Spring 2006

Jesuit Education and Mathematics: Review of the Literature on Jesuit Education and Mathematics

Ernesto A. Diaz
Dominican University of California

https://doi.org/10.33015/dominican.edu/2006.EDU.01

JESUIT EDUCATION AND MATHEMATICS

Review of Literature on Jesuit Education, and Mathematics

Ernesto A. Diaz

Submitted in Partial Fulfillment of the Requirements for the Degree

Master of Science in Education

Division of Education
School of Business, Education, and Leadership
Dominican University of California

San Rafael, CA

August 2006

"Above all, trust in the slow work of God
We are quite naturally impatient in everything
to reach the end without delay.
We should like to skip the intermediate stages.
We are impatient of being on the way to something
unknown, something new.
And yet it is the law of all progress
that it is made by passing through
some stages of instability –
and that it may take a very long time.

And so I think it is with you.
Your ideas mature gradually—let them grow,
Let them shape themselves, without undue haste.
Don't try to force them on,
As though you could be today what time
(that is to say, grace and circumstances
Acting on your own good will)
will make of you tomorrow.

Only God could say what this new spirit
gradually forming within you will be.
Give Our Lord the benefit of believing
that his hand is leading you,
and accept the anxiety of feeling yourself
in suspense and incomplete."

Pierre Teilhard de Chardin S.J.

ACKNOWLEDGEMENTS

This project is the synthesis of support, advice, guidance, nurture, editing, thought provoking comments, gentle and at times very clear directive to change, help, stimulus, and more support from a number of people. As in any project, one cannot work in the vacuum, nor can we produce anything of quality without leveraging the contributions of others.

My teachers and mentors at Dominican University, Dr. Madalienne Peters and Dr. Lin Muehlinghaus, have been a constant source of encouragement, advice and support that has sustained me at times and improve my work often. The project benefited from the ever present and generous help of the Library staff at Dominican University, and in particular that of G. Gorka, R. Hayes, S. Pelayo, A. Schut, L. Wendell, and A. Whiteley. I would also like to acknowledge my classmates, their openness, and search for excellence have inspired me to do better.

The majority of the work presented here is based on the intellectual and scholarly achievements from a number of people. Some of them have been extraordinarily generous with their personal encouragement, advice, support, mentorship, guidance, and at times editing of my ideas and focus, as well as by sharing their work with me when I could not locate it by other means. I have been incredibly fortunate to have been the recipient of the aid from Fr.Vincent Duminuco S.J. at the Graduate School of Education at Fordham University in New York, NY; Fr. John O'Malley S.J., Distinguished Professor of Church History at Weston Jesuit School of Theology in Cambridge, Massachusetts; Dr. Antonella Romano, at the Department of European History and Civilization at the European University Institute in Florence, Italy; and Fr. Dennis Smolarski S.J., at the Department of Mathematics and Computer Science at Santa Clara University in Santa Clara, CA.

In order to be able to function as a scholar and student, I have found that the enthusiastic support, contributions, and space created by my wife Giulia A. Welch is indispensable and the reason I could begin, continue and finish this work. Her editing, intellectual discussion, and perspective have also shaped this project, its content and its format. Watching my twin daughters Elisa Mariana, and Cristina Pilar is how I begun the questions that led to this project. When I needed strength, I returned to them and fed from their love and laughter.

Finally, in some ways, this project is one more part of a circle that begun long time ago in the sixth grade with my first spiritual director, Fr. Pedro Galdos S.J. who to this day is a friend, a mentor and an inspiration for the path I have chosen. This thesis is dedicated to him.

TABLE OF CONTENTS

	Page
Title Page……	1
Acknowledgements……..	3
Table of Contents……	5
List of Figures…….	6
Abstract……	7
Introduction……..……	9
Statement of Problem……...……	12
Purpose Statement……	12
Theoretical Rationale……...……	13
Assumptions…….....……	16
Background and Need…….……...…..	17
Review of the Literature……...…	21
Origins…..…….…….……..	21
Expansion…….……...…….	34
Restoration……	44
Renewal……	50
Discussion…….	54
Summary of Major Findings…….	54
Limitations/Gaps in the Literature……..…..	60
Analysis of Themes and/or Inferential Analysis……...	61
Limitations of the Study…….....	63
Implications for Future Research……..…	63
References…….	64
Appendix……...	73
Geometry Lesson Plan: Solids, Spheres, and Cross Sections……..…….	74
Calculus Lesson Plan: Introduction to Limits……...……...…..…..	76
Calculus Lesson Plan: L'Hopital's Rule ……..……..	77

LIST OF FIGURES

Page

Figure 1: *Ratio Studiorum*'s cover ……. ……..……..…….. 25

Figure 2: Christoph Clavius portrait ……...……... 30

Figure 3: Clavius's *Opera Mathematica* with Euclid's commented text (cover)…….... 32

ABSTRACT

The purpose of the thesis is to review recent literature on diverse aspects of Jesuit education including its historiography, pedagogy, teaching, philosophy, and its contributions to the field of Mathematics. The time frame studied has been divided in four main periods. Origins; encompassing the founding of the Society of Jesus in 1540 to the publication of the *Ratio Studiorum* in 1599. Expansion; covering from the publication of the *Ratio* to the suppression of the Society in 1773. Restoration: covers the period between the 1814 Restoration, until the beginning of the Vatican II Council. Renewal; the Society in the post-Vatican area to the present day.

In creating their educational system, the Jesuits combined their fundamental documents and the "best practices" available. The *Spiritual Exercises* from Ignatius inspired their mission and the pedagogical process they implemented in their methods. The *modus Parisiensis* gave them a model for an educational institution, and the Italian Humanists an orientation for their education. The *Constitutions* gave them the focus and direction to implement their network of schools. Together with the product of local experiences and consultations for over fifty years they produced the *Ratio Studiorum*, a manual for the operation of a school, to be used everywhere.

The *Ratio* has provisions for mathematics instruction that survive to the present, as well as for the foundation of the Collegio Romano. Mathematics and the Collegio Romano played an important role in the beginning of the Scientific Revolution, and it affected the work of influential minds of the sixteenth, seventeenth and eighteenth centuries, and declined after that.

Behind the mathematics of the *Ratio* and generations of Jesuit mathematicians is the influence of Christoph Clavius, his work, educational strategies and textbooks. The characteristics of Jesuit pedagogy, mathematical work and its influence in philosophical thinking in the Seventeenth century are examined. After the Restoration of the Society the *Ratio* was no longer the universal norm for their schools. Jesuit education in the eighteenth and nineteenth centuries had the most success in those areas were education was under the control of Protestants.

The mission and current documents on educational pedagogy, characteristics and methodology are also reviewed. In the last several years, there has been a renewed interest the Jesuits, their influence and their educational system, but scholarly work is rare and the areas of study focus mostly in the Counter-Reformation period. Further work is suggested in using the tradition, experience and methodology of Jesuit education, particularly in the role of Mathematics and its teaching.

INTRODUCTION

The project originated with my present job. I am currently teaching 3 very different courses in mathematics. The first one is on geometry and it is for grades 9-10. The second one combines economics and business math, and it is for students in grades 11-12 that for different reasons have been traditionally unsuccessful academically in general and in mathematics in particular. The third is for advanced students in grades 11-12 that need to go beyond the minimum mathematics requirements to be accepted in college and want to make their profiles more desirable during admissions or because they are considering going into fields that need higher math. While thinking about what is it that I wanted to provide in these courses I realized that there are different objectives: Geometry is about developing skills set; logic, deductive thinking and 3-dimensional spatial visualization. Economics/Business Math is about the relevance of mathematics in our lives, and about being able to transform fear of math born from lack of success into a useful tool to function in a real and difficult world. Precalculus is about cognitive development, where I need to transform traditional math thinking at lower levels, based on algorithms for problem solving (FOIL is an example), into strategic thinking that is comfortable in dealing with unexpected situations as well as into modeling, this being the first step into creative scientific thinking.

The coexistence of those goals and the fact that my own background is rooted in Jesuit education generated several questions that form the genesis of the project; what are the roots of Jesuit Education? When and how did Jesuit Education begin? What exactly is different in the Jesuit educational system from others? Is there a link between the origins of Jesuit Education and the product of its schools? What does it mean to teach Mathematics in a Jesuit School? How is mathematical thinking created in Jesuit education? Has it always been that way? Can the lessons be applied in other schools?

The purpose of the thesis is to review existing literature on diverse aspects of Jesuit education including its historiography, pedagogy, teaching, philosophy, and its contributions to the field of mathematics. In terms of historical scope, the literature covers several centuries, beginning with the creation of the Society of Jesus in the sixteenth century and extending to the present day. After its creation in the sixteen century, the Society began to expand worldwide very rapidly and along with the expansion came the need for schools to educate students and prospective Jesuits alike. Education began as one of the most important aspects of the Society in its origins as a means of molding the future members of the society into the type of man that could fulfill its mission anywhere that was required.

The Jesuit educational system was the first systematic approach to education in the western world and had its origins in the humanistic tradition of the early Renaissance and the ancient Isocratic ideals of creating men (and women) that would influence positively their society. The system was also influenced by the S*piritual Exercises* created by Saint Ignatius of Loyola, the Society's founder, and in particular by the tradition of discernment coming from the *Exercises*, which is the process of reflection from one's experience and decision making based on the experience itself and one's reflection about it, becoming a process that permeated Jesuit Pedagogy.

Early in the history of the Society, and following the mandate of the general superior, the Jesuits set into a multinational project that lasted fifty years and collected the current thinking and experience of Jesuits, teachers, and students in their many schools to establish a "handbook" of what should be taught, how, and in which order, including the roles and responsibilities of faculty, administration and students. This manual was published in its third and last version in 1599 under the name *Ratio atque Institutio Studiorum Societatis Iesu,* more widely known as the

Ratio Studiorum. The *Ratio* Studiorum was innovative in that it has provisions for mathematics instruction, as well as for the foundation of the Collegio Romano. The particular Ignatian search to *find God in all things* led to the inclusion of ideas, concepts and theories even if they were not officially accepted or concurrent with consensus views. This approach affected curriculum choices and mathematical science in Jesuit academics to influence the making of scientific knowledge. Mathematics and the Collegio Romano played an important role in the beginning of the Scientific Revolution, and it affected the work of influential minds such as Galileo, Descartes, Leibniz, Newton, and others. The architect of the inclusion of mathematics teaching in the *Ratio* was Cristoph Clavius. Clavius advocated for the importance of Mathematics in mainstream academics, and through his pedagogical approach, curriculum chosen, and series of textbooks written had a lasting and powerful legacy that was felt throughout the schools of the Society. An example was Matteo Ricci, who was the first westerner accepted in the upper casts of China in the sixteenth century and the man who brought Euclidean Geometry and Western thought to the Ming dynasty.

Aside from the curricular emphasis, one of the characteristics of Jesuit education is the role of ‘cura personalis’ (Latin meaning "care for the [individual] person") where the teacher establishes a personal relationship with the students, listens to them in the process of teaching, and draws them toward personal initiative and responsibility for learning. This characteristic played a role in educating countless members of the societies in which the Jesuits were living and working. Some of those students grew up to have enormous influence, Rene Descartes being a particularly important example.

The Jesuits and their schools grew up in numbers and influence until the eighteenth century, when for a variety of reasons the Society of Jesus was suppressed by papal decree and

subsisted in very small and disperse pockets protected by friends. In the Eighteenth century the Society was restored but its influence in academics in general and Mathematics in particular was never the same. A number of secondary and higher education institutions were founded in the eighteenth and nineteenth centuries and they had the most success in those areas were education was under the control of Protestants.

Since 1999, the 400th anniversary of the publication of the Ratio Studiorum, there has been a renewed interest in scholarly work associated with the Jesuits, their influence and their educational systems, but unfortunately, work is rare and the areas of study focus mostly in the Counter-Reformation period. Further work is suggested in using the tradition, experience and methodology of Jesuit

Statement of Problem

Several questions form the genesis of the project; what are the roots of Jesuit Education? When and how did Jesuit Education begin? What exactly is different in the Jesuit educational system from others? Is there a link between the origins of Jesuit Education and the product of its schools? What does it mean to teach Mathematics in a Jesuit School? How is mathematical thinking created in Jesuit education? Has it always been that way? Can the lessons be applied in other schools?

Purpose Statement

The purpose of the thesis is to review existing literature on diverse aspects of Jesuit education including its historiography, pedagogy, teaching, philosophy, and its contributions to the field of Mathematics.

Specifically

I. To find about the origins, roots, philosophy, methodology and characteristics of Jesuit education in general and in particular in mathematics.
II. To find the state of research on Jesuit Education in the area of mathematics.
III. To find what can be learned from 400 years of experience in an education system applied worldwide to the teaching of mathematics in diverse environments.

Theoretical Rationale

In trying to identify the theoretical rationale behind Jesuit education, the following ideas can be found among the most important contributions to its foundation:

I) One can find four key themes emerging in the beginnings of Jesuit education. First, the objective of the educator to stimulate the student in relating his studies to the knowledge and love of God and the salvation of his soul; second, the goal of the curriculum in the formation of a Christian outlook on life, enabling the student to live well and meaningfully for this world and the next; third, the moral and intellectual formation of students; fourth, the preparation of capable and influential leaders for society (Cesareo, 1995).

II) In one formulation (Robert Newton's *Reflections on the Educational Principles of the Spiritual Exercises* [1977] in Traub, 2003), Jesuit education is not an end in itself, but a means to the service of God and others; student centered, adapted to the individual as much as possible so as to develop an independent and responsible learner; characterized by structure, with systematic organization of successive objectives and systematic procedures for evaluation and accountability; flexible, encourages freedom and personal response; expects self-direction, with the teacher an experienced guide,

not primarily a deliverer of ready-made knowledge; eclectic, drawing on a variety of the best methods and techniques available; and personal, whole person affected, with the goal of personal appropriation, attitudinal and behavioral change.

III) In another formulation (*Ignatian Pedagogy: A Practical Approach from the International Center for Jesuit Education* [Rome, 1993] in Traub, 2003), Ignatian pedagogy is a model that seeks to develop men and women of competence, conscience and compassion. Similar to the process of guiding others in the *Spiritual Exercises*, faculty accompany students in their intellectual, spiritual, and emotional development. They do this by following the Ignatian pedagogical paradigm. Through consideration of the context of students' lives, faculty create an environment where students recollect their past experience and assimilate information from newly provided experiences. Faculty help students learn the skills and techniques of reflection, which shapes their consciousness, and they then challenge students to action in service to others. The evaluation process includes academic mastery as well as ongoing assessments of students' well-rounded growth as persons for others.

