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M.G. Agnesi, R. Rampinelli and the Riccati Family: A Cultural Fellowship Formed for an Important Scientific Purpose, the *Instituzioni analitiche*

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> *Not every learned man makes a good teacher, nor is he able to transmit to others what he knows. Rampinelli, however, was marvellously endowed with this talent.* [Brognoli, 1785, 85][2]

1. *Introduction*

> "Shortly after I arrived in Milan I had the pleasure of meeting Signora Countess Donna Maria Agnesi who was well versed in the Latin and Greek languages, and even Hebrew, as well as other more familiar tongues; moreover, she was well educated in the most important Metaphysics, the Physics of the day and Geometry, and she knew enough of Mechanics for the purposes of Physics; she had a little knowledge of Cartesian algebra, but all self-acquired as there was no one here who could enlighten her. Therefore she asked me to assist her in that study, to which I agreed, and in a short time she had, with extraordinary strength and depth of talent, wonderfully mastered Cartesian algebra and the two infinitesimal Calculi,[3] to which she added the application of these to the most lofty physical matters. I assure you that I have always been and still am amazed by seeing such talent and such depth of knowledge in a woman as would be remarkable in a man, and in particular by seeing this accompanied by quite remarkable Christian virtue."[4]

On 9 June 1745, Ramiro Rampinelli (1697-1759) thus presented to his main scientific interlocutor of the time, Giordano Riccati (1709-1790), the talents of his Milanese pupil

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[2] Brognoli, 1785, 85: «Non tutti i dotti sono capaci di essere instruttori, né sanno comunicare agli altri quello che sanno. Il Rampinelli di questo talento era maravigliosamente dotato.»

[3] I.e. Differential and Integral Calculus.

[4] R. Rampinelli to G. Riccati, 9 June 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843 1745, letter 143]: «Poco dopo, che io venni in Milano ebbi il piacere di conoscere la Signora Contessa Donna Maria Agnesi Zittella molto versata nelle lingue Latina, Greca, ed anco Ebrea, oltre altre più famigliari; di più molto dotta nelle migliori Metafisiche, e nella moda Fisica, nella Geometria, e nelle Mecaniche quanto basta per la Fisica, aveva qualche notizia nell'algebra cartesiana, ma acquistata da sé, perché non aveva qui chi potesse darle lume. Volle per tanto, che io la servissi in tale studio, come ho fatto, ed in poco tempo con robustezza e profondità di talento straordinaria si è impossessata a meraviglia della Cartesiana, e de' due Calcoli infinitesimali, al che si ha aggiunta l'applicazione di essi alle cose fisiche più sublimi. L'assicuro che mi ha sempre fatto, e mi fa stupore il vedere tanto talento, e tanto fondo di sapere in una Donna, che sarebbe particolare in un Uomo, e massime il vedere l'accompagnamento di una virtù morale cristiana molto particolare.»

Maria Gaetana Agnesi (1718-1799), who was near to completing a treatise on mathematical analysis designed to instruct young students. In order to complete this important project, he requested the material aid of the mathematicians from the Riccati family, above all the famous Count Jacopo Riccati (1676-1754), and his sons Giordano Riccati, who at the time resided with his father in Castelfranco Veneto, and the Jesuit Vincenzo Riccati (1707-1775), who had been teaching mathematics at the *Collegio di Santa Lucia* in Bologna since 1739.

The intense correspondence that developed between Rampinelli, Agnesi and the three Riccatis from 1745 to 1752 – now available in a critical online edition – documents with a wealth of details the fascinating exchange of scientific ideas that developed around the writing, editing and printing of *Instituzioni analitiche ad uso della gioventù italiana* ('Introduction to Analysis for the Use of the Youth of Italy'). Reconstructing the history and significance of this undertaking (which we may call collective) can help us understand the role that Agnesi's work played in the mathematics and general culture in Italy at the time, as well as the farsightedness of her tutors and supporters. It can also help demonstrate why today we no longer consider valid the excessively severe judgments that G. Loria [Loria 1903, 388; 1904, 339; 1936, 453-455] and C.A. Truesdell passed on this exemplar of a female intellectual [Truesdell, 1989; 1991].

2. *The protagonists*

Regarding the subjects of our study, the biographical notes and the comments on Agnesi and her cultural context [Frisi, 1799; Cantù, 1836; Anzoletti, 1900; Masotti, 1940; Mazzotti, 2007; Minonzio, 2000; Roero, 2011; Roero, Luciano, 2013; Findlen, Roworth, Sama, 2009], as well as that of the three members of the Riccati family are well known [Federici, 1790; Bernardi, 1844; Michieli, 1942-43, 1943-44, 1944-45; Piaia, Soppelsa, 1992; Mazzone, Roero, 1997 and 2012], whereas the scientific background of Rampinelli, the young Agnesi's tutor in Milan who acted as intermediary and was instrumental in the creation and functioning of the successful cultural network in which she participated is more obscure [Torriceni, 1760, 1781; Brognoli 1785; Roero, Vendola, 1999]. Born in Brescia in 1697 to a family of nobles, Ludovico Rampinelli studied letters and philosophy with the Jesuits at the Collegio delle Grazie in his native city. Then, against the will of his father, who had chosen a legal career for him, in the 1720s he began to develop an interest for mathematics. In 1722 he entered the congregation of 'San Benedetto sul Monte Uliveto' in Bologna as a novice, taking the name Ramiro. Under the guidance of Gabriele Manfredi – who had been teaching the course in Infinitesimal Analysis at the University of Bologna since 1720 [Giuntini 2009] – he learned algebra and Cartesian geometry, as well as differential and integral calculus. From 1727 to 1731, Rampinelli lived in the Veneto region, in the monastery of Sant'Elena in Venice and then the convent of San Benedetto in Padua. In September 1727 he came into contact with Jacopo Riccati, whom he contacted in order to deliver a letter from Eustachio Manfredi, the brother of Gabriele, and to ask for news about the progress of his mathematical research.

