasions where candidates could have some contact with technology as they plan their lessons. First, while planning the inquiry lesson (designing inquiry lesson - part one, left side of figure seven), candidates will develop a conceptual map of the chosen topic in power point. After planning an inquiry unit (designing inquiry lesson - part two, right side of figure six), candidates will be required to develop a web site with the unit and link it to the methods course site. Thus all candidates will be able to check one another and share developed materials on different topics.
Phase two is almost the same, where the instructor discusses a research approach to test the lessons. The only change is that, as had been planned in the original version (see figure three) only one pilot will be implemented. This is because candidates have only one semester to design a research project, select the research instrument, test it, and at the end of the semester have some results for this research. Thus it would be very hard to pilot the lessons more than once in an undergraduate course. However, candidates can redesign the lessons after the pilot.

The new design for module one (figure seven) needs to be tested again. As the changes were based on the results, if applied under the same conditions better results can be expected, at least for phase one. We cannot assume the same for phase two (or former phase three on the first version of module one, see figure three phase three) because the high impact of the international experience on the workshop. This phase can never be replaced but it taught us a lot in terms of integrated approaches. Phase one on the new module (left portion of figure seven) seems to be more integrated than the first version (figure three or six) and as a result we anticipate that candidates would create more integrated plans.

Module II

Module two was a victory in itself from the start because interns came to me to ask for help and supervision. They wanted to create activities that would bring some hands-on activities to the museum. Only this step could be celebrated since we mentioned before that this museum has a very traditional approach with stuffed
animals and scientific collections. We listened carefully to all interested people and prioritized real demands, such as the lack of space in the museum, intern and teacher interests, and the one semester course for internship. Thus, even though small, the module established a very significant entry point for museum and college of education partnerships.

We worked in a sensitive situation, wanting to avoid criticism of museum personnel work, while at the same time suggesting changes on the exhibit designs. The strategy may have had a payoff. At the end of the project, other interns started developing new games and activities to be part of the museum kit with the idea of increasing student participation. Thus even if it is only one small result, it seems that other people started to be engaged in new exhibit approaches.

The design itself needs more testing. It seems that the design should be replicated with other teachers and interns. It could also be replicated in other museums and centers. For the strategy selected there are some issues to be pointed out. The strategy based on rotating activity stations was not very functional, since all the activities had different timing. The activities are also dependent on the group speed. So if activities were conducted while students are waiting to come inside they would play enthusiastically. However when the activities were done after the group finished visiting the museum, then students would be tired and with no energy to play. Sometimes they would be even anxious to leave because of bus schedules and so on. One possible explanation resides in the activity designs. Interns developed five games, complicated by different rules and many pieces. All
of them ought to be played at the same time by a group of 15-20 students with a supervision of one intern. The approach outlined did not work properly since students have had many doubts regarding how to play and what to do in each activity. Thus we can conclude with certainty that if the strategy remains the same, more interns are needed to develop the activity with students. Furthermore, research is needed to investigate the best schedule to apply the activities or what activities should be selected to reshape the visit, balancing play time and time to go through the exhibits without fatiguing students. Clearly the game technique has promise as a tool for museum needs when students are waiting to come inside and even for museum kits.