IV) The Jesuit educational system is influenced by a program promoted by Italian Humanists that consisted on the study of classical texts to produce literate, cultured, and socially responsible citizens (Simmons, 1999).

V) The Jesuit educational system is influenced by an elaborate program of public and private spiritual education based on the *Spiritual Exercises* (Simmons, 1999). This is the root for Jesuit education to be based on the concept of discernment, where discernment is the process of reflecting on one’s experience, articulating that

experience and interpreting and making decisions based on both the experience itself and one's reflection about it (Letson & Higgins, 1995).

VI) The early Jesuits made a conscious decision to follow the pedagogical model used at the University of Paris, the rigorous *modus Parisiensis* which included a graded class system with a single master assigned to each class and specific material which it had to get through, a strict daily schedule, and an elaborate system of student work in the form exercises such as repetitions, disputations, and compositions (Simmons, 1999).

VII) Jesuit education is characterized by the role of 'cura personalis' (Latin meaning "care for the [individual] person") where the teacher establishes a personal relationship with the students, listens to them in the process of teaching, and draws them toward personal initiative and responsibility for learning (Traub, 2003).

VIII) Almost from its beginning, Jesuit education has had several controversial elements, and one of the most noticeable is a willingness to meet and converse with many varieties of unbelief on their own terms, and a determination, prominent in our own time, to think in radical solidarity with the poor and the oppressed. The Jesuit approach insists from the start that God has never been and could never be completely alien from anything. This approach embodies and Ignatian impulse to *find God in all things*, which in turn answers a theological imperative to affirm the unity and the grace of all creation, even when there is neither evidence nor testimony to immediately encourage that endeavor. This open, Catholic attitude would be the founding antecedent of Jesuit education today, which rarely hesitates to bring a student into contact with the work of thoroughly secular thinkers like Marx, Freud, and Durkheim (Bloechl, 2004).

IX) "…our prime educational objective must be to form men-and women-for-others... people who cannot even conceive of love of God which does not include love for the least of their neighbors; people convinced that love of God which does not issue in justice for human beings is a farce.... All of us would like to be good to others, and most of us would be relatively good in a good world. What is difficult is to be good in an evil world, where the egoism of others and the egoism built into the institutions of society attack us.... Evil is overcome only by good, egoism by generosity. It is thus that we must sow justice in our world, substituting love for self-interest as the driving force of society" (Arrupe, 1973; Traub, 2003, para. 49).

Assumptions

In reviewing the literature and subsequent analysis, I have found convenient to present four distinctive periods of the history of the Society of Jesus. These periods are not equal in length, but they share common characteristics that are useful to understand different aspects of Jesuit education in general and mathematics in particular.

Time period	***Key Themes in Jesuit Education***
I) Origins: This is the period that roughly encompasses the founding of the Society of Jesus in 1540 to the publication of the *Ratio Studiorum* in 1599.	**I)** Foundation of the Society and genesis of the identity and philosophy of Jesuit Education. Education as charter to become the first teaching order of the Catholic school. The Jesuits choose to follow the *modus Parisiensis* for the pedagogy and a humanistic approach in the founding of a network of schools and the development of a plan of studies called *Ratio Studiorum.*

II) Expansion: This period covers from the publication of the ratio in 1600 to the suppression of the Society in 1773.	**II)** Worldwide expansion of the Society and its schools, and the influence of the educational system in the different regions and environments where the Jesuits are actively working and teaching.
III) Restoration: covers the Society and its efforts to revamp its mission, structure and system of schools, covering the period between the 1814 restoration by Pope Pius VII, until the beginning of the Vatican II Council in the 1960s.	**III)** Society struggles to implement old formulas in a world where separation of church and state imposes limitations in the schools, Focus on seriousness and rigor of studies, strict discipline, and sound religious and moral formation.
IV) Renewal: The Society in the post-Vatican area to the present day.	**IV)** An emphasis on social justice becomes the stated mission of the Society of Jesus and its educational objectives. "Today our prime educational objective must be to form men-and women-for-others..." (Arrupe, 1973 in Traub, 2003, para.49). Creation of the guidelines for Jesuit institutions in the coming decades: *Characteristics of Jesuit Education* and *Ignatian Pedagogy: A practical approach*.

Background and Need

The Society of Jesus has been an agent of change throughout its history and therefore it has been faced and dealt with the problem of maintaining its identity, ethos, philosophy and

mission while facing “the Other”, the Other being major cultures and faiths around the world. As an agent of change, the Society has used its system of education as a means to achieve the goal of the salvation of souls and preparation for a fruitful and positive life of service to society and others. Jesuit institutions have formed a cultural ecosystem that has affected me and many others while at the same time have had to adapt to the cultural realities it has faced in its missions (O’Malley, 1999). The missions drew forth cultural accommodation and social experimentation (Buckley, 1999); we see examples in the communal life of the Reductions of South America, the inculturation of Matteo Ricci and how he brought Euclidean Geometry and Western thought to the Ming dynasty in China, the schooling of the intellectual circles in France with examples like Rene Descartes and Voltaire, the introduction of Mathematics in mainstream academics by Christoph Clavius and the Collegio Romano, and the exploration of Quebec by Jean de Brebeuf and its knowledge of the Hurons. The Society has undergone a process of evolution over the centuries, and yet a few key themes are intrinsic to its identity, one of them being the importance and role of education. Consistently with the finds of this paper, Jesuit education tries to mold both Jesuit and lay people into a person that is consistent with the mission of the Society. In its latest period since the end of the Vatican II Council in the 1960s, its mission, and therefore the mission of its educational institutions is social justice. As such, Jesuit education seeks to create men and women for others, members of society that work in their own environments to be closer to God and in service to one another.

In order to understand the Jesuit educational system we need to look at the background and context for the origins of their global network of schools. We also need to look at the framework used to establish those schools. The success of the early Jesuit colleges and universities is due in part to the deliberate choice to combine different educational programs. The

first one had been promoted by Italian Humanists and consisted of the study of classical texts to produce a literate, cultured, and socially responsible citizen. The second program that influenced the Jesuit educational system is an elaborate program of public and private spiritual education based on the *Spiritual Exercises.* The third influential program was the rigorous *modus et ordo* of Parisian scholasticism, the *modus Parisiensis*, which included a graded class system with a single master assigned to each class and specific material which it had to get through, a strict daily schedule, and an elaborate system of student work in the form exercises such as repetitions, disputations, and compositions. The curriculum was novel in its ability to combine the humanist approach to classics with the Aristotelian philosophy and Thomistic theology of Paris (Luckàcs, 1999; Cosentino, 1999; Homann 1999; Simmons, 1999), and the inclusion of specific instruction in mathematics.

In an unusual approach, the experience of administrators, teachers and students around the world was collected and merged into the document that would be used as framework for the schools; the *Ratio Studiorum* published in 1999. There are four principal areas contained in the *Ratio*; administration, curriculum, method, and discipline. It begins with Administration by defining the function, interrelation, and duties of such officials as the rector, and prefect of studies. It outlines a curriculum by placing in their proper sequence and graduation courses of study. It sets forth in detail a method of conducting lessons and exercises in the classroom. It provides for discipline by fixing norms of conduct, regularity, and good order for the students (Farrel, 1970 in Padberg, 2000). The *Ratio* dictated the way schools would operate everywhere. This meant that by the year 1749, it was used in 669 colleges and 24 universities administered by the Society worldwide (Chapple, 1993).

One can find four key themes emerging in the beginnings of Jesuit education. First, the objective of the educator to stimulate the student in relating his studies to the knowledge and love of God and the salvation of his soul; second, the goal of the curriculum in the formation of a Christian outlook on life, enabling the student to live well and meaningfully for this world and the next; third, the moral and intellectual formation of students; fourth, the preparation of capable and influential leaders for society (Cesareo, 1995). The colleges engaged the Jesuits and lay people in mathematics, astronomy, and, the same as in the renaissance schools; it engaged them in art, rhetoric, and drama.

It is difficult to assess the depth of the cultural influence that Jesuit schools had in those environments that hosted them. Two examples of that influence can be drawn from the historiography of the Society of Jesus during the period between the sixteenth and eighteenth centuries. The first one is the inclusion of pure mathematics as part of mainstream academics in opposition to current the current thinking that stated it was not a "true" science in the Aristotelian sense because it was based on abstract thought and not on facts (Romano, 1999; Smolarski, 2002). In the second example, mathematical science in Jesuit academics involved methodological conceptualization of scientific knowledge (Dear, 1995), and became part of the Scientific Revolution. From the two points of origin (the background and framework for the education system) we can then look at the evolution and experience gained during the last four hundred years in an incredibly diverse and widely spread network of educational institutions.

Review of the Literature

The review is structured around four main periods, each one with similar characteristics and providing a separate chapter in the historiography of Jesuit education; Origins, encompassing the founding of the Society of Jesus in 1540 to the publication of the *Ratio Studiorum* in 1599; Expansion, covering from the publication of the *Ratio* to the suppression of the Society in 1773; Restoration, which covers the period between the 1814 Restoration, until the beginning of the Vatican II Council; and Renewal, the Society in the post-Vatican area to the present day.

First Period: Origins

Pope Paul III signed a document called *Regimini militantis ecclesiae* on September 27, 1540. This papal bull became the foundational document of the Society of Jesus, and in the revised and somewhat expanded form of *Exposcit debitum*, approved by Pope Julius III on 21 July 1550, remains to this day the license officially allowing the Jesuits to operate within the Catholic Church.

The first Jesuits drafted a list of ministries that is included in the papal bull, with some of them fitting into the pattern set by the great mendicant orders of the Middle Ages, specially Dominicans and Franciscans. The list mentions the *Spiritual Exercises* (a current translation can be found in Fleming, 1996), an unprecedented form of ministry created by Ignatius of Loyola in divergence from the other Orders. The ministry invited people to an inward journey and provided various roadmaps for making it. The *Exercises* was the first book to organize and codify procedures in a practical, organized, yet flexible way to retire from one's ordinary circumstances

for reflection and meditation. The *Exercises* are an ordered set of instructions integrating the freedom necessary in a genuinely Christian religious experience with the guarantees that insure the experience is both authentically from God and respectful to human reason and dignity (Gray, 2000, p.6). The creation of this new Christian ministry (the spiritual "retreat") helped contribute to the Jesuits' self-definition and style. The style would favor a reflective and fully articulated approach to problems and their solutions.

When the *Exposcit debitum* of 1550 was published, a change of absolutely primary importance in the formation of the Society was underway, the momentous impact of the decision by the Society to undertake schooling as a formal ministry. The decision immediately affected almost every aspect of the Jesuits self-understanding and gave the Society an enlargement of its mission. It would come almost to define the Society itself and had a transforming effect on all the other ministries and on almost every aspect of Jesuit procedure (O'Malley, 2006).

At the time of Ignatius of Loyola's death in 1556, the Society had in its possession two fundamental documents, his *Spiritual Exercises*, and the *Constitutions,* later approved by the First General Congregation in 1558 (a current translation can be found in Moell & Padberg). At that moment, there were 936 Jesuits in the Society, and 32.6% of them were distributed among 46 colleges that had been founded up to that point (Romano, 2004).

The first fundamental influence in Jesuit education is the *Spiritual Exercises* created by Ignatius. Years before attending the University of Paris for his formal education in philosophy, Ignatius lived through an experience that was to shape him as well as the companions that have since accompanied him (Letson & Higgins, 1995). In early 1522, Ignatius went in a pilgrimage that took him to the Benedictine monastery of Montserrat in Catalonia, and after a few days under the direction of the master of novices, he planned to spend a few days at the small town of

Manresa, near Barcelona, in order to reflect upon his experience up to that point (O'Malley, 1993). Ignatius' stay in Manresa lasted almost a year, from March 1522 until early 1523. In his dictated memoir, Ignatius narrates how "God was dealing with him in the same way a schoolteacher deals with a child while instructing him" (Gray, 2000, p. 2). Ignatius believed that the communication he felt with God was a gift not only to understand God's descent into the human but of the human ability to rise to God from created reality. Manresa symbolizes the foundation of Ignatian education. It was an event that was experiential; it was based on trust; and it invited a discovery of God in a variety of realities, a view that would be transferred to his educational outlook. Coming from this view, Traub (2003) can describe Jesuit education as characterized by the role of 'cura personalis' (Latin meaning "care for the [individual] person") where the teacher establishes a personal relationship with the students, listens to them in the process of teaching, and draws them toward personal initiative and responsibility for learning. In Ignatius's educational outlook there is a reverence for the pedagogical character of God's revelation; a trust that this process invited not only participation but imitation, and an assumption that this process was mutually beneficial both to the one that taught as well as to the one who learned (Gray, 2000). The *Spiritual Exercises* emerged out of Ignatius's stay at Manresa and then refined in the subsequent years. The *Exercises* are centered in the process of discernment which is the process of reflecting on one's experience, articulating that experience, and interpreting and making decisions based on both the experience itself and one's reflection about it (Letson & Higgins, 1995).

The second fundamental influence in Jesuit education is the *Constitutions,* which calls for separate treatment of matters pertaining to education, and it advises that the teaching in Jesuit institutions be conducted with the end of the Society itself, specifically to work for the salvation

of the souls of the members' fellow men with the same intensity as for their own. This implies, and has been understood by the Jesuits since their foundation, that there is a call for engagement with the world as it presents itself, and that the world, for all its plea for support and guidance, has a degree of truth and goodness. In response to the call from the *Constitutions* to treat separately matters regarding education, and following the mandate of the general superior, the Jesuits started a multinational project that lasted fifty years and collected the current thinking and experience of Jesuits, teachers, and students in their many schools to establish a "handbook" of what should be taught, how, and in which order, including the roles and responsibilities of faculty, administration and students. This manual was published in its third and last version in 1599 under the name *Ratio atque Institutio Studiorum Societatis Iesu* ("The Official Plan for Jesuit Education", a contemporary translation and associated bibliography can be found in Pavur, 2005) more widely known as the *Ratio Studiorum* (see Figure 1). The *Ratio* takes an early and decisive step toward recognizing the importance schools must place on the inclusion of humanities in their curriculum (Luckàcs, 1999; Padberg, 2000; Smolarski, 2002).