Count Jacopo Riccati, a friend of the Manfredi brothers' who often visited Bologna as his sons were studying there, was not only generous with his advice, but also personally supervised Rampinelli's education, giving him lessons and clarifying his doubts when he made his way to Castelfranco for a number of weeks in both 1728 and 1729, and obtaining "a

number of documents, canons and problems" for his subsequent visits and correspondence.[5] His requests revolved around the subjects of the mechanics of solid and fluid bodies, such as impacts and active forces, pendulums, resistance and the methods for solving differential equations.

From June 1731 to the spring of 1732, Rampinelli stayed at the monastery of Santa Maria Nuova in Rome. During this stay, he had the opportunity to exchange ideas with Celestino Galiani and Antonio Leprotti and also to teach mathematics to Giuseppe Orlandi, with whom maintained correspondence for many years. In 1731 he also made a trip to Naples, where he met Nicola De Martino, author of *Elementa Statices in tyronum gratiam* ('Elements of Statics for beginners') [De Martino, 1727], whose merit lay in his ability to unite the Galilean tradition with the most recent theories and results of Newton, Leibniz, the Bernoullis, J. Hermann and P. Varignon that particularly interested Rampinelli.

In June 1732 he went to live at the convent of San Bartolomeo in Pavia for approximately a year, and from May 1733 to the summer of 1740 he resided at the monastery of San Michele in Bosco, Bologna, where he taught courses in mathematics, analysis and physics to the young monks; he often turned to the Riccatis for help and advice on matters of hydrostatics and mathematical physics. Among his students from this period we find Cesareo Giuseppe Pozzi and Cesareo Maria Sommariva.

Rampinelli then spent six months in Brescia, at the monastery of San Francesco, from July to December 1740; at the beginning of January 1741, he was called to the convent of San Vittore al Corpo in Milan to instruct the resident monks on the disciplines of mathematics and physics.

In parallel to his orally given lessons, Rampinelli drew up texts and short treatises for his pupils, which were never published, with the sole exception of *Lectiones Opticae*, published posthumously in Brescia in 1760. Among his papers we can still find conserved in Padua the manuscripts for his *Institutionum Mechanicarum Lectiones* (Lectures on the Principles of Mechanics),[6] *Lectiones Hydrostaticae* (Lectures on Hydrostatics),[7] *Institutionum Trigonometricarum Libri* (Book of Trigonometry Principles),[8] *Lectiones Opticae* (Lectures on Optiks)[9] and the essay *Dell'idrostatica* (On Hydrostatics)[10] all written in his own hand, alongside various other documents and manuscripts, many of which he received from the Riccatis. The most notable of these is *In Geometriam Infinitesimalium, Analyseos Infinitorum Principia* (On the Infinitesimal Geometry, Principles of the Analysis of the Infinities), a short compendium of differential calculus that was never completed and that Rampinelli presumably used in his lessons with Agnesi.[11]

His *Elementi Meccanici e Statici* ('Basic Mechanics and Statics'), on the other hand, can be found in Udine, accompanied by a number of handwritten notes made by Giordano Riccati, further proof that Rampinelli usually gave the fruits of his studies to the Riccatis to have their

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[5] Cf. R. Rampinelli to J. Riccati, 12 August 1728 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1728 letter 4].
[6] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 1.
[7] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 1.
[8] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 1.
[9] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 2, ff. 1r-122r.
[10] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 2, ff. 1r-12v.
[11] Padua, Biblioteca del Seminario, ms. DCCXI, vol. 2, ff. 1r-21r.

opinions and suggestions for revisions before transferring them to the lessons given to his young students.

His 'marvellous' teaching abilities, praised by his contemporaries, spurred the Senate of Milan to offer him the chair in mathematics at the University of Pavia in 1747, where Rampinelli taught until his death in Milan on 8 February 1759.

His love of teaching students was one of his main purposes in life, as Brognoli testifies in his 'Eulogy':

> "As he completely gave himself over to teaching the young, I must add in his praise that which seems rather difficult, and is but seldom found in these lofty thinkers, who, absorbed by their own arcane meditations know not how to adapt their intelligence to others' lesser minds. He was easily accessible, of remarkable modesty, I could say of an almost childlike bashfulness, full of respect towards his colleagues and far removed from any controversies; he had nothing more to heart than bending and lowering his genius to the level of others, studying the easiest ways to communicate his ideas to others and transmitting his knowledge by following the method he believed best suited and most fitting to the various intellects of his followers. He was wont to encourage and comfort his pupils if he saw that they had been so frightened by the complex horrors of Algebra as to fling themselves down and pull back. He faced up to obstinate difficulties, which he endeavored to work upon, so that many took courage and threw themselves wholeheartedly into overcoming the rough terrain that at first sight had so terrified them. … Not every learned man makes a good teacher, nor is he able to transmit to others what he knows. Rampinelli, however, was marvellously endowed with this talent."[12]

His example, or 'teaching style', was imitated faithfully by Agnesi, who inherited the same feeling towards her pupils and was endowed with a capacity for clarity, order and accuracy that exceeded even her master's.