It was clear that testing of activities needs improvement. The evaluation questions were too open-ended which resulted in a mixed set of answers, from the activities to the exhibits and the way museums work. Besides this, because of the tight schedule we only had time to ask some questions orally with one group of visitors, and their opinions and answers were given in a hurry. Thus, at least three issues need improvement. First, the type of questions needs to be focused on the activities themselves, to avoid mixing opinions from the activities to the exhibit and the guided tour. Second, the timing to administer the questionnaires needs to be studied to avoid rushed, superficial, and one-word answers. Third, samples should be more diverse, including a variety of grade level activities, and teacher candidates, providing answers that can really help with developing and redesigning the activities.
As for museum educators’ preparation, or in the case of the University museum, interns’ preparation, literature has shown that the problems we are facing with museum interns today were raised long ago. Even back in 1958, Hellmann mentioned the problem of staff qualification: “the staffing of modern natural history museums with properly trained and qualified educators has, as a result, been one of the growing pains of modern museumdom” (p.49). He pointed out that the qualification problem should answer three questions or aspects: what are the museum teacher’s duties? What qualifications do museum teachers need to fulfill their professional obligations? And how to keep highly qualified museum teachers? His paper suggested that a bachelor’s degree in science with teaching experience, preferably a masters, degree is necessary and even a person with a doctoral degree is not overqualified. It is interesting to notice that almost fifty years later we are still struggling with museum educators’ qualification problems in Brazil. On the other hand we cannot forget that the science museums and centers’ educational perspective in Brazil is much younger than in European countries, for example, especially in smaller cities like Curitiba where sometimes educational activities and exhibit design are part of curator duties. Laub (1985) noted that a “wide range of activities and responsibilities that traditionally have been included in the curator domain. Add to this the proliferation of specialists in museums as those institutions have grown more complex” (p.47). Thus we need curators with a more educational approach to deal with exhibits and interns.

The lack of tradition in science museum education or non-formal education preparation in Curitiba may have played a role when museum administration made
decisions about what kind of education museum personnel should have. It seems that the scientific tradition of the Natural History Museum drove the attention to science fields only, without specific teacher education.

Another thing to consider is that science museums and centers in Curitiba have to rely mostly on interns, temporary, or part time staff to do the educational tasks. Most of them have scholarships to do that. Thus even considering that research is needed to compare and contrast budget uses, museum priorities, and educational staff development, we can infer with confidence that staff training on educational issues is not a priority on the tight museum budget. However if the goal is to improve public science literacy, and develop a public culture of museum visiting, education staff preparation should be required.

Some things need to be said about teacher preparation and intern education. First what amazed me the most was the strong connection created between student teachers, faculty, and me after the international portion of module one. Even one year later, we are still working together and two papers about the experience have been written, one of them has already been presented at a national research meeting on education in Brazil and published as a conference proceedings. Those student teacher candidates who participated began teaching their peer students during the following two semesters about what they have learned during the project. This is for me the best and most powerful result I could ever imagine.

The museum interns’ results from the second module were not as dramatic. However museum personnel are still using the activities, especially in the kits they
send to schools and they are now developing other materials based on the same idea. Thus it seems that it was not just a one shot project with no expansion at the end. Perhaps museum interns needed educational guidance so badly that even a small project is a good start. In this case I still think that it paid off.

Summary of Recommendations

Combining what I have learned from the different phases of this study leads me to have a number of recommendations for the Biology Education program at Federal University of Paraná. These recommendations are summarized as follows:

1. The Methods course should not be the only opportunity in the program for teacher candidates to learn inquiry-based teaching. It should be included much earlier in the program.

2. Teacher candidates should start having school experiences earlier in the program. The Methods course did that informally, however, it should be mandatory to include a school experience in this course as well as in other courses in previous semesters.

3. The Methods course and practicum internship should be connected by one overarching project that is designed in one course and tested in the other course. This gives candidates the opportunity to design and test lesson units with field trips.
4. Before or during the lesson design process, candidates should have a classroom experience, observing classes and asking students and teachers expectations about the lessons.

5. The Education Research Methods Course and internship should also be connected by an overarching project related to non-formal/informal experiences. In the same way, the Education Research Methods would help Biology Education majors design and prepare small hands-on exhibits based on educational goals while the internship would give them the opportunity to act as “insiders”, testing the exhibit design and its hands-on activities.

6. A Post-visit research should be included as part of the internship to give majors more input on the use of non-formal settings as a learning tool.

7. The program should provide more experiences connecting teachers, college instructors, and teacher candidates, to create a stronger net of support during the practicum internship process and perhaps the first years of professional teaching.

8. The Methods course must model the activities with teacher candidates before the design of inquiry lesson units.

9. The Methods course should not have more than 25 teacher candidates enrolled in order to maintain class quality and allow modeling of activities.
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