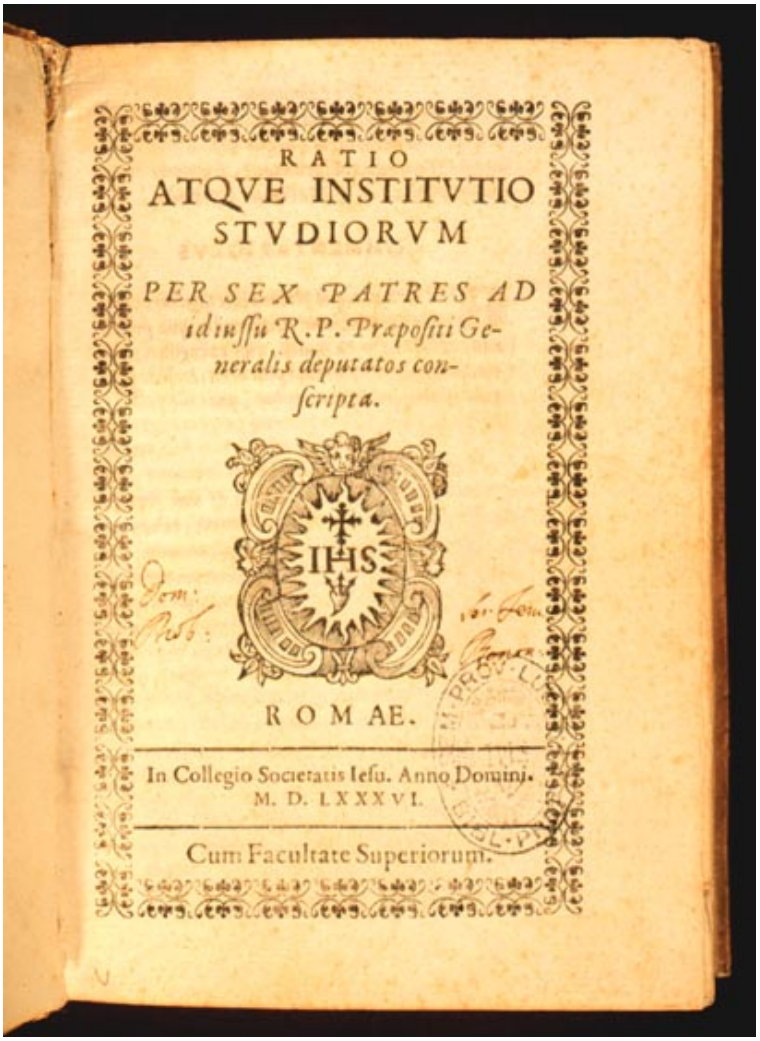
RATIO
ATQVE INSTITVTIO
STVDIORVM
PER SEX PATRES AD
id iuſſu R. P. Præpoſiti Ge-
neralis deputatos con-
ſcripta.
IHS
ROMAE.
In Collegio Societatis Ieſu. Anno Domini.
M. D. LXXXVI.
Cum Facultate Superiorum.

Figure 1

The sixteenth century is marked by events that have profoundly marked the course of modern history. The Renaissance opened the doors for the Scientific Revolution, worldwide exploration and colonization, and what O'Malley (1999) calls "Early Modern Catholicism", which includes the Catholic Reform mandated by the Council of Trent, the Tridentine Reform, and the Counter Reformation. The traditional view prevalent until a few years ago was to categorize the Society of Jesus as a group of agents of the Catholic Church involved in concentrated efforts against Protestantism. O'Malley (1999) has challenged this idea and proposed that the question to answer regarding the origin of the Jesuits should be 'What were the

Jesuits like?' in that time. The implication of this view is that the Jesuits can be seen less as ecclesiastical agents and more as practitioners and promoters of the traditional practices of the Christian religion. This is the context in which one can review the first of the four key periods that are examined in this paper, the foundation of the Society and the genesis of the identity and philosophy of Jesuit education.

The founder of the order, Saint Ignatius, lived in an age that saw two trends in education; the emphasis on *veritas* (the pursue of truth from the Aristotelian tradition) as exemplified in the Universities founded in the twelfth and thirteenth centuries, and the emphasis on *pietas* (the formation of an upright person conditioned by Christian godliness) of the Humanistic schools of the early Renaissance that had their roots in the ancient Isocratic ideals of creating men (and women) that would influence positively their society (O'Malley, 2000). Prior to the formation of the Society, Ignatius sought education as a means to pursue his goal of working for the salvation of souls. This is critical in understanding the genesis of the Jesuit education. On a cold day in February 1528, a mature student of thirty-seven quietly entered Paris "alone and on foot" arriving from Spain. Ignatius begun to study at the University of Paris in the fall of 1529, being admitted to the College of Montaigu were the Humanism had taken root (Cesareo, 1993; Codina, 2000). There is where he met his companions, the future "first Jesuits", and where many of the models of humanistic education would be adopted.

Ignatius did not pursue learning for its own sake. Education was meant to be part of a greater goal in assisting humanity in its quest for God. Jesuit education differed from Renaissance education in its desire to provide a religious vision to the academic endeavor that would benefit not only the individual, but society as well. This religious dimension gave meaning and identity to the educational program of the Society of Jesus. Ignatius's objective in

education seems to have been twofold: to form a good, solid Christian leader who could exert a positive influence on the social, political, and cultural environment in which he lived and, by means of this, to allow for the spiritual progress of one's soul on its pilgrimage toward salvation (Cesareo, 1993).

At a turning point in history, Ignatius of Loyola and the first Jesuits had the intuition to take part in the culture of Italian Humanism, without leaving behind the wealth of the past. They also had the wisdom to adapt what they considered to be the best pedagogical models regardless of where they came from, in this case, outside of Italy.

In the sixteenth century Italy and Spain had followed the *modus Italicus* for their universities, whereas France had chosen the *modus Parisiensis*. In Paris, the faculty took precedence in determining the practices of the University, while in Italy; it was the students who more directly ran the university. In Paris, classes were given in colleges or residential houses attached to the university; in Italy, the classes were given in the university itself. In Paris there was much more order, regularity, and discipline, as opposed to Italy where the students had much more freedom in determining the same matters. In Paris the progress of the students came through a set program that the teacher and the students followed, the professors lectured frequently, the students engaged in academic exercises following the lectures and were divided in classes according to the state of their academic ability and preparation, and moving up from one class to the next after examinations. The Jesuits specifically chose to follow the *modus Parisiensis*, which involved the personal knowledge and concern of the teacher and helped the young student progress more surely and more quickly than in other systems (such as the *modus Italicus*). There are other elements that have persisted in schools up to this day such as the idea that the best way to acquire a skill in writing and speaking is not simply to read good authors but

to be an active learner by being forced to compose speeches, and deliver them in a classroom and elsewhere. At the same time, the Jesuit education's openness to other views and ideas take root to produce one of the *Ratio Studiorum*'s great innovations, the attempt to include the teaching of mathematics within a classical curriculum (Luckàcs, 1999; Romano, 1999; Homann, 1999; Padberg, 2000; Codina, 2000; O'Malley, 2000).

The wording on the *Constitutions* set mathematics as a field apart, and all relevant scholarship supports two interpretations to the choice of words in the text: *et etiam mathematicae* which can be translated as "and *even* mathematics". The first interpretation is that the passage underlines the innovative intention (at the time) to include mathematics in the curriculum. In the second interpretation, the passage may seem to react to the likely impression that mathematics is too abstract to serve the moral and religious aims prescribed for Jesuit education. There is a possible third interpretation for the phrase "and *even* mathematics"; those who drafted and approved the final version of the *Ratio Studiorum* were aware of the significant changes underway in the field of mathematics and perhaps the suggestion that the new mathematics might prove resistant to the classical humanism present in the Jesuit curriculum (Bloechl, 2004;Romano, 1999).

One way to understand the context of the apparition of the *Ratio Studiorum* among the significant events in the history of science is to take a look at some of those events: Nicolas Copernicus published "On the Revolutions of the Heavenly Spheres" in 1543, Galileo was condemned in 1633, Sir Isaac Newton published "Mathematical Principles of Natural Philosophy" in 1687, and in the same century, Descartes was having a deep influence in modern mathematics by creating analytical Geometry and changing the field of philosophy with a shift to

a pursuit of knowledge that is no longer bound in any way to the cultivation of character (Bloechl, 2004; Smolarski, 2002).

The Society of Jesus had to overcome many and diverse obstacles to produce in 1599 the final version of the *Ratio Studiorum* after several drafts. One of the issues of the spectacular growth in numbers of the Jesuit colleges in the sixteenth century, making necessary to elaborate a common standard capable of maintaining unity in the teaching inside the Society. The Jesuit model is peculiar in that general rules were built up from local experiences in an organic growth since the *Constitutions* directed the schools to adapt locally and take into account local events, places, and people (Julia, 2004; Romano, 1999; Romano, 2004). This situation made up for a confrontation between the elaboration of a normative text and autochthonous practices. There are different components of such a construction, including the social and political context that allows demands for mathematics, a precise intellectual context within which a new epistemology of science is developing, and the constitution of a group of professors able to teach it (Romano, 2004).

Among the several authorities of the early Society was Jerónimo Nadal, Ignatius's peripatetic and plenipotentiary agent of the Jesuit communities across Europe. Nadal was one of the most important architects of the network of schools the Society begun to establish (Cosentino, 1999; O'Malley, 1999; Romano, 1999) with the founding of the first fully constituted classical college at Messina in 1548. Nadal was probably the first to try his hand at composing a Jesuit order of studies, including a preeminent role for mathematics, in several curricular documents over a period of more than 10 years that reached to Ignatius's secretary, Juan Polanco, in 1551. Nadal's contributions were of primary importance in the shaping of the Roman College, inaugurated in 1551, and soon to become the flagship of early Jesuit education.

By 1552, Nadal was calling for a three year course in mathematics, including Euclid as well as a wide range of more recent works such as those of Finaeus, Stoeffler, and Peurbach.

With the exception of Nadal, for the next three decades after the establishment of the College at Messina, the Jesuit attitude toward the study of mathematics was characterized by a weak conviction that a good theologian only needed limited competence in mathematics (Bloechl, 2004; Cosentino, 1999 Homann, 1999; Romano, 1999). This was the scene when Christoph Clavius (see figure 2) arrived at the Roman College in 1565. Though Clavius is best

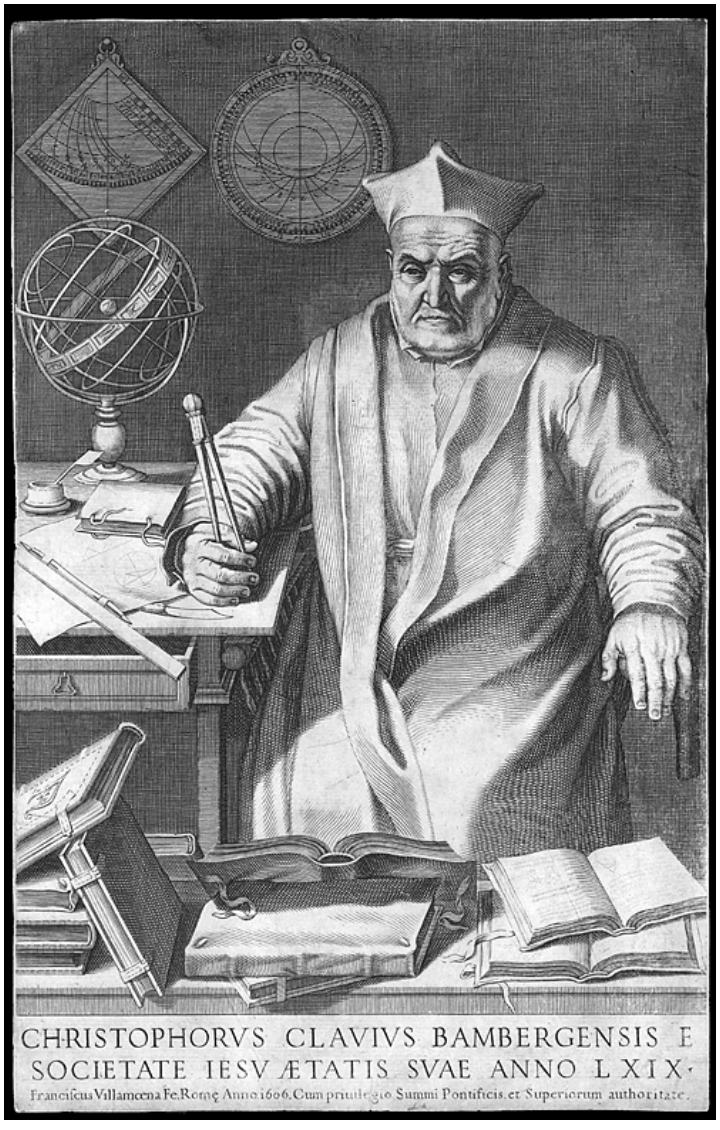

Figure 2

known for his role convincing Pope Gregory XIII to introduce the Gregorian calendar in 1582 through his astronomical and mathematical justification for shifting from the Julian calendar, he also was the first Western mathematician to use notation the decimal point, produced a much-used version of Euclid's *Elements*, and in general promoted the study of mathematics more than anyone else in his time, earning him the title of "the most influential teacher of the Renaissance" (Lattis, 1994 in Bloechl, 2004; Sarton, 1957 in Smolarski, 2002, p. 261).

Even though Clavius was not an official member of any commission involved in the development of the *Ratio* (Codina 1999, pp. 8-9 in Smolarski, 2002, p. 450), his influence in the 1586 version of the *Ratio* cannot be overestimated. "Some modern scholars view the 1586 draft of the *Ratio* as a radical document for raising mathematics to a level on a par with other university-level disciplines and for giving it a prominence unheard of in Italian universities" (Dear, 1995, p 35 in Smolarski, 2002, p 452; Feldhay 1995, pp. 221-22). His influence on the definitive version of the *Ratio Studiorum* led to the inclusion of mathematics as a standard subject taught in Jesuit schools. He also proposed establishing an "academy" that can be viewed as the precursor of modern honors, seminar, or directed study classes in contemporary schools where students with exceptional gift and love for mathematics can be nurtured and challenged in the field. Another contribution of Clavius to the mathematical community of later generations was his set of mathematical texts (see figure 3). An example is his "Elements of Euclid" which was more than simply a translation to be a text with Euclid's work as well as comments on it from previous commentators and editors as well as Clavius's own criticisms and elucidations of Euclid's axioms. In his texts, Clavius included the several examples of the same notation used today, such as the square root sign, parentheses, and the x-like symbol for an unknown (Romano, 1999; Smolarski, 2002, p. 261).