3. Requests, Revisions and Annotations

In his role as the mathematics tutor in the Agnesi house from 1741 onwards, Rampinelli had directed his young pupil's studies on Cartesian geometry and infinitesimal calculus.

In June 1745, as soon as he heard of Pietro Agnesi's desire to publish the treatise written by his daughter, he decided that the ideal consultants for assessing and approving this work were the mathematicians from Castelfranco. Having already made use of the teachings and advice of Jacopo and Giordano Riccati on Leibnizian and Newtonian analyses and their relative applications to problems in the fields of mechanics, geometry and physics, Rampinelli believed they were the most willing and able to offer advice and comments, to re-read, revise and suggest amendments to the text. It was an onerous task, as it was the first exposition in the Italian language of the methods of both Cartesian geometry and differential and integral calculus, accompanied by the solution of differential equations and various

[12] Brognoli 1785, 85: «Sacrificatosi tutto all'istruzione della gioventù, io debbo per sua lode soggiungere quello che assai difficile sembra, e rade volte si trova in questi sublimi pensatori, che assorbiti nelle proprie arcane meditazioni non si sanno all'altrui facile intelligenza adattare. Egli di accesso facile, d'una modestia singolare, d'una verecondia direi quasi fanciullesca, pien di rispetto verso i Colleghi, lontan dalle contese null'altro avea più a cuore, che di piegare, ed abbassar il suo ingegno all'altrui capacità, studiando i modi più facili per comunicare agli altri le sue idee, e trasfondere il suo sapere col seguire quel metodo ch'ei credea ai varj genj, e ai pensamenti altrui più atto, e più confacente. Egli solea i suoi allievi animare e confortare, se dall'intricato orrore dell'Algebra li vedea spaventati ributtarsi, e retrocedere. … Non tutti i dotti sono capaci di essere instruttori, né sanno comunicare agli altri quello che sanno. Il Rampinelli di questo talento era maravigliosamente dotato.»

problems and exercises designed to aid learning of the new techniques. As he felt he was not up to the task himself, Rampinelli wrote to Giordano Riccati:

> "Her Ladyship has noted the great amount of twaddle heard from my lips about Analysis, she has greatly improved, tidied and added to it with her own work, and with a reading of books; in substance she has compiled a corpus that can be called an accomplished Introduction to Analysis. Her father is very keen to publish this little work, but, as I both lack the necessary ability and also have had a small part to play in its composition, I feel unable to judge its merits; therefore I ask you and Count Jacopo to kindly accept the task of endeavoring to read the writings I shall send you one part at a time when I have apprised that you are willing to perform this favor, which I beg you do."[13]

Upon her tutor's advice, on 20 July 1745 Maria Gaetana Agnesi wrote directly to Jacopo Riccati with the following words:

> "Among the enormous feelings of obligation I hold towards my esteemed teacher Father Don Ramiro Rampinelli, I count also the honor your Lordship has granted me by deigning to cast your expert eye, and that of your worthy son Count Giordano, over the little that my meager talents have allowed me to produce under the title of Instituzioni analitiche following the guidance and direction of a man with such great mathematical faculties, with the aim of as far as possible making the study of such a difficult and laborious study in itself easier for the young, by stripping it down to the order and clarity it is capable of, which task, as far as I am aware, none have yet so much as attempted. The fact is that I have in this succeeded at least tolerably well and therefore I turn to the infallible oracle of your Lordship, of whose immense knowledge and learnedness I am assured not only by your public reputation but also by the authoritative testimony of the aforementioned Father Don Ramiro who – oh, how many times! – has worthily and honorably remembered your powers, not without envy towards all those who have the great benefit of communicating with and revering you at close quarters and thus admiring your exceptional gifts. Therefore I beg your most excellent Lordship to honor me with your sage criticisms and at the same time oblige me by placing your corrections in the margins, since Father Rampinelli, as my overly biased – or rather my overly modest – Tutor, refuses to pass judgment on my work and has referred me to your infallible and unbiased opinions, advice and aid."[14]

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[13] R. Rampinelli to G. Riccati, 9 June 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 143]: «Essa Signora ha notate le molte ciarle da me udite intorno all'Analisi, le ha di molto megliorate, ordinate, ed accresciute col proprio, e con la lettura de' Libri, in somma ne ha formato un corpo, che si può chiamare una compita istituzione d'Analisi. Il Padre di lei averebbe caro, che si pubblicasse quest'operetta; ma io e perché sono incapace, e perché in qualche modo ne ho picciola parte, non voglio darne giudicio; quindi mi faccio a pregar lei ed il Sig.r Conte Jacopo, acciò benignamente voglino prendersi la briga d'andar leggendo le scritture, che a parte a parte io le manderei, quando sento che sieno per farmi il favore, di cui supplico».