Figure 3

The final version of the *Ratio Studiorum* had less mathematics than in earlier versions but it contained more than in the curriculum used in the Roman College at the time, and in keeping with the Thomistic Aristotelian scheme that the Jesuits found conducive to the Christian humanism supporting the "end proposed" in the *Constitutions*. Clavius's insistence on the importance of mathematics was not simply motivated by an interest in developing better practical support for physics and in turn, metaphysics. Contemporary mathematics and the sciences increasingly understood themselves to be defined solely by an impulse to present an ordered and comprehensive account of the available data, an example being Copernicus's *De*

Revolutionibus orbium coelestium, and later, the mathematical support for it provided by Kepler. It is not difficult to recognize the approach of serious difficulties for the *Ratio Studiorum* and the Jesuit Ideal of Christian humanist education. While Clavius was likely arriving at some painful conclusions regarding the quiet shift of mathematics from its place at the threshold of metaphysics and theology, René Descartes was getting acquainted with some of the new mathematics in his course of studies at La Flèche, one of the first Jesuit institutions attempting to implement the *Ratio Studiorum* (Bloechl, 2004; Romano, 1999).

The main question is whether the nascent modern mathematics and rationality can be taught in a spirit that is still recognizably Ignatian. We can choose to present Nature whose order is disclosed in the very process of becoming present in thought, or in other words, by finding order in truths that are observable everywhere (Aristotelian sense), or we can choose to present nature in a mode of undefined futurity, with the idea that humans can be better by a program of mastering a nature that is external, where truth can be located entirely within human rationality. Why is this important? Because it becomes a matter of pedagogy the moment one recognizes the distinction between a vision of an ordered whole in which human beings dwell, and a vision of Nature as the open expanse of untamed resources that either serve or impede human purpose and desire. The process of teaching should include more than description and clarification to encompass discussion and reflection of implications, allowing students to recognize and take responsibility for choosing to see the world and other people in one mode or another. This is essential to understand two of the most controversial elements in Jesuit education: a willingness to dialog with many varieties of unbelief, and a determination, echoed and important in the present time, to think in radical solidarity with the poor and the oppressed. The Jesuit approach insists from the start that God has never been and could never be completely alien from anything.

This approach embodies and Ignatian impulse to *find God in all things*, which in turn answers a theological imperative, to affirm the unity and the grace of all creation, even when there is neither evidence nor testimony to immediately encourage that undertaking(Bloechl, 2004). This open, catholic attitude would be the founding antecedent of Jesuit education today, which rarely hesitates to bring a student into contact with the work of thoroughly secular thinkers like Marx, Freud, and Durkheim. For Bloechl, this marks the appeal of the Jesuit institution to the restless intellect illuminated by faith and yet compelled by ways of thinking that proceed without it.

For Romano (1999) the process of elaboration of a program of studies (the *Ratio Studiorum*) in the second half of the sixteenth century at the same time that Aristotelism was in crisis, contributed to recognize this period as an essential phase in the re-composition of knowledge and in fostering reflection on the definition, the state, and the role of mathematics on both theology and *philosophia naturalis*.

Second Period: Expansion

Once it was formally approved and just a few months after being officially sanctioned by Pope Paul III in 1540, the Society launched into a worldwide expansion that began with Saint Francis Xavier traveling to India to evangelize following the motto of the Society; ad majorem Dei gloriam, “for the greater glory of God”. The expansion of the Society constitutes the second major historical period reviewed, and one can pick it up shortly after the publication of the Ratio Studiorum and follow it to the Society’s suppression in 1773.

There was enormous diversity in the Society during this period and Buckley (1999, p. 714) proposes that there was also an unplanned organic unity. “The Society of those centuries seems to present not a single culture, certainly not a single set of perspectives, but something of

an evolving ecosystem of individual units of disciplines, skills, commitments, achievements, whatever, that in fact fed into one another in the churches, on the missions, and through the colleges and even supported one another as do living elements in a vital biosphere".

The extent of the circulation of people and information that was woven into the fabric of the Society itself can be seen in the list of offices created and requiring frequent travel as itinerant preachers, missionaries, procurators, visitors, or diplomats to places as varied as the courts of Europe, the Mughals in India, the king of Ethiopia, the Chinese emperor, and the king of Siam. The peripatetic Jesuits explored, mapped the lands, and lived among the peoples of Mozambique, Peru, Egypt, the lands and riverine routes from Quito to the Atlantic via the Amazon, the Malabar Coast, southern China, the Philippines, Ceylon, Rio de la Plata region in South America, up and down the Baja Peninsula of Mexico, across the Himalayas and Tibet, the upper Nile, the Amazon river, along the coast of Maine, or on the shores of the Great Lakes and the Mississippi river. In order to keep administrative control and maintain morale in this vast and widely disperse network, the Society maintained an elaborate correspondence system. The exchange was not limited to ideas in letters, but extended to scientific texts, objects and instruments (Harris, 1999).

There is an interesting ramification to the existence of the global network of schools and the fact that with few exceptions, the Jesuits that found themselves in remote lands were working as missionaries and /or served in one capacity or another, as educators (not necessarily professors) within the Society. This means that the development of a robust tradition in the natural sciences took place in the daily and local context in which the Jesuits found themselves (Harris, 1999). The curricular inclusion of sciences account for the development of competent mathematicians, astronomers, geographers, naturalist and their work in science, which was

exchanged in a regular discourse with each other and with colleagues who did not share their confessional allegiance. This is an important feature of the social context of Jesuit science and it concerns the connections among Jesuit educational institutions, local political authorities, and the upper-classes. Jesuits corresponded with figures such as Tycho Brahe in the sixteenth century; Kepler, Galileo, Mersenne, Descartes, Newton, and Leibniz in the seventeenth; and similarly distinguished figures in the eighteenth, such as Euler, Lalande, and Daniel and Johann II Bernoulli (Feldhay, 1999; Harris, 1999; O'Malley, 2000).

As we saw in the last section, it is not possible to tell the history of Jesuit sciences without mentioning Clavius. After more than fifty years of involvement with teaching the mathematical sciences at the Collegio Romano, he left a remarkable legacy and formulated a tangible policy of mathematics teaching in the Society. In particular, the Ratio Studiorum called for what today might be called student colloquia and interactive review sessions. For this reason, Clavius might be considered the father of certain contemporary pedagogical techniques in mathematics. Particularly in the last twenty years, much time and energy has been focused on university-level calculus courses, with such well-known results as the Harvard Reform Calculus approach. Another example of current practices with references in the Ratio Studiorum is the idea of cooperative learning often used to describe techniques such as student presentations and interactive classroom sessions. In particular, a guideline in the Rules for the Professor of Mathematics in the Ratio requires that students present a solution to some famous mathematical problem before an assembly of other students, a precursor of contemporary student presentations. This 400-year old document also advocated the insight that students would understand mathematical concepts better by explaining them to others and by questioning mathematical derivations during a review and working with each other on questions such as "Repeat that

proposition", "How is it proven?", "Can it be proven otherwise?" "What use does it have in the arts or in the other practices of common life?". Such practices are still effective tools for helping students of the twenty-first century appreciate the beauty and wonders of mathematics (Luckàcs, 1999; McGucken, 1932; Pavur, 2005; Romano, 1999; Romano, 2004; Smolarski, 2002, p. 260).

The inclusion of mathematical instruction in all Jesuit colleges offering a three-year philosophical course created a tradition. Mathematics was the only course taught by a specialist. Parallel with his involvement with teaching, Clavius started in 1570 an ambitious program which begun with the production of commentaries, textbooks and manuals in all branches of mathematical sciences, which constituted the initial core of mathematical knowledge transmitted by the Society.

Clavius trained a whole generation of mathematicians (sent later to other European and missionary centers) though his "academy", a seminar for advanced students who were allowed to specialize in mathematics. His model for an academy was probably reproduced elsewhere, and his correspondence shows a vast network of international relations cherished by the Collegio Romano and used to transform it into one of the most prestigious academic centers in Europe for the study and training in mathematics.

Clavius constructed what, at the time, was an ideal course of studies defined as a high level scientific project meant for the formation of specialists. The cycle of studies begun with the first four books of Euclid, exposure to practical arithmetic and a brief introduction to astronomy. The following steps in succession were to study Euclid's books five and six, a series of lessons on astronomical measurement instruments, Euclid's books seven to ten, algebra, the remaining five books of Euclid, trigonometry, geometry of the sphere, astrolabe, geography, planimetrics, perspective, astronomy, speculative music, proportion problems, mechanics, and conics. He

suggested dividing the mathematical sciences into two groups: the first one being pure mathematics, composed from arithmetic and geometry, and mixed mathematics, dealing mathematically with physical phenomena such as rays of light. The second group consisted in six major branches: (natural) astrology, perspective, geodesy, canonics (music), suppotatrics (practical arithmetic), and mechanics. Some of the major works of Clavius include In Sphæram Ioannis de Sacro Bosco commentarius (1581), Epitome arithmeticæ practicæ (1583), Astrolabium (1593), Geometria practica (1604), Algebra (1608), and Triangula sphærica (1611). These well-written texts were reprinted numerous times and widely used in Jesuit schools (Romano, 1999; Smolarski, 2002; Baldini, 2003; Romano, 2006).

Clavius wrote about how mathematical entities can be considered apart from any sensible (tangible) matter, holding a place between metaphysics and natural science. Clavius's emphasis on mathematical entities as a bridge between abstract and sensible entities was a strategy of legitimization against the current philosophical view that mathematical abstractions could not originate real science in the Aristotelian sense (Cosentino, 1999; Feldhay, 1999; Romano, 2004). Perhaps an example of this frame of mind is Clavius work on the problem of four-dimensional Geometry. In the second half of the sixteenth century (before Descartes's Geometry), Clavius tried a detailed proof that no more than three concurrent lines can be drawn, each perpendicular to each of the others. This proof was not published until its appearance in a German encyclopedia in 1802 (Deal, 1989).

By the 1620s the conditions for production and reproduction in mathematics sciences were well institutionalized: transmission through teaching, a generation of mathematicians trained by Clavius at the Roman College, a tradition of textbooks and treatises (Romano, 2006), an emerging tradition of mathematical academies in the colleges, a few positions for specialists,

a network of international relations, and a dynamic and inclusive vision of the problems to be dealt with by mathematicians. The Jesuits sought to draw young people into their colleges and universities based on the reputation of top-level professors. This strategy worked particularly well in France, where the activity of Jesuit colleges was under control of the French government and the level of education and Jesuit mathematicians was attractive to the children of the ruling elite of the country. It is in France where the faculty developed a process of professionalization that led to the foundation of chairs of mathematics. A similar approach, the use of science, mathematics, and reason was indeed the method used successfully by the Jesuit Matteo Ricci with the Ming dynasty in China. Ricci introduced western thought and Euclid mathematics (using Clavius's texts) to gain honor and recognition in China to the present day.

At this point, Rome was no longer the only center of scientific research, although it was the most important by far. This made possible the development of provinces with a local style of scientific research. In Portugal and its colonies, this meant they were largely untouched by the new mathematics; due to the combination of a local indifference to those studies and a continual need to satisfy technical demands from a government bent on maintaining Jesuit mathematical teaching and activity narrowly utilitarian (Leitão, 2003). A very different example is Naples, where Giacomo Staserio (1565-1635), a Roman-educated, Clavius academy-trained Jesuit was teaching mathematics. Staserio was instrumental in the inclusion of Vieta's algebra in the Jesuit mathematical curriculum after 1620, and Naples became the most important center for the diffusion of Descartes's Geometry and Cartesian studies in Italy because Jesuit teachers had transmitted to students the technical expertise necessary to understand Descartes (Feldhay, 1999).

Another side of this proliferation of local scientific cultures is that tensions between Jesuit mathematicians and philosophers, and between scientists in general and the leadership of the Society were not rare since the official framework endorsed by the cultural policy of the Society was still Thomistic-Aristotelian. Here we see a characteristic of the Jesuit education that has been passed down through the centuries; an essential inclusiveness of the Jesuit tradition which consisted in the way alternative theories, concepts, opinions, and hypothesis were always represented by the author of a text, even when criticized, censured, or rejected by the Jesuit author himself, or by the Jesuit community. The transmission of knowledge by the Jesuit educational system was far broader than the ideas supported by the consensus of Jesuit writers, by the Society's hierarchy, or by the church. As an example, it is interesting to note that, at least in the German province, there were almost no commentaries or manuals on Aristotelian physics, while there was a continuous line of transmission of Clavian traditions in more theoretical mathematical direction (Feldhay, 1999; Romano, 1999).

In 1635, Paul Guldin began publishing his work on mathematics with the first volume of his Centrobaryca. Guldin produced a major change in the sphere of pure sciences with the introduction of algebra as a discipline in between the two traditional fields of arithmetic and geometry. In order to do it, he used the Clavian strategy of introducing a major innovation as an old science with a respectable genealogy. Guldin used the same strategy to work on a second inclusion; Archimedean problems regarding the subject-matter of statics (namely, weight) and the study of machines. Guldin also used the Clavian strategy (and this can be understood as the impact of the success of Clavius approach) of emphasizing that every mathematical science has a theoretical and a practical part, and that the theoretical part was the space were the objects of science, its methods, and its boundaries were determined. An example of the implications of

Guldin's this emphasis is that the nature of "quantity" was no longer to be determined by the philosophers but discussed by the mathematicians themselves.

Perhaps the most subversive act on the part of Guldin's role in remapping the space for Jesuit mathematicians could be found in his representation of the scope of systematic astronomy dealing with the constitution of the world, in which he emphasized three main hypotheses to be represented and researched: the Ptolemaic, the Copernican, and the Tychonic. Before this, even Clavius had been careful to recognize the division between the construction of a cosmological picture (done within the sphere of philosophy) and an astronomical theory within the domain of the mathematics. Guldin's work and inclusions in the curriculum were in frontal contraposition with current consensus (Feldhay, 1999).

Algebra threatened the boundaries between continuous and discrete, thus opening the way for the reception of Cartesian analytical geometry and corpuscularism. The Archimedean project threatened the boundary between mathematics and the study of motion, thus opening the way for the acceptance of Galileanism. Copernicanism threatened both the old cosmology and the traditional interpretation of the Scriptures. The representation of theories, concepts, and theses with a status of hypothesis or probable opinions not approved by consensus enabled the reproduction of ideas such as Copernicanism as options within the Jesuit map of knowledge, even though they were finally doomed to rejection (Feldhay, 1999). "The Roman Inquisition's controversial proscription of Copernicus and the condemnation of Galileo in the early seventeenth century again raised issues about the interpretation of Scripture and Church doctrine and how much freedom Jesuit theologians, natural philosophers, and mathematicians had to treat such matters in the public forum" (Homann, 1999, p. 4). These examples represent striking

outcomes of the Jesuit mathematicians' policy of inclusion, and as important, the realization that inclusion meant less than assimilation.

For Feldhay (1999), the fact that Guldin was present in Rome from 1612, when Galileo's telescopic discoveries were much debated at the Collegio Romano, his close relation with Kepler, and the innovations introduced in his work, exhibit the strong tension between autonomous and heteronomous principles in the field of Jesuit mathematics. The same tensions can be observed in the frequent critiques that Clavius produced regarding the incompetence of philosophers in comprehending natural phenomena (Romano, 1999).

For Cosentino (1999) and Romano (2004), the tension between a completely assumed Aristotelian heritage and an overture to mathematical sciences in renewal meant that the Society participated in the creation of a discipline which in the seventeenth century constituted the beginning of the Scientific Revolution. By asking how universal-claims about the natural world can be justified from singular items in individual experience (directly in opposition of Aristotelian tradition that required universal observation and experience), Dear (1995) shows that Jesuit academics involved methodological conceptualization of scientific knowledge.

As central as they were, figures like Galileo, Descartes and Newton were not the only forgers of the new ethos and procedures that coalesced during the seventeenth and early eighteenth centuries. It is possible to trace Jesuit ideas on Galileo by studying the Jesuit teachers at the Collegio Romano and show that Galileo's early views on scientific method and on the study of motion were influenced by those of young Jesuits, colleagues and probably disciples of Clavius, who were currently teaching logic and natural philosophy in Rome (Wallace, 2003).

Descartes was very familiar with the works of many Jesuits, and for all his attacks on the Society, he also endorsed his old school (La Flèche) when recommending to his friends the

philosophy education received from the Jesuits. When he sent a copy of his newly published Discourse to one of his old teachers at La Flèche, Descartes wrote that it was a fruit that belonged to his teacher "whose first seeds were sown in his mind by him" (Ariew, 2003, p. 159).

Leibniz used Clavius's texts and used Jesuit writings in his efforts to induce the Catholic Church to lift its ban on Copernicanism, and a significant proportion of Catholic men of science were educated by Jesuits. The Society and its schools produced Torricelli, Descartes, Mersenne, Fontenelle, Laplace, Volta, Diderot, Helvétius, Condorcet, Turgot, Voltaire, Vico, and Muratori. Jesuit practitioners and teachers were instrumental in elevating the status of mathematics over that of philosophy; they made early and important contributions to the mathematization of physics, and they were pivotal to the development of experimental science. However hostile Blaise Pascal might have been to the Jesuits in religious matters, he followed their scientific and rhetorical example in dealing with universal generalization regarding experiments on air pressure. Even Newton could not have spoken without paradox or disciplinary impudence about the 'mathematical principles of natural philosophy' in his published work on optics and the prism but for the physico-mathematics forged by the Jesuits in the middle decades of the seventeenth century. This is one of the layers of a view that describes how the Jesuit historiography is integrated to the common patrimony forming the intellectual history of Europe in the sixteenth, seventeenth, and eighteenth centuries (Dear, 1995; Smolarski, 2002; Feingold, 2003, Wallace, 2003, Ariew, 2003; Romano, 2004).

The Jesuits' influence and their conspicuous contributions generated prejudice, hatred and opposition over time, and due to a complex combination of reasons, the Jesuit schools and colleges were prohibited from operation in country after country beginning in 1759, exerting enormous pressure on the papacy. The Society of Jesus was totally and universally suppressed by

Pope Clement XIV when *Dominus ac Redemptor* was proclaimed on July 21, 1773, after a protracted and successful campaign against the Jesuits by the partisans of the Enlightment and by European courts resentful of their independent presence. In September 1773, the global network of schools forming the most powerful teaching body and the most influential educational work in existence abruptly stopped. The closure affected 728 educational institutions responsible for the education of some 250,000 students (Schlafly, 2006; Whitehead, 2004).

Third Period: Restoration

When the Society of Jesus was formally suppressed in 1773, the Jesuits were forced to abandon approximately 250,000 students all over the world. All properties were transferred to either the State or to Church jurisdictions. The global network of schools and their work after two centuries was stopped almost completely except for thirteen colleges scattered in various countries (Codina, 2003).

Even after the Society's general suppression, Jesuits were actively involved in scientific work around the world. One example is João de Loureiro who returned to Lisbon in 1782 after forty years as a Jesuit missionary in Cochinchina (Vietnam) where he served Vietnam's king as both court mathematician and physician. Jesuit mathematicians in the mid eighteenth-century were commissioned to conduct painstaking cartographic and meridian surveys of the Palatinate, Austria, Hungary, Silesia, China, and the Papal states (Harris, 1999).

The most important example of surviving work by Jesuits during the second half of the seventeen hundreds is that of Roger Boscovich (Ruđer Bošković); perhaps the most

accomplished of all Jesuit scientists, who died in 1787, fourteen years after the Society's suppression. Boscovich developed a theory of an attraction-repulsion force producing all physical phenomena, generalizing Newton's law of gravitational attraction, and making it capable of accounting for apparently non-mechanical facts. While using a matter-space language, he introduced the notion of infinitesimal force points that attract or repel each other as a function of distances. According to some, this theory paved the way for Faraday and post-Faraday field theory. The transcendence of his work derives from his attempt, being a Jesuit who was also a scientist, to bring contemporary science and natural theology in agreement, a precedent that would be followed in the coming centuries by Jesuits scientists like Teilhard de Chardin (Baldini, 2006).

The eighteenth century in Germany saw the Jesuits playing an important role in higher education and holding a virtual monopoly over the chairs of the arts faculties at almost every Catholic University. The occupants of those chairs produced masses of multivolume textbooks, dissertations, lecture manuscripts, and other materials on science (Hellyer, 1999).

After the suppression, despair and desolation became the descriptors of most things Jesuit, although there were some pockets of Jesuits working in unlikely places. One example is the English Province of the Society of Jesus, with members in England, Wales, Maryland and Pennsylvania, as well as educational outposts in continental Europe. They became unique, with the exception of the Russian empire, in that they maintained their corporate identity throughout the suppression period, and eventually their schools began to develop their curriculum in important new ways , beyond the confines of the *Ratio Studiorum.* The curriculum reform allowed the intermingling of the primary and secondary classical traditions with tertiary-level scientific and philosophical traditions in an amalgam that was unknown anywhere else. The

transatlantic link of the group had an important influence not only in English Catholic education, but in the foundation in 1789 of Georgetown Academy in Washington that later became Georgetown University. The divergence from the norms of the *Ratio* demonstrated the Society's ability to adapt to the needs of the time. By 1814, Georgetown claimed to teach English, Latin, Greek, and all other branches of classical education, Sacred and Profane History, Geography, Use of Globes, Arithmetic, Book Keeping, Algebra, Geometry, Trigonometry, Mensuration, Navigation, Surveying, Astronomy, Fluxions (Newton's Calculus), and the other parts of Mathematics in general, plus Natural and Experimental Philosophy, Italian and Spanish (Whitehead, 2003).

The ruler of the Russian Empire in 1776, Catherine II, included 201 Jesuits as her subjects. By the Russian law, the sovereign was also the head of the church in Russia, and the Jesuits in the empire depended absolutely on the will of the sovereign. At that time, Catherine was setting an example of patronage of European arts and culture, and the nobility , many of whom had studied and traveled abroad, were eager to provide for their children the superior Western education that the Jesuits could provide. Catherine II wanted to assert her independence of the papacy and refused to accept in her domains the Pope's suppression which she considered an affair of state, allowing the Society to continue as an organized community. Catherine II gave specific instructions not to implement the suppression of the Jesuits or to interfere with their work. Education was the critical factor for the Society's success in the Russian Empire. The curriculum implemented at the Russian colleges was largely prescribed by the *Ratio Studiorum*, although the schools begun to give greater importance to the vernacular languages, the sciences, and other 'modern subjects (Schlafly, 2006).

The Society of Jesus was formally restored by Pope Pius VII with the promulgation of *Sollicitudo Omnium Ecclesiarum* on 7 August 1814, and it began to draw from a handful of surviving elderly Jesuits (about 600) and the remnants of the school network, and for two generations it was mostly engaged in reconstructing its enterprise. By 1914 there were 16,894 Jesuits and 234 colleges and Universities in forty-three countries. Civil authorities begun to clamor for the opening of Jesuit schools and many were opened, sometimes too hastily. At the same time, nineteenth-century politicians, historians, and litterateurs in Europe were hostile to the Society (Codina, 2003; Shlafly, 2006). Intensely aware of the hostility and the antecedents to the suppression, the Jesuits tried to slow down the expansion and controlled the schools by ordering not to open more schools unless they could be staffed by enough Jesuits. Education became rigorous to guarantee the quality of their product. It seemed logical for the schools to try and be faithful to the traditions of the past centuries and they were trying to follow the original *Ratio Studiorum*, but the world had changed rapidly and it made it impossible the replication of a single model to be used everywhere.

Institution of the *Ratio* in the sixteenth century had placed the Society and its students at the very forefront of Renaissance educational thought and pedagogical practice, although strict description of methodology and the continuous monitoring from Rome eventually suppressed or made obsolete the advantages the system had enjoyed. Innovation and openness was strictly forbidden and it was now difficult to be against the pressures of change in the current times. Modern states had a different view of the interaction between Church and Society, and in order to insure certification and approval of their education programs, Jesuit schools and universities gradually accommodated to the requirements of states and ministries of education. In this environment, Fr. Jan Roothan, the first Superior General of the restored Society strongly

supported drafting a new *Ratio*. The new version paying more attention to science and vernacular literature appeared in 1832 was not only not accepted but rejected outright by the provinces. "Jesuit colleges gradually adapted their programs and methods to the demands of the ministries of education and distanced themselves from the mythical *Ratio*, of which only outward symbolic traces remained" (Codina, 2003, para. 56).

By the end of the nineteenth century, Jesuits from the top down felt they were not free to choose curriculum content but they did feel freedom to choose teaching methodology. In 1906, the 25th General Congregation refused to adopt a common *Ratio* for all the schools for the Order, given the variety of secular legislation in effect in the places where they operated. They went as far as grudgingly admitting that the study of non-classical authors 'is not contrary to our Institute' (Codina, 2003; Donohue, 1999; Duminuco, 2000, pp.146-147; O'Malley, 2000; Schlafly, 2006; Whitehead, 2004;).

The first half of the twentieth century was characterized by social upheaval and war. There were still pockets of animosity towards the Jesuits, and separation of Church and State in many places implied withdrawing of funding and support. Every province began to adapt to the new political and financial realities. The most curious and ironic characteristic of this period is that Jesuit education had the most opposition in traditionally Catholic environments, while it flourished in those areas were education was under Protestant control. A good example is how in the US, Great Britain and the Netherlands Jesuit education prospered in an atmosphere of complete freedom, while in Spain, the Jesuits were expelled from the country seven times between 1820 and 1932.

In order to provide excellence of education, schools focused on seriousness and rigor of studies, strict discipline, and sound religious and moral formation, and social contact with certain

circles. Conflicts between ‘classical’ and ‘modern’ studies began to appear, especially in Europe, and polarization between the state school and the Catholic school begun to grow. In mid-twentieth century, a college of the Society was unmistakable. The director of the school and the superior of the Jesuit community were one and the same. There was a large community of Jesuits who taught in the college, who gave the college an air of youth and dynamism. All were strictly clad in cassock (soutane, gown) and biretta. Functions were well defined, studies were demanding and discipline was strict. A spirit of rivalry, prizes, and sanctions played an important role. Governance was vertical and participation of faculty and families was severely restricted. All activities and schedules were strictly regulated (Codina, 2003).

The absence of fees guaranteed through the eighteenth century practically disappeared in the restored Society with the rise of the modern state. In general, Jesuit Colleges tried to obtain endowments to survive, sometimes without success, and despite all attempts, Jesuit education tended to serve primarily the middle and upper classes and constantly became more elitist in some countries, which begun to create discontent among the Jesuits themselves. Despite critics, it is undeniable that Jesuit colleges provided a level of academic excellence and a solid Christian formation that was valued by their public (Codina, 2003).

Donohue’s (1999, p. 20) comments regarding the first Jesuit schools still applied in the twentieth century; “The secret of the success of those Jesuit schools cannot be found in the letter of the *Ratio*…What made the 17th-century Jesuit schools effective could only have been the element that is indispensable for every school that works well—good teaching.”

Forth Period: Renewal

By the beginning of the second half of the twentieth century, social consciousness began to permeate all levels of society. After the Second World War it was possible to see certain currents that would have an impact in the Society, such as social unrest in Europe that produce harsh and destructive criticism of societal institutions in general and education in particular. Those were the years of the Worker-Priests, the strong surge of the communist party in the most Christian countries in Europe and the shocking realization that education itself should always have a social dimension and impact. In the 1960s a new and unstoppable wave of discussion gripped the Church regarding the poor, the disadvantaged, the alienated members of society. In 1960, there was number of young Jesuits that felt disaffection toward the colleges and in a letter to the General asked if education was a ministry proper to the Society of Jesus and asserted that the colleges were not in conformity with the spirit of St. Ignatius. Steps were taken and the work of education in the Society begun to take a corporate character. This is the environment that saw the birth of the Vatican II. The Church could not turn away from the social reality and recognized the need for education and work for social justice. Just after the end of Council Vatican II, the Society elected a new father General, Pedro Arrupe S.J. Arrupe revitalized the Society in general and revamped education with a renewed sense of mission (Codina, 2003).