[14] M.G. Agnesi to J. Riccati, 20 July 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 145] «Fra le molte sovragrandi obbligazioni, che io professo al chiarissimo P. Don Ramiro Rampinelli, ascrivo l'onore che V.S. Ill.ma mi accorda di sottoporre all'occhio suo purgatissimo ed a quello del Sig.re Conte Giordano di lei degnissimo figlio, sotto titolo d'Instituzioni analitiche, quel tanto che la picciolezza del mio talento ha saputo approfittare, seguendo la scorta e direzione di sì gran Uomo nelle matematiche facoltà; con idea di facilitare, per quanto sia possibile, alla Gioventù uno studio per se stesso cotanto difficile e laborioso, riducendolo a quell'ordine e chiarezza di cui esso è capace, la qual cosa da veruno, ch'io sappia, non è stata per anco tentata di fare. Il punto sta ch'io vi sia, almeno tollerabilmente riuscita, quindi è che ricorro all'oracolo accertatissimo di V.S. Ill.ma, del di cui alto sapere e dottrina me ne assicura, non meno la pubblica fama, che l'autorevole testimonianza del P. Don Ramiro suddetto, con cui, oh quante volte! se n'è fatta degna ed onorevole commemoranza, non senza mia

The following day it was Rampinelli who sent Giordano Riccati the manuscript on Cartesian Algebra, with the entreaty to "encourage, correct, remove and supplement" as needed and "to examine everything with the utmost rigor".[15]

He trusted the judgment of the authoritative Count Jacopo Riccati because during his visits to the Count's house and in their correspondence, Jacopo Riccati had expressed critical judgments on a number of contemporaries' treatises on analysis, such as Bernard de Fontenelle's *Eléments de la géométrie de l'infini*, about which he wrote to Rampinelli with an ironic and misogynistic undertone:

> "You ask me first of all what judgment I have formed about the book by the renowned M. Fontenelle entitled 'Geometry of the Infinite'. My feeling on this point is not different from yours or from that of all the mathematicians in Europe. You should therefore know that as long as the learned M. Varignon was alive, this work did not see the light, as it never met with his approval, or with that of other Academicians who, no matter how much the author corrected and reformed his work, continued to find new fallacious arguments in it. After the death of Abbé Varignon, it was finally printed: but as it has met with the opposition of more than one person, word is about that a revised edition is being prepared; whether there will be a reduction or an increase in the errors I cannot say. Know also that M. Fontenelle's treatise is nothing more than a collection of lessons that he gave to several Lady Geometers who were disciples of his, and we can safely say that it is more suited to the weaker sex as it has all been woven out of pure fantasy, in which realm women better men as much as they are bettered in the realm of intellect."[16]

Giordano Riccati then reported the negative opinion circulating in his family concerning the first volume of *De' Calcoli differenziale e integrale Memorie Analitiche* (Analytical Memoirs on Differential and Integral Calculus) by Domenico Corradi d'Austria, which appeared in Modena in 1743:

> "Sig. Corradi has kindly sent as a gift to my Father the first part of his Memoirs on differential and integral calculus. I myself read a few pages of this work, but as I saw that he errs

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grande invidia verso chiunque ha il gran bene di trattarla e riverirla da vicino, ed ammirarne le eccelse doti. Supplico per tanto V.S. Ill.ma ad onorarmi della dotta sua critica e farmi nel tempo stesso la grazia di contraporre in margine la correzione, giacché il P. Rampinelli come mio troppo parziale, anzi come mio troppo modesto Precettore, ricusa di pronunciarne sentenza, e mi rimette all'infallibile disappassionata di lei decisione, consiglio ed ajuto.»

[15] R. Rampinelli to G. Riccati, 21 July 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 146]: «incitare, correggere, togliere, od aggiungere … ad esaminare ogni cosa con tutto il rigore».

[16] J. Riccati to R. Rampinelli, 16 August 1729 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1729, letter 10]: «Ella mi dimanda in primo luogo, che giudizio io formi intorno il Libro del celebre M.r Fontanelle intitolato la Geometria degl'Infiniti. Il mio sentimento su questo punto non è diverso dal suo, e da quello di tutti i Matematici dell'Europa. Dee dunque sapere, che sin a tanto che ha vissuto il dottissimo Sig.r Varignon, l'Opera non è uscita alla luce, perché non ha mai potuto meritare la sua approvazione, né quella degli altri Academici, i quali per quanto l'Autore l'andasse correggendo, e riformando, sempre scoprivano in essa nuovi paralogismi. Dopo la morte dell'Abate Varignon è stata finalmente stampata: ma avendo incontrate varie opposizioni, dicesi che se ne vada preparando una ristampa, in cui non so se sminuiransi, o si accresceranno gli errori. Sappia di più altro non essere il Trattato di M.r Fontanelle, che una raccolta di lezioni, ch'egli dettava a parecchie Dame Geometresse sue Discepole, e ben può dirsi, che fosse adattato al sesso più debole, veggendosi lavorato tutto a fior di Fantasia, in cui tanto le Donne superano gli Uomini, quanto sono superate nei pregi dell'intelletto.»