In 1967, the new General established the Secretariat for Jesuit Education which in subsequent years would play a role of prime importance. In a now famous address to alumni of Jesuit schools in Europe (July 31, 1973), Pedro Arrupe painted a profile of what a graduate should be. Admitting that Jesuit schools have not always been on target here, Arrupe called for a re-education to justice:

> Today our prime educational objective must be to form men-and women-for-others... people who cannot even conceive of love of God which does not include love for the least of their neighbors; people convinced that love of God which does not issue in justice for human beings is a farce.... All of us would like to be good to others, and most of us would be relatively good in a good world. What is difficult is to be good in an evil world, where the egoism of others and the egoism built into the institutions of society attack us.... Evil is overcome only by good, egoism by generosity. It is thus that we must sow justice in our world, substituting love for self-interest as the driving force of society (Arrupe, 1973 in Traub, 2003, para.49).

Two years later, the Thirty-second General Congregation redefined the mission of the Society as the service of faith and the promotion of Justice and asked all Jesuits to engage in a process of reflection and revision of all their apostolic works. The schools were the target of profound criticism and most accepted the challenge and begun a brave process of evaluation and transformation. At the same time, both vocations and the current number of priests began to dramatically decrease with a profound effect in educational works. The balance between Jesuits and lay people working on educational institutions of the Society swapped, and on the threshold of 2000, the proportion of Jesuits in the schools was around 5.8% against 94.2% of lay people.

The Jesuits of the second half of the twentieth century had to confront a crisis which begun at the end of World War II and became universal in 1960. It was beyond a decline in numbers and answering criticism. It was a matter of rediscovering the direction of Jesuit education in a new context and of meetings the needs of the present day. Schools all over the world adapted and changed to accommodate to this mission. The Jesuits of the sixteenth century were successful in the creation of a uniform system of education with the help of an instrument

that brought together projects, programs and methodology in a single humanistic concept of formation: the *Ratio Studiorum*. Their successors in the twentieth century at first thought to reconstruct the same unity built in the *Ratio* until they realized that the task was impossible. Their merit lays in the fact that they provided a sense of unity to their educational work, not based on a common plan or method, but on a fundamental Ignatian inspiration (Codina, 2003).

The deepest raison d'etre of the colleges and of all educational works of the Society is the vision of Ignatius and the mission of the Society: "the commitment to the service of faith, of which the promotion of justice is an absolute requirement" (Society of Jesus, n.d.). The goal of Jesuit education is described in terms of the formation of 'multiplying agents' and 'men and women for others'. The society has rediscovered the *Spiritual Exercises* of Ignatius as the inspirational source of its works, rather than a predetermined pedagogical code.

In 1980, father Arrupe summoned to Rome a small group of Jesuits and lay people to discuss a number of points regarding the colleges. The big question was how to bring the schools to comply with the apostolic purposes of the Society in the context of the new reality, and how to face the challenge of the future. The meeting created the International Commission for the Jesuit Apostolate of Education (ICAJE), which met in 1982 to prepare a document that would capture the spirit of the challenge. After four years of consultations held all over the world, the document "*Characteristics of Education of the Society of Jesus*" (Society of Jesus, n.d.) was promulgated by the new General, Father Peter-Hans Kolvenbach, who requested the document to be available to all teachers, administrators, and members of governing boards of Jesuit educational institutions. The document has extraordinary impact and some 2000 educational institutions worldwide claim to an inspiration that is Ignatian, if not necessarily Jesuit. At present time, about 10,000 Jesuits work in close collaboration with nearly 100,000 lay people in providing education

to more than 1,500,000 people in 56 countries around the world. The *Characteristics* have brought a greater clarity to the being and work of Jesuit education than no other document since the *Ratio*.

In 1993, the Secretariat for Jesuit Education published a new document, the *Ignatian Pedagogy: a Practical approach* (Society of Jesus, n.d.), whose purpose was to be a guide in applying the *Characteristics* to the concrete situation of the Classroom by means of pedagogical practice inspired by the experience of the *Spiritual Exercises* of St. Ignatius. The pedagogical paradigm that emerges from Ignatian spirituality has a central element in the focus on the human meaning imbedded in what one studies. The process in Ignatian pedagogy is a way in which teachers accompany learners and it includes *context* of students lives, a broad base of *experience* fostered by the teacher, *reflection* helping students discover the meaning of their experience and learning, *action* compelled by the students convictions from making truth their own, and *evaluation* of the whole person using effective methods (Duminuco, 2000; Codina 2003). Appendix A contains a few examples of lesson plans in mathematics following the Ignatian Paradigm.

Ignatian pedagogy is a model that seeks to develop men and women of competence, conscience, and compassion. Father Duminuco (2000), one of the original members of ICAJE, believes that the principles of the Ignatian pedagogy of order, sequence, individualization and personalization of instruction (*alumnorum cura personalis*); the necessity of clear goals and objectives; the paramount importance of self-activity on the part of the student are all essential in creating a community of faith and trust which is an alternative to live in the cynicism and duplicity, the materialism and fatalism of many in the world around us.

On October 6, 2000 in Santa Clara University, speaking in front of a national gathering of American Jesuit higher education institutions Father Kolvenbach laid the goals for the 21st century: "The real measure of our Jesuit universities lies in who our students become. Tomorrow's 'whole person' cannot be whole without a well-educated solidarity. We must therefore raise our Jesuit educational standard to educate the whole person of solidarity for the real world! Solidarity is learned through 'contact' rather than through 'concepts' When the heart is touched by direct experience, the mind may be challenged to change…" (Traub, 2003, para. 53).

Discussion

Summary of Major Findings

The review of the literature reveals a rich and colorful historiography of both the Society of Jesuits and its education mission. In this historiography, Mathematics has played several roles, the most important of them being the role played in the Jesuits work and influence in the establishment of the Scientific Revolution. Mathematics alone was not the cause of it, but the new emphasis on studying it, teaching it, and working on it, was (Ariew, 2003; Dear, 1995; Feingold, 2003; Feldhay, 1999; Romano, 1999; Romano, 2004; Smolarski, 2002; Wallace, 2003).

The literature review covers the period between the signing of the bull allowing the existence of the Society of Jesus and the present day, however, it is not possible to look at this journey through time without also looking at the ancient roots of some of the ideas that led to the ethos of the Society and its educational mission. Neither it is possible to separate the product from its source, Ignatius of Loyola. The ancient clash of ideas and points of view regarding the

purpose of education has been passed down and repeated or echoed with different strength and depth over the centuries, beginning with the polarization between the Aristotelian search for truth and the Isocratic purpose of formation for the benefit of Society. We encounter these dualities of views much later, in the beginning of the Renaissance when the Universities' inspiration on Aristotle and the Humanist polarization towards Isocratic goals come again to play as choices for the orientation of the young members of the Society (O'Malley, 2000). The choice of the Humanist views was both a product of the influence of the *alma mater* of the first Jesuits, the University of Paris, and of the result of the life experiences and faith of Ignatius.

Ignatius began on a journey that took him places and events he could have never imagined and perhaps not intended at the beginning. His fateful stop at Manresa in the beginning of his pilgrimage became a transformational experience and the origin of the most enduring and fundamental influences in Jesuit education, the *Spiritual Exercises.* The *Exercises* gave Ignatius the means of molding the hearts and minds of both Jesuits and lay people in his vision of a life *ad majorem Dei gloriam*, for the greater glory of God (Gray, 2000; O'Malley, 1993; Traub, 2002). The *Exercises* are also the pedagogical root behind the Jesuit educational system and the spirit behind the ethos of the Jesuits.

By the time Ignatius arrived to the University of Paris, he had recognized the need for education and already had the *Exercises* as part of his unique approach to his vision. In the University of Paris, Ignatius and his companions, the future first Jesuits share the experience of the *Exercises* as well as the work for the salvation of souls and decide to band together following some principles that eventually will be collected and expanded in the Bull that made them into an Order of the Catholic Church. The *Exercises* also became part of their mission and stated as such

in their commitment as an Order, making them unique among the Catholic Orders by creating the spiritual retreats as a ministry proper (O'Malley, 2006).

Immediately after their foundation, the Jesuits embark in the intense and inexhaustible activity that has made them so successful though the centuries. They collected their views on how to proceed and organize and created the second fundamental document that will influence their education, the *Constitutions*. They also set in a worldwide expansion and went to work in establishing the means for their growth in numbers, the schools. The almost passing thought of creating the schools modified and focused their mission to the point that eventually could be thought of as the role that defines them (O'Malley, 1999).

In the Jesuits' view, God is in all creation and therefore, it is worth to work in search to find Gods perfection in Nature as well as all human endeavors (Bloechl, 2004). This has several implications. On one dimension, The Society sets to bring together the best ideas and methodologies they knew in order to create their educational system. This means that they chose to adopt the *modus Parisiensis* as the best methodology and pedagogy available at the time they decided to pursue education as a ministry proper. The Jesuits had the wisdom or fortune to take advantage of a critical change in history and opted to combine the "best practices" available to fit their goals.

The *Exercises* set the spiritual dimension, inspiration for their mission, and the pedagogical process that would be implemented in their methods. The *modus Parisiensis* would give them a model for an educational institution, and the Italian Humanists an orientation for their education. The *Constitutions* would give them the focus and direction to implement their network of schools, and the freedom to adapt to local environments. They created buildings for the specific purpose of teaching and trained faculty to teach in them. All these will be combined

with the product of local experiences and consultations for over fifty years to produce the *Ratio Studiorum*. The *Ratio* is a manual that will set guidelines for the operation of a school; the role and duties of administration, the curriculum to follow, the procedures for teachers and the duties of the students. Once it was officially promulgated in 1599, it became the *modus operanda* for all schools. The *Ratio* included a major innovation in that its curriculum had the ability to combine the Humanist approach to classics with the Aristotelian philosophy and Thomistic theology of Paris (Luckàcs, 1999; Cosentino, 1999; Homann 1999; Simmons, 1999; Padberg, 2000; O'Malley, 2000) and the specific teaching of mathematics, in no small part due to the enormous influence of a teacher at the flagship school of the society, Father Cristoph Clavius.

Thanks to Clavius, the *Ratio* included methods that are still in use today, such as the "academy" for gifted students. Clavius's influence affected the textbooks that would be used as a norm in mathematics teaching, the formation of a professional faculty and practitioners of mathematics, and the curriculum to be used. This influence did not come easy or without obstacles and heated arguments, but the strategy of inclusion of ideas used by Clavius would prove to be a characteristic of Jesuit education to travel down through time to us: its openness to concepts even if they did not conform with accepted consensus. This openness to concepts outside of the "sanctioned" knowledge stems from the belief in the presence of God in everything, infusing His goodness in all it touches (Bloechl, 2004; Feldhay, 1999; Luckàcs, 1999; McGucken, 1932; Pavur, 2005; Romano, 1999; Romano, 2004; Smolarski, 2002, p. 260).

This same openness to ideas that was found in the intellectual work of the Jesuit mathematicians, and the specific instructions to adapt to local realities as prescribed in the *Constitutions* meant a proliferation of science fitting local needs and conditions. The inevitable debates coming from the strategy of inclusion of ideas and the Roman College influence on the

mathematicians led to the mathematization of natural philosophy against the time honored tradition of using Aristotelian views. Together with the expansion of the school system and the immensely rich and diverse network of communications between Jesuits worldwide and lay people associated with their work begun to mold the beginning of the Scientific Revolution and the minds of influential people and societies wherever the Jesuits might be working (Ariew, 2003; Cosentino, 1999; Dear, 1995; Feingold, 2003; Feldhay, 1999; Romano, 2004; Smolarski, 2002; Wallace, 2003).

Although traditionally the Jesuits have been seen or portrayed as agents of the Counter Reformation, a more modern approach is to see how they actually were in the worldwide context of their operation, where working for the Counter Reformation might have been a regional priority and not a general one. Instead, it is possible to see them in the context of an "ecosystem" connected through a global network of schools that had an incredibly powerful influence (Buckley, 1999; O'Malley, 1999). The same conspicuous activity originated jealousy and opposition and eventually meant the dissolution of the Society in 1776.

The Order was disbanded and the schools abandoned, confiscated or transferred to other hands, with a few exceptions, the most important being in Russia. The appreciation for the education the Jesuits provided, and the reality of global politics led Catherine II to protect the Society within her Empire and this continued until the Society's Restoration in 1814 (Schlafly, 2006). Once this happened, the Jesuits began in earnest to reconstruct their global "ecosystem" and the school network. The logical approach was to continue using the *Ratio* although the world had changed so much that it seemed better to come up with a new version that included more emphasis on mathematics and vernacular literature to reflect the changes. The task proved to be impossible due to the broad range of relationships with the new states around the world. The

education system focused instead in strict norms and academics in a political environment that pitted Church and Ministries of education against each other almost everywhere. A notable exception was in all the countries where the education was under Protestant control. In those countries, the Society would be allowed to operate without restrictions (Codina, 2003).

This state of affairs would continue until the mid-twentieth century and by then, the realities of society would call for social justice and this will have profound repercussions in both the Catholic Church and the Society of Jesus. The Vatican II will set the Catholic Church into a new path of openness and search for justice and the Society was not to be left behind. The newly elected General, father Pedro Arrupe will set the course of the Society in search for a sense of renewal of its Ignatian roots and the mission of education as part of those roots.

The Jesuits rediscovered the *Spiritual Exercises* as the source of inspiration for their work and beyond a pedagogical tool. The result is the change an evolution in Jesuit educational institutions and the creation of two critical and influential documents: "*Characteristics of Education of the Society of Jesus*" and "*Ignatian Pedagogy: a Practical approach"*. These documents reflect the mission of the Society in this century; the service of faith and the promotion of Justice. All Jesuit educational institutes have those documents to guide them in their mission (Codina, 2003; Duminuco, 2000; O'Malley, 2000).

Ignatian pedagogy is based on order and sequence, individualization, personalization of instruction, and clear goals and objectives. Beyond that, education is constructed as a process in which the teacher is modeled after the Spiritual Director in the *Spiritual Exercises;* accompany learners and it includes *context* of students lives, fosters a broad base of *experience*, helps *reflection* in the students in order to discover the meaning of their experience and learning,

facilitates *action* compelled by the students convictions from making truth their own, and practices *evaluation* of the whole person using effective methods (Duminuco, 2000).