completely in his ideas, I quickly put the book to one side. It is a strange thing that the majority of geometers does not fully grasp these infinities and infinitesimals!"[17]

The first impression made by Agnesi's manuscript on the old count Jacopo Riccati was a very positive one, as we can see from the letter he sent to her dated 18 August 1745:

"… and I was amazed when casting my eye over an accomplished treatise on Cartesian analysis that a young lady could reach these heights in such delicate and abstruse matters. I am quite satisfied at having spent my hours of leisure and freedom from domestic affairs in such studies, as I now find myself granted the honor of giving my judgment, whatever it may be, on Your Ladyship's lofty endeavor. I will therefore fill the shoes of a critic completely against my inclination, and I will fill them in such a way that I may seem indiscreet: however I shall not withdraw into silence as I perform against my nature that which has been asked of me. This said, having skimmed over the whole work, I have apprehended that there is full little to be removed or added … In any case, the manuscripts will be passed into the hands of my son Count Giordano, and also of Father Vincenzo of the Company of Jesus, my other son and Lecturer in Mathematics at Bologna, who will a few days hence come to pass a number of days with us."[18]

Giordano Riccati was of the same opinion as his father and shared his thoughts with his friend Rampinelli on 19 August:

"We read the most learned writings with great avidity and found many reasons to admire the Lady's great intelligence, the accuracy of her method and the clarity of her explanations … In substance, I ask you to humbly defer to Her Ladyship and assure her, with utmost sincerity, that, having received the permission she so graciously bestowed upon my esteemed father and I, we will soon give her our respectful opinion."[19]

In September 1745 it was the turn of the manuscript on integral calculus to be sent and with it Rampinelli bore the news that Agnesi was rearranging the section on differential

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[17] G. Riccati to R. Rampinelli, 27 June 1743 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1743, letter 133]: «Il Sig.r Corradi ha spedita cortesemente in dono al Sig.r Padre la prima parte delle memorie sopra i calcoli differenziale, ed integrale. Ne ho letto anch'io qualche carta, ma conforme che ho veduto ch'egli sbaglia, totalmente nell'idea, così ho messo ben presto il libro da parte. Ella è una gran cosa che la maggior parte de' Geometri non capisce rettamente questi infiniti, ed infinitesimi!»

[18] J. Riccati to M.G.Agnesi, 18 August 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 147]: «ed io sono rimasto soprafatto nello scorrere un compiuto trattato di Analisi Cartesiana, che una giovine Dama poggi tant'alto in materie così delicate ed astruse. Io mi compiaccio d'aver impiegate le ore d'ozio e libere dalle cure domestiche in sì fatti studi perché mi veggio impartito l'onore di dare il mio giudizio, qualunque si possa essere, sopra le di Lei sublimi produzioni. Vestirò dunque la persona di critico onninamente aliena dalla mia inclinazione, e la vestirò in modo tale che comparirò forse indiscreto: né mi ritiro tutta via taccia, eseguendo contro mio genio ciò che mi vien comandato. Sebbene, avendo letta alla sfuggita l'opera intiera, comprendo che pochissimo ci è da levare, o da aggiugnere…. Non ostante ciò passeranno per mano del Conte Giordano mio figlio, ed anco del P. Vincenzo della Compagnia di Gesù, altro mio figliuolo e Lettore di Matematica in Bologna, il quale fra pochi giorni se ne verrà a stare parecchi giorni con esso noi.»

[19] G. Riccati to R. Rampinelli, 19 August 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 148]: «Abbiamo scorso con avidità le dottissime scritture, ritrovando per tutto motivi di ammirare l'ingegno grande della Dama, l'esattezza del metodo, e la chiarezza della dettatura. … In somma Ella inchini divotamente la Sig.ra Contessa e l'assicuri, che con tutta sincerità, stante la licenza da essa benignamente permessaci, il Sig.r Padre ed io, le indicheremo la rispettosa nostra opinione.»

calculus.[20] The proof of this is found in the letter written by Maria Gaetana to Jacopo Riccati requesting some clarification on the explanation of maxima and minima, as she could not call directly on her tutor who was at that time in Brescia. Before returning to Milan, Rampinelli renewed his solicitation to the Riccatis to be severe in their judgment and painstaking in their corrections, given the author's intention to go to print:

> "I would not wish to press you in any way, but for our greater ease, if you have by chance already made a full examination of the writings on Cartesian Algebra produced by Her Ladyship the Countess Donna Maria, I would be very pleased to have them before the Feast of All Saints so that I may bring them with me to Milan … I beg you anew to express your sentiments in all freedom, and if you have trouble explaining yourself directly to the Lady you may do so to me because, as the aforementioned Lady's father means to print the work, it is a very peculiar matter."[21]

On 13 April 1746, he informed Riccati that "the aforementioned Lady has almost ready the part on Differential Calculus and the Inverse Tangent Method" and on 12 May Giordano Riccati repeated his praise for the clarity, rigor and method shown in the work, as well as expressing his regret that he could not dedicate himself more fully to the matter, for which reason he had forwarded the letter to his brother Vincenzo Riccati in the hope of obtaining his help:

> "I can assure you in all sincerity that my esteemed father's sentiment and my own is that the manuscripts are more than worthy of seeing the light of publication, as throughout the work are found truth, method and admirable clarity. My excellent father examined the work on Integral Calculus, and he will very shortly finish drafting some notes he deems necessary … As I was unable to meditate on the contents of your letter … I sent it to my brother, Father Vincenzo, who, upon thinking it over, found that the issue was much more complicated than he first thought."[22]

Well aware of the difficulties that would have to be faced in order to print the work, and hinting at the responsibility he felt resting on his shoulders, on 25 May 1746, Rampinelli again pressed Giordano Riccati and his family to be sincere when expressing their opinions:

> "Her Ladyship the Countess Donna Maria and I most heartily thank you and his Lordship Count Jacopo for this kind favour you are both performing for us by examining and expressing your observations about the many writings, which in all truth, being so voluminous, must be causing

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[20] R. Rampinelli to G. Riccati, 12 September 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 149].

[21] R. Rampinelli to G. Riccati, 7 October 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 152]: «Non per farle alcuna premura, ma per maggior comodo, se ella avesse di già pienamente esaminate le scritture d'Algebra Cartesiana della Sig.ra Contessa Donna Maria, averei molto caro di averle prima de' Santi, per poterle meco portare a Milano. … Nuovamente la prego a dire con tutta la libertà il suo sentimento, e quando avesse difficoltà a spiegarsi con la Sig.ra, lo può far meco perché pensando il Padre della suddetta Sig.ra di farne la stampa, la cosa è molto gelosa.»

[22] G. Riccati to R. Rampinelli, 12 May 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 155]: «Posso assicurarla con tutta sincerità essere sentimento del Sig.r Padre e mio, esser esse degne degnissime della pubblica luce, trovandovisi da per tutto e verità, e metodo, e chiarezza ammirabile. Il Sig.r Padre ha esaminato il Calcolo integrale, e quanto prima terminerà di estendere alcune avvertenze che giudica necessarie … Non potendo meditare sopra il contenuto della sua lettera … l'ho spedita al Padre Vincenzo mio Fratello, il quale pensandovi sopra ha trovato la facenda più imbrogliata di quello a principio pensava.»

you no little bother. When you have completed this favor, I beg you to please safely enclose the manuscripts and have them handed over to the Venice post, with my address on them, but protected in every possible way so that they may not become lost, and if you opine that it would be judicious to pay the carriage and everything else in Venice and send them franked, please do so. Of course you will then let me know the expenses incurred. And if you, or Count Jacopo, see fit to pen a few lines expressing your opinion about printing them I should be most obliged, as this would permit me to authenticate what the Lady shall hear from my lips; however, I also beg you to write separately to me and express your candid and sincere opinion, as the undertaking to print the work is such a delicate one. I shall remain alert for the opportunity to send you the rest of the work; in it you shall see the notoriously tricky case of tangents perhaps explained with somewhat more clarity than is found in Paris memoirs, which may allow you to better grasp and overcome the difficulty I wrote to you about some time ago and which I shall also dedicate some thought to, although my head is so full of calculations that there is scarcely room for more."[23]

At the end of June, Rampinelli informed Giordano Riccati that the manuscript on differential calculus and the inverse tangent method had been sent.[24] A missive was returned from Castelfranco in which Giordano Riccati again expressed his praise and promised to shortly send his notes on the Cartesian algebra section. The letter was dated 15 July 1746:

"I shall make sure to forward Cartesian Analysis to you with all haste, together with a number of notes of little import dictated not by any real necessity but simply for your and the Lady's service. Thus may Her Ladyship go ahead with publication and do credit to her sex through a work that will show her wonderful talent."[25]

Again on 4 August he underlined his opinion that the work would do credit to the Italian nation:

"As soon I had the opportunity, I cast my eye over the geometric foundations upon which my esteemed patron the Countess has established the differential calculus. These could be neither more correct nor more precise. I find all the writings of the praiseworthy Lady overflowing with

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[23] R. Rampinelli to G. Riccati, 25 May 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 156]: «La Sig.ra Contessa Donna Maria, ed io sommamente la ringraziamo unitamente al Sig.r Conte Jacopo del gentilissimo favore, che ci fanno in esaminare, e far le loro osservazioni intorno alle molte Scritture, le quali per verità, essendo voluminose, loro devono portare non picciol noja. Quando ella abbia compito il favore, la prego di volerle in un involto ben custodito e difeso far consegnare alla posta in Venezia e a me dirette, ma raccomandate nella miglior maniera, acciò non abbiano a perdersi, e se giudica buona cautela il far pagare il porto, ed ogni cosa in Venezia, e spedirle franche, lo faccia. E pure dandomi poi avviso della spesa. E se ella, o il Sig.r Conte Jacopo vorranno accompagnarle con poche righe, che esprimano il loro giudicio circa lo stamparle, mi sarà carissimo, per autenticare così ciò, che la suddetta Sig.ra sentirà da me in voce; ma la prego altresì di volere a parte scrivere a me il loro sentimento schietto e sincero, perché l'impegno della stampa è troppo delicato. Starò in attenzione di qualche congiontura per mandarle il resto della intera Opera; in essa vedrà il noto particolare caso delle tangenti messo forse con qualche maggior chiarezza di quello sia nelle memorie di Parigi, e così potrà meglio rilevare e levare la difficoltà, che le scrissi tempo fa, sopra cui io pure procurerò di pensarvi; ma ho così piena la testa di calcoli, che non ne posso più.»