Limitations/Gaps in the Literature

Among the findings in the literature is worth mentioning that the availability, quantity, focuses, and perceptions of the research on Jesuit history in general and education in particular have seen tremendous growth in the last decade. With this in mind, the availability of research is not consistent across the time period or thematic emphasis.

Two major trends areas of study found are the Society of Jesus in the fifteenth to the eighteenth century, and the role of the Society in the development of the Scientific Revolution. The most influential period of Jesuit mathematics and science corresponds with the seventeen century, and it has not been possible to repeat it. The work on the educational system in general and mathematics in particular follows those trends.

There seems to be also a peak of research surrounding the anniversaries of the publication of the *Ratio Studiorum*, specially the few years before and after 1999. In the case of mathematics, the scarce availability of sources regarding the implementation of mathematical education after the seventeenth century makes it very difficult to follow in its evolution, let alone the description of methodologies and successes or failures. The same can be said for assessment methods beyond the prescribed ones in the *Ratio.* O'Malley (2006) and Romano (2004) argue that the practices in the classrooms not always follow the accepted official corporate guidelines.

The period corresponding to the suppression of the Society, as well as the Restoration until the mid-twentieth century are covered by only a few authors in the broadest way possible

with some emphasis in the numbers associated with Jesuits and schools. The literature covering the period between the Vatican II and the present is mostly concerned with the implementation of the changes prescribed by the Council and by Father Arrupe, with particular emphasis on the preparation, importance and implementation of the two documents on the Characteristics and approach of the Jesuit education and pedagogy.

Regarding mathematics, only a few sources written by Smolarski were found and they are focused around the role of mathematics in the *Ratio* and possible implications in current teaching practices. This period also has the vast majority of the scholarship currently available.

Analysis of Themes and/or Inferential Analysis

In looking at the themes and periods presented in the literature review, a few questions and ideas can be posted for further thought.

- The Ignatian impulse to *find God in all things*, which in turn answer a theological imperative to affirm the unity and the grace of all creation (Bloechl, 2004) is a theme found behind the openness to secular ideas in modern Jesuit education. The same argument is used for the openness, beginning with Clavius, to ideas not present in the consensus of knowledge such as the mathematization of natural philosophy, and later for the strategy of inclusion used in introducing Copernicanism, Cartesianism, etc. Perhaps the same frame of mind was behind the decision to use an eclectic combination of sources and "best practices" when the first Jesuits were articulating their way of proceeding in education.

- Clavius used the approach of linking novel ideas to old intellectual traditions in order to legitimize their introduction in the curriculum (Feldhay, 1999). Although the same approach is

found in his students, perhaps it can be said that it was a tradition part of the Jesuit culture from the beginning and used in arguments to combine Italian Humanism with the heritage from the University of Paris.

- Clavius seems to have understood at the end of his life that Aristotelian philosophy was doomed to be abandoned. Perhaps impossible to prove but interesting to ask is his deep motivation for the emphasis in mathematical instruction. Was his love for the Society, and more important, his Jesuit mission to work *ad majorem Dei gloriam* behind Clavius' emphasis on mathematical instruction because he could foresee the inability of the Society to adapt to the coming Scientific Revolution and the later secularism of the Enlightment and therefore was trying to save her?

- Dear (1995), Smolarski, Wallace (2003) and others have worked on the link between the use of mathematical arguments to describe natural phenomena and its deviation from Aristotelian tradition in the work of the Jesuit mathematicians. That work was influential in the methodological conceptualization of scientific knowledge. Much later, in the twentieth century, Jesuits rediscovered the *Spiritual Exercises* as the source of inspiration for their work. Perhaps it can be said that the pedagogical tool of the process of discernment found in the *Spiritual Exercises*, in other words, the process of experience, articulation of and reflection on that experience, and decision to action based on that reflection, is the model behind the influence in the scientific methodology familiar to us: the design of an experiment (experience), analysis of the experience (articulation and reflection) and conclusions for further work (actions based on discernment). This model was legitimized and adopted through the evolution shown in the literature.

Limitations of the Review of the Literature

The review is limited by the scarcity of primary sources as well as time. Also, it has been argued by others (O'Malley, Romano) that the use of official documents and the reality of teaching practices and curriculum in the different periods suggest the need for further scholarship to understand the praxis of the Jesuit system, this especially true regarding the field of mathematics. It is not possible with the current allocation of time and resources to answer the some of the original questions behind the motivation for this thesis.

Implications for future research

Based on the current literature and feedback form some of the authors (particularly from Fr. Duminuco S.J.) it might be worth to pursue further study on the implications of the original *Ratio* and the implementation of current Society documents on education in the praxis within existing Jesuit Institutions. It is undeniable that Jesuit education has produced a number of influential minds in different intellectual fields. I suggest further research in possible influence of Jesuit pedagogy on cognitive development, specifically in mathematical thinking, as a way to answer some of the original questions of this thesis. Further work is also necessary to find ways to implement Ignatian pedagogy in an inherently secular environment such as public education institutions.

REFERENCES

Ariew, R. (2003). Descartes and the Jesuits: Doubt, novelty, and the Eucharist. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. 157-194). Boston, MA: Massachusetts Institute of Technology Press.

Babula, A., Buckley, P., Dye, D., et al (n.d.). *IPP Lesson Plan. Mathematics; Solids, Spheres, and Cross Sections: Geometry*. Retrieved February 21, 2006 from Jesuit Secondary Education Association, Ignatian Pedagogy Paradigm research program Web site: http://www.jsea.org/

Baldini, U. (2003). The academy of mathematics of the Collegio Romano from 1553 to 1612. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. 47-98). Boston, MA: Massachusetts Institute of Technology Press.

Baldini, U. (2006). The reception of a theory: A provisional syllabus of Boscovich literature, 1746-1800. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 405-450). Toronto, Canada: University of Toronto Press.

Bangert, W.V., S.J. (1986). *A history of the Society of Jesus* (Revised Edition). St. Louis, MO: The Institute of Jesuit Sources.

Barthel, M. (1984). *The Jesuits, history and legend of the Society of Jesus* (First Quill Edition). New York, NY: Quill William Morrow.

Bloechl, J. (2004). The Jesuit Ratio Studiorum and the teaching of mathematics; on the incursion of modern rationality into classical pedagogy. *Fundamental questions; a journal of the liberal arts, 1*(1), 41-60.

Brotóns, V.N. (2006). Science and Enlightment in eighteenth-century Spain: The contribution of the Jesuits before and after the Expulsion. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 390-404). Toronto, Canada: University of Toronto Press.

Buckley, M. J., S.J. (1999). Reflections. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 713-717). Toronto, Canada: University of Toronto Press.

Campbell, T.J., S.J. (1921). *The Jesuits, 1534-1921, a history of the Society of Jesus from its foundation to the present time* (Volume 1). New York, NY: The Encyclopedia Press.

Campbell, T.J., S.J. (1921). *The Jesuits, 1534-1921, a history of the Society of Jesus from its foundation to the present time* (Volume 2). New York, NY: The Encyclopedia Press.

Cesareo, F. (1993). Quest for identity: The ideals of Jesuit education in the sixteen century. In C. Chapple (Ed.), *The Jesuit tradition in education and missions a 450 year perspective* (17-33). Scranton, PA: University of Scranton Press.

Chapple, C. (1993). Introduction. In C. Chapple (Ed.), *The Jesuit tradition in education and missions: a 450 year perspective* (pp. 2-12). Cranbury, NJ: Associated University Presses.

Codina, G., S.J. (2000). The "Modus Parisiensis". In V. Duminuco, S.J. (Ed.), *The Jesuit Ratio Studiorum, 400th anniversary perspectives* (28-49). New York, NY: Fordham University Press.

Codina, G., S.J. (2003, September 10). *A century of Jesuit education, 1900-2000*. Retrieved February 1, 2006 from Boston College, Vice President for Mission & Ministry Web site: http://www.bc.edu/offices/mission/exploring/jesuniv/

Cosentino, G. (1999). Mathematics in the Jesuit Ratio Studiorum. In F. A. Homann S.J. (Ed.), *Church, culture & curriculum. Theology and mathematics in the Jesuit Ratio Studiorum* (pp. 47-79). Philadelphia, PA: Saint Joseph's University Press.

Deal, D.E. (1989). Four-dimensional Geometry. In J. K. Baumgart, D. E. Deal, B. R. Vogeli & A. E. Hallerberg (Eds.), *Historical topics for the mathematics classroom* (pp. 211-214). Reston, VA: National Council of Teachers of Mathematics.

Dear, P. (1995). *Discipline and experience: The mathematical way in The Scientific Revolution* (chapter 2). Chicago, IL: University of Chicago Press.

Dinis, A. (2003). Giovanni Batista Riccioli and the science of his time. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. 195-203). Boston, MA: Massachusetts Institute of Technology Press.

Donohue (1999, May 22). A School plan's 400th birthday. *America, 180 (18),* 19-20+.

Duminuco, V.J., S.J. (2000). A new Ratio for the new millennium?. In V.J. Duminuco S.J. (Ed.), *The Jesuit Ratio Studiorum, 400th anniversary perspectives* (pp. 145-160). New York, NY: Fordham University Press.

Feingold, M. (2003). Grounds for conflict: Grienberger, Grassi, Galileo, and posterity. In M. Feingold (Ed.), *The new science and Jesuit science: Seventeenth century perspectives* (1-120). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Feingold, M. (2003). Preface. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. vii-xi). Boston, MA: Massachusetts Institute of Technology Press.

Feingold, M. (2003). Jesuits: Savants. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (1-46). Boston, MA: Massachusetts Institute of Technology Press.

Feldhay, R. (1999). The cultural field of Jesuit science. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 107-130). Toronto, Canada: University of Toronto Press.

Fleming, D.L., S.J. (1996). *Draw me into your friendship; The Spiritual Exercises, a literal translation & a contemporary reading*. Saint Louis, Missouri: The Institute of Jesuit Sources.

Fumaroli, M. (2006). Between the Rigorist Hammer and the Deist Anvil: The fate of the Jesuits in eighteenth-century France. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 682-690). Toronto, Canada: University of Toronto Press.

Grant, E. (2003). The partial transformation of medieval cosmology by Jesuits in the sixteenth and seventeenth centuries. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (127-156). Boston, MA: Massachusetts Institute of Technology Press.

Gray, H., S.J. (2000). The experience of Ignatius Loyola: Background to Jesuit education. In V.J. Duminuco S.J. (Ed.), *The Jesuit Ratio*

Studiorum, 400th anniversary perspectives (pp. 1-27). New York, NY: Fordham University Press.

Gorman, M. J. (2003). Mathematics and modesty in the Society of Jesus: The problems of Christoph Grienberg. In M. Feingold (Ed.), *The new science and Jesuit science: Seventeenth century perspectives* (1-120). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Gorman, M.J. (1999). From 'the eyes of all' to 'useful quarries in philosophy and good literature': Consuming Jesuit science, 1600-1665. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (170-189). Toronto, Canada: University of Toronto Press.

Hamilton, D. (2003, December 12-14th). *When does a 'house of studies' become a 'school'? a comment on the Jesuits and the beginnings of modern schooling*. Annual Conference of the History of Education Society, Cambridge, England.

Harney, M.P., S.J. (1962). *The Jesuits in history, the Society of Jesus through four centuries*. Chicago, IL: Loyola University Press.

Harris, S.J. (1999). Mapping Jesuit science: The role of travel in the geography of knowledge. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 212- 240). Toronto, Canada: University of Toronto Press.

Hellyer, M. (1999). Jesuit Physics in eighteenth-century Germany: Some important continuities. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 538- 554). Toronto, Canada: University of Toronto Press.

Hellyer, M. (2005). *Catholic physics, Jesuit natural philosophy in early modern Germany*. Notre Dame, IN: University of Notre Dame Press.

Homann, F. A., S.J. (1999). Introduction. In F. A. Homann S.J. (Ed.), *Church, culture & curriculum. Theology and mathematics in the Jesuit Ratio Studiorum* (pp. 1-15). Philadelphia, PA: Saint Joseph's University Press.

Homann, F., S.J. (1999). Moral and theological life and the mathematical sciences. In M. R. Tripole, S.J. (Ed.), *Promised renewed Jesuit higher education for a new millennium* (213-222). Chicago, IL: Loyola Press.

Hsia, F. (1999). Jesuits, Jupiter satellites, and the Académie Royale des Sciences. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (241-257). Toronto, Canada: University of Toronto Press.

Kane, G. (n.d.). *IPP Lesson Plan; Mathematics, Introduction to limits: Calculus*. Retrieved February 21, 2006 from Jesuit Secondary Education Association, Ignatian Pedagogy Paradigm research program Web site: http://www.jsea.org/

Julia, D. (2004). Entre universel et local: le collège Jésuite à l'époque moderne. *Paedagogica Historica, 40*(1&2), 15-31.

Lacouture, J. (1993). *Jesuitas I: Los conquistadores* (1ª edición). Barcelona, Spain: Ediciones Paidós.

Lacouture, J. (1994). *Jesuitas II: Los continuadores* (1ª edición). Barcelona, Spain: Ediciones Paidós.

Lacouture, J. (1995). *Jesuits, a multibiography*. Washington, DC: Counterpoint.

Leitão, H. (2003). Jesuit mathematical practice in Portugal, 1540-1759. In M. Feingold (Ed.), *the new science and Jesuit science: Seventeenth century perspectives* (229-247). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Letson, D. & Higgins M. (1995). *The Jesuit mystique*. Chicago, IL: Loyola Press.

Loach, J. (2006). Revolutionary pedagogues? How Jesuits used education to change society. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 66-85). Toronto, Canada: University of Toronto Press.

Lowney, C. (2003). *Heroic Leadership. Best practices from a 450-year-old company that changed the world*. Chicago, IL: Loyola Press.

Luckàcs, L., S.J. (1999). A history of the Ratio Studiorum. In F. A. Homann S.J. (Ed.), *Church, culture & curriculum. Theology and mathematics in the Jesuit Ratio Studiorum* (pp. 17-46). Philadelphia, PA: Saint Joseph's University Press.