[24] R. Rampinelli to G. Riccati, 29 June 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 158].

[25] G. Riccati to R. Rampinelli, 15 July 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 159]: «L'Analisi Cartesiana procurerò di quanto prima spedirgliela, unitamente con alcune avvertenze di poco rilievo dettate non perché ce ne fosse bisogno ma unicamente per servire la Dama e Lei. Così la Sig.ra Contessa potrà intraprenderne la stampa e fare onore al sesso con un'opera che farà vedere il suo maraviglioso talento.»

the same characteristics and it would be well for her not to deprive the public of a work that would do credit to our Italy."[26]

On 23 August 1746, Agnesi begged Count Jacopo Riccati to send her his comments, as she was shortly to leave for her summer vacation:

"… I have a great fear that these writings may arrive at a time when I am absent from Milan and could therefore be lost … which, as you can imagine, would be a great affliction for me. I am most sorry to have to bother your Lordship in this way, but as your Lordship has been so good as to assist me I hope that he will pardon my impertinence given my reasons above, especially as for me it is enough to have those that you have already perused, which I shall endeavor to read during my vacation in order to profit from your most learned teachings. Meanwhile I shall make ready to print the work, which task I intend to begin at the end of the vacation, while your Lordship may peruse the remaining pages at leisure and then send them after granting me the honor of making your wise observations upon them, together with those of your excellent son, Giordano."[27]

At the beginning of October, Agnesi thanked him for his comments on the section regarding integral calculus[28] and asked for the notes written by Giordano Riccati on Cartesian algebra:

"I cannot find words enough with which to thank your Lordship for the graciousness with which you have borne my feeble attempts, and for the goodness with which you have considered them, and for the notes you have made that are truly worthy of your great knowledge and learning.

I must ask you to pass on my most particular thanks to the excellent Count Giordano for the trouble he endured over Cartesian Algebra and, since you tell me that he has already examined your most worthy comments, I make bold to ask you (as long as it is not excessively troublesome) if you could pass them on to Father Rampinelli before All Saints', because, as he has to leave Brescia for Milan at that time, they will be safer; furthermore, having your gracious approval, once the vacation is over I may start printing the work."[29]

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[26] G. Riccati to R. Rampinelli, 4 August 1746 [Mazzone, Roero, Luciano 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 160]: «Appena capitatomi ho data subito un'occhiata ai fondamenti geometrici su i quali la Sig.ra Contessa mia Riverita Padrona stabilisce il calcolo differenziale. Non ponno questi essere né più giusti né più precisi. Io trovo gli scritti tutti della lodata Dama ricolmi delle stesse prerogative ed è ben di dovere, che essa non defraudi il pubblico di un'Opera che ha da far onore alla nostra Italia.»

[27] M.G. Agnesi to J. Riccati, 23 August 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 161]: «temendo io sommamente che le dette scritture, quando arrivassero in tempo, in cui io sia assente da Milano potessero andare perdute … la qual cosa ella può immaginarsi quanto mi sarebbe di pena. Spiacemi sommamente di dover recare a V.S. Ill.ma questo incomodo, ma giacché ha avuta tanta bontà per favorirmi spero che mi averà per iscusata a cagione del motivo addotto, tanto più che mi basta di avere quelle che, come diceva, ella avrà già in pronto, le quali anderò leggendo nel tempo della villeggiatura e mi approfitterò nello stesso tempo de' dottissimi di lei insegnamenti, disponendomi fra tanto alla stampa, a cui ho intenzione di dare principio passate le vacanze, mentre V.S. Ill.ma avrà il comodo di vedere il rimanente e poscia di trasmettermelo quando mi abbia continovate le sue grazie al farvi sopra le saviissime sue riflessioni unite a quelle del Sig.r Conte Giordano di lei stimatissimo figlio …

[28] J. RICCATI, *Annotations* to Agnesi's *Instituzioni*, Tomo 2, Libro 3, *Del Calcolo Integrale*, [Mazzone, Roero, Luciano, 2010, letter 164a].

[29] M.G. Agnesi to J. Riccati, 1 October 1746 [Mazzone, Roero, Luciano 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 164]: «Non ho bastanti espressioni con cui rendere a V.S. Ill.ma le grazie per la benignità, con cui ha voluto compatire le debolissime mie fatiche, e per la bontà con cui le ha considerate, e vi ha fatte le dottissime annotazioni veramente degne

Jacopo and Giordano Riccati's annotations on Cartesian algebra arrived early in December of 1746[30] and were received with enthusiasm and gratitude by Agnesi and Rampinelli, who started preparing to print the book straight away:

> "In consideration of the kind indulgence and all too fine expressions his Lordship Count Jacopo and your good self have made on my feeble efforts, I am now making so bold as to have the book printed, sure that the work will be well received after its being granted the honor of being scrutinised by your sharp eye… I am with great pleasure looking over the notes that are truly worthy of your great knowledge and shall make all possible use of them, bearing in mind the order of these comments as some of them cannot be inserted in the places mentioned because the reader cannot be supposed to be informed of the methods that your Lordship's great learning allows you to use in such circumstances."[31]