Massimi, M. (2001). A Psicologia dos Jesuitas: Uma contribuição à historia das idéias psicológicas. *Psicologia: Reflexão e critica, 14*(3), 625-633.

McCoog, T., S.J. (2001). *A guide to Jesuit archives*. St. Louis, MO: Institute of Jesuit Sources; Roma: Institutum Historicum S.I.

McGucken, W., S.J. (1932). *The Jesuits and education, the Society's teaching principles and practice, especially in secondary education in the United States*. New York, NY: The Bruce Publishing Company.

Moell, C.J., S.J. & Padberg, J.W., S.J. (n.d.). *The Constitutions of the Society of Jesus and their complementary norms*. Saint Louis, Missouri: The Institute of Jesuit Sources.

O'Hare, J. A., S.J. (1993). Jesuit Education in America. In C. Chapple (Ed.), T*he Jesuit tradition in education and missions, A 450 year perspective* (143-154). Scranton, PA: University of Scranton Press.

O'Malley, J.W., S.J. (1993). *The first Jesuits*. Cambridge, MA: Harvard University Press.

O'Malley, J.W., S.J. (1999). The historiography of the Society of Jesus: Where does it stand today?. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 3-37). Toronto, Canada: University of Toronto Press.

O'Malley, J. W., S.J. (2000). How the first Jesuits became involved in education. In V. Duminuco, S.J. (Ed.), *The Jesuit Ratio Studiorum, 400th anniversary perspectives* (pp. 56-74). New York, NY: Fordham University Press.

O'Malley, J. W., S.J. (2000). From the 1599 Ratio Studiorum to the present: A humanistic tradition?. In V. Duminuco, S.J. (Ed.), *The Jesuit Ratio Studiorum, 400th Anniversary perspectives* (pp.127-144). New York, NY: Fordham University Press.

O'Malley, J.W., S.J. (2000). How humanistic is the Jesuit tradition? From the 1599 Ratio Studiorum to now. In M.S. Tripole, S.J. (Ed.),

Jesuit education 21: Conference proceedings on the future of Jesuit higher education (pp. 189-201). Philadelphia, PA: St Joseph's University Press.

O'Malley, J.W., S.J. (2006). Introduction: The pastoral, social, Ecclesiastical, civic, and cultural mission of the Society of Jesus. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. xxiv-xxxvi). Toronto, Canada: University of Toronto Press.

O'Malley, J.W., S.J. (2006). Part three: Scientific knowledge, the order of Nature, and natural theology.. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 288-290). Toronto, Canada: University of Toronto Press.

Padberg, J.W., S.J. (2000). Development of the Ratio Studiorum. In V.J. Duminuco S.J. (Ed.), *The Jesuit Ratio Studiorum, 400th anniversary perspectives* (pp. 80-99). New York, NY: Fordham University Press.

Pavur, C., S.J. (2005). *The Ratio Studiorum, the official plan for Jesuit education, Ratio atque Institutio Studiorum Societatis Iesu*. St. Louis, MO: The Institute of Jesuit Sources.

Romano, A. (1999). *La contre-réforme mathématique. Constitution et diffusion d'une culture mathématique Jésuite a la Renaissance (1540-1640)*. Paris, France: École Française de Rome.

Romano, A. (2004). Réflexions sur la construction d'un champ disciplinaire: les mathématiques dans l'institution jésuite à la Renaissance. *Paedagogica Historica, 40*(3), 245-259.

Romano, A. (2006). Teaching mathematics in Jesuit schools: Programs, course content, and classroom practices. In J.W. O'Malley S.J., G.A. Bailey, S.J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II: cultures, sciences, and the arts, 1540-1773* (pp. 355-370). Toronto, Canada: University of Toronto Press.

St. Ignatius College Preparatory (2005). *Excellence in teaching*. Retrieved March 18, 2006 from St. Ignatius College Preparatory, San Francisco, CA, Professional Development for Educators Web site: http://www.siprep.org/prodev/excellence/index.cfm

Schlafly, D.L., Jr. (2006). The Post-Suppression Society of Jesus in the United States and Russia: Two unlikely settings. In J.W. O'Malley

S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 772-784). Toronto, Canada: University of Toronto Press.

Schwickerath, R., S.J. (1904). *Jesuit education its history and principles viewed in the light of modern educational problems* (2nd ed.). St. Louis, MO: B Herder.

Simmons, A. (1999). Jesuit Aristotelian education: The de anima commentaries. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits, cultures, sciences and the arts, 1540-1773* (pp. 522-537). Toronto, Canada: University of Toronto Press.

Sixteenth Century Journal, The (2003). La Contre-Réforme mathématique [book review]. *The Sixteenth Century Journal, 33*(3), 852-854.

Smolarski, D., S.J. (1999). GC 34, higher education, and computer science. In M. R. Tripole, S.J. (Ed.), *Promised renewed Jesuit higher education for a new millennium* (pp. 106-119). Chicago, IL: Loyola Press.

Smolarski, D., S.J. (2000). The Ratio Studiorum and new technology: Opportunities and challenges. *Explore (Bannan Institute, Santa Clara University), Fall 2000*.

Smolarski, D., S. J. (2002). Teaching mathematics in the seventeenth and twenty-first centuries. *Mathematics Magazine, 75*(4), 256-262.

Smolarski, D., S. J. (2002). The Jesuit Ratio Studiorum, Christopher Clavius, and the study of mathematical sciences in universities. *Science in Context, 15*(3), 447-457.

Smolarski, D., S. J. (2005). Jesuits on the moon, seeking God in all things...Even in Mathematics!. *Studies in the spirituality of Jesuits, 37*(1), 1-40.

Society of Jesus (n.d.). *Characteristics of Jesuit education*. Retrieved December 18, 2005 from Curia Generalis of the Society of Jesus, Jesuit Education Web site: http://www.sjweb.info/education/doclist.cfm

Society of Jesus (n.d.). *Ignatian Pedagogy: A practical approach*. Retrieved December 18, 2005 from Curia Generalis of the Society of Jesus, Jesuit Education Web site: http://www.sjweb.info/education/doclist.cfm

Society of Jesus (1986). In L. Luckàcs S.J. (Ed.), *Monumenta pedagogica Societatis Iesu* (vol. 5). Rome: Historical Institute of the Society of Jesus.

Society of Jesus (1986). In L. Luckàcs S.J. (Ed.), *Monumenta Pedagogica Societatis Iesu* (vol. 5). Rome: Historical Institute of the Society of Jesus.

Society of Jesus (2002). Historical documents, part I, sections on mathematics from various editions of the Ratio Studiorum. *Science in Context, 15*(3), 459-464.

Spence, J.D. (1985). *The memory palace of Matteo Ricci*. New York, NY: Penguin Books.

Traub, G., S.J. (2003, September 16). *Do you Speak Ignatian?*. Retrieved February 1, 2006 from Boston College, Vice President for Mission & Ministry Web site: http://www.bc.edu/offices/mission/exploring/jesuits/traub_speak/

Vanpaemel, G.H.W. (2003). Jesuit Science in the Spanish Netherlands. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. 389-432). Boston, MA: Massachusetts Institute of Technology Press.

Wallace, W.A., O.P. (2003). Galileo's Jesuit connections and their Influence on his science. In M. Feingold (Ed.), *Jesuit science and the republic of letters* (pp. 99-126). Boston, MA: Massachusetts Institute of Technology Press.

Wallace, W.A., O.P. (2006). Jesuit influences on Galileo's Science. In J.W. O'Malley S.J., G.A. Bailey, S. J. Harris & T.F. Kennedy S.J. (Eds.), *The Jesuits II, cultures, sciences and the arts, 1540-1773* (pp. 314-335). Toronto, Canada: University of Toronto Press.

Whitehead, M. (2004). Jesuit secondary education revolutionized: the Académie Anglaise, Liège, 1773-1794. *Paedagogica Historica, 40*(1&2), 33-44.

Woodrow, A. (1995). *The Jesuits a Story of power*. New York, NY: Geoffrey Chapman.

Wright, D. (n.d.). *IPP Lesson Plan; Mathematics, L'Hopital's Rule: Calculus*. Retrieved March 18, 2006 from Jesuit Secondary

Education Association, Ignatian Pedagogy Paradigm research program
Web site: http://www.jsea.org/

Wright, J. (2004). *God's soldiers adventures, politics, intrigue, and power - a history of the Jesuits*. New York, NY: Doubleday.

APPENDIX

Examples of lesson plans in Jesuit schools following the Ignatian Pedagogy model:

I. Geometry: Solids, Spheres, and Cross Sections (Babula et al, n.d.)

II. Calculus: Limits (Kane, n.d.)

III. Calculus: L'Hopital's Rule (Wright, n.d.)

Ignatian Pedagogical Paradigm Lesson Plans

Context
Experience
Reflection
Action
Evaluation

Lesson Title	"Solids, Spheres, and Cross Sections"
Discipline	Mathematics (Geometry)
Contributor	Andrew Babula – St. John's Jesuit High School Paul Buckley – Gonzaga College High School David Dye – McQuaid Jesuit High School Carol Hardtke – Marquette University High School Gretchen Kane – Jesuit High School, New Orleans Tom Larsen – Bellarmine Preparatory School Teri Stroschein – Jesuit High School, Portland
Goals	Students will be able to identify and draw spehres and various solids, including cylinders, cones, pyramids, and prisms. Furthermore, students will be able to identify and draw the sections of spheres (great circles and small circles), hemisphere, and those sections of cylinders, cones, pyramids, and prisms which are both parallel and perpendicular to the base.
Context	Students come into the lesson with some prior experience with solids. They have been exposed to definitions. They have seen classroom models. The following lesson will probably take two or more days, more than ninety minutes of class time. "The Hook" – Students are either given a handout or view a screen projection of the "Candy Bar Game." Students identify the candy from cross-sectional pictures. They are also asked to identify the overall shape of the candy and the shape of the visible cross-section.
Experience	David students into groups. Each student is asked to divide their potato in half and carve both potato halves into a specified solid (i.e. prism, cylinder, cone, sphere, or pyramid). Students are then directed to create a vertical cross section in one 'potato solid' and a horizontal cross section in the other 'potato solid.' Students should record the shapes of both the vertical and horizontal cross sections. Students are given a worksheet. Students match a given solid with possible cross sections and vice versa. Students are then given a homework assignment. (a) Using Geometry Sketchpad, if available, students draw the various solids and sections; they are to use the colors and other properties of Sketchpad to indicate three dimensions. They are to indicate clearly the relationship between a given solid and its possible sections. (b) The assignment will also include various problems that encourage the students to use prior knowledge with geometric terminology.

Reflection & Action	Class discussion follows. Why do we study this? Where are these objects seen in the real world? In architecture? In Medicine? In Geology? In Engineering? In Nature? Discussion is followed by a couple of possibilities: (a) Students write about those real world applications that did not come up in the class discussions, and/or (b) Students are encouraged to bring in objects and pictures of these various objects and shapes.
Experience, Reflection & Action	As a possible project for the quarter, students real all or part of *Flatland*, a book about a sphere entering a two-dimensional world. This book lends itself to sociological and theological discussion, reflection, and writing.
Evaluation	Students will be assessed in a variety of ways. A student's understanding of the properties of solids will be evidenced by their ability to carve their potato correctly. The first worksheet will demonstrate a student's ability to recognize the cross sections of various solids. The reflection worksheet will demonstrate that higher order learning has taken place. Traditional assessment will take place in subsequent lessons and exams when students are asked to find the area of various cross sections.

Ignatian Pedagogical Paradigm
Lesson Plans

Context
Experience
Reflection
Action
Evaluation

Lesson Title **Discipline** **Contributor**	Introduction to Limits Calculus Gretchen Kane – Jesuit High School, New Orleans
Context	The song *Take it to the Limit* by the Eagles is played for the class. Students are asked to discuss how the lyrics describe a limit. Students are given a reflection essay to do on anything in art, music, media, etc. that describes the concept of a limit.
Experience	The concept of a limit is established through analogies to football, art, etc. Students are given an advanced organizer describing different mathematical situations in which limits of functions may or may not exist. Each situation is connected to previously learned material about function values. The mathematical symbol for limits and terminology used is discussing limits is reiterated. Students work sample problems.
Reflection	Students are assigned an in class reflection sheet where they are required to create their own example of a function whose limit exists as x approaches a certain value but whose function value is different from the limit.
Action	Students return to their advanced organizer and work through four different limit/function value situations (1. function value doesn't exist at a number, but limit exists as x approaches that number; 2. function value exists at a number, but limit doesn't exist as x approaches that number; 3. function value exists at a number, and limit exists as x approaches that number, but these are not the same; 4. function value exists at a number, and limit exists as x approaches that number, and the two are the same). Each situation has its own example with a graphing calculator exercise allowing students to see the function's graph and infer the function value and limit from the graph. (These visuals will be a precursor to discussion of discontinuity.)
Evaluation	A quiz on function values and limits from a graphical standpoint.

Ignatian Pedagogical Paradigm
Lesson Plans

Context
Experience
Reflection
Action
Evaluation

Lesson Title **Discipline** **Contributor**	L'Hopital's Rule Calculus David Wright – Jesuit High School, New Orleans
Context	Create a desire to use precise mathematical methods in computing indeterminate limits by re-visiting the limits computed earlier in the year using intuitive or graphical analysis (called cowboy math).
Experience	Computation of limits of rational algebraic expressions based on the intuition of relative rates and strength of growth of the numerator and denominator. Exs. $\lim_{x\to\infty} \frac{3x^4+4x^2+5}{x^6-x+8} = 0$ due to the dominance of the higher power of the denominator in the "race" to ∞. $\lim_{x\to\infty} \frac{5x^3-x}{3-7x^3} = \frac{-5}{7}$ due to relative equality of the dominating powers of the numerator and denominator. How is the $\lim_{x\to\infty}(1+\frac{1}{n})^n = e$ computed from Pre-Calculus classes?
Reflection	How does the precise mathematics of L'Hopital's Rule reflect the intuitive analysis of earlier computations? Why does L'Hopital's Rule fail when it is not an indeterminate?
Action	Discovering and perfecting methods of calculation based on rewriting, simplifying, and logarithmic L'Hopital when the traditional applications fail to produce a result.
Evaluation	Appreciation of the "power" acquired with this procedure and the recognition that it is not always the only or best way of calculation. Execution of a variety of different types of limit calculations in a testing mode.