In the letters written in 1747 and 1748, alongside requests for clarification on specific points in the explanations we find information about the stage of preparation for publication at the Agnesi residence and the question of whether she should include Jacopo Riccati's polynomial method, citing him as its creator:

> "Her Ladyship the Countess Donna Maria is not of the opinion to expound Count Jacopo's integration method, which I already have knowledge of, his Lordship having informed me of it some time ago. The good Lady's reason for this is that, as this method has until now not been published in any book, at least as far as I am aware, she would gain credit for it and be acknowledged as its author unless she named as author his Lordship Count Jacopo, which she does not dare without his permission; I pray you to ask it of him."[32]

The notes on differential calculus were sent in the late spring of 1748. On 10 May, Jacopo Riccati accompanied his sheaf of notes with a reminder of the importance of the

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dell'alto suo sapere e dottrina; … La prego di rendere a mio nome le grazie più distinte al Sig.r Conte Giordano per l'incomodo che si è preso in ordine all'Algebra Cartesiana e giacchè ella mi dice che egli ha già esaminato le degnissime sue annotazioni vorrei inoltrarmi a pregarla (quando non le fosse di soverchio incomodo) di farle avere al P. Rampinelli prima de' Santi, perché dovendo egli per quel tempo partire da Brescia per Milano, saranno più sicure, ed in oltre, attesa la di lei favorevole approvazione, potrei, passate le vacanze, dare principio alla stampa.»

[30] G. and J. RICCATI, *Annotations* to Agnesi's draft of *Instituzioni*, book *Dell'Analisi delle Quantità finite*, [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 166a].

[31] M.G. Agnesi to G. Riccati, 12 December 1746 [Mazzone, Roero, Luciano 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 166]: «Atteso il benigno compatimento, e le troppo fini espressioni del Sig.r Conte Jacopo e di V.S. Ill.ma, riguardo alle mie debolissime fatiche, mi faccio coraggio d'intraprendere la stampa del primo libro sicura del comune aggradimento dell'opera dopo che questa ha avuto l'onore di essere sottoposta all'occhio loro purgatissimo; … Io sto vedendo con grandissimo piacere le note veramente degne dell'altissimo di lei sapere e ne farò tutto quell'uso che mi sarà possibile, avuto riguardo all'ordine di esse instituzioni, non potendosi alcuna cosa inserirsi in que' luoghi, che vengono citati, perché il leggitore non si suppone per anco informato di que' metodi, che da V.S. Ill.ma in tali circostanze, da par suo, si adoperano.»

[32] R. Rampinelli to G. Riccati, 18 January 1747 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1747, letter 169]: «La Sig.ra Contessa D. Maria non vorrebbe porre il metodo per l'integrazione de' Polinomj del Sig.re Conte Jacopo, il quale era già a mia notizia, perché da lui communicatomi molto tempo fa. La ragione della suddetta Sig.ra è, che non essendo questo metodo in libro alcuno pubblicato, almeno per quanto io sappia, verrebbe così ad arrogarselo, ed a farsene Autrice, quando non nominasse per Autore il Sig.re Conte Jacopo, la qual cosa stima di non dover fare senza di lui licenza, sopra di che è pregata interrogarlo.» Riccati's method for polynomials was then added to Agnesi's *Instituzioni* [Agnesi, 1748, 693-700].

comparison between infinitesimals to which he had dedicated the first four of his long *Annotazioni*[33] and prepared himself for the final effort:

> "Here I am with my fatuous annotations on the learned writings of Your Ladyship, my esteemed patron. There are but few, as there was no need for a greater number; however I have written at some length about the nature and use of the first and subsequent differentials, so that the reader may form a clear and candid idea about them. I will be well satisfied with this work if I manage to earn Your Ladyship's kind indulgence for it. Then I must humbly beg for forgiveness for my great tardiness … I shall set myself to studying the inverse tangent method without delay and I hope to get through it in a short time; I have already observed from a superficial reading from beginning to end that there should be little to note, although, as oft happens, it may be that when working more closely on it some matters will emerge."[34]

The promise to send the comments on the methods for solving differential equations – the subject of the fourth book of Agnesi's *Instituzioni* – was kept (albeit after a little pressing). The letters, dated 19 and 21 August 1748, show the enthusiastic expressions used by Agnesi to thank Jacopo Riccati and to voice her hope that she would continue to receive his epistles, while Rampinelli apologized to Giordano Riccati for the heavy burden placed on his and his father's shoulders:

> "I have received the last part of my *Instituzioni* illustrated by your Lordship's wise observations, certainly worthy of your great mind, to which my work owes any merit it will earn with scholars thanks to these comments. Therefore I will not fail to profit from them immediately … I feel great shame at having troubled your Lordship when so busy with domestic matters and literary occupations, so much so that I can find no words corresponding to my inner feelings of gratitude with which to properly express my thanks. Oh how obliged I shall be to you if you will do me the honor of informing me of your discoveries! Oh how I long to see complete your work on the principles and methods of Physics! How much profit and pleasure I will derive from it! And how much the Republic of litters will gain! If only I were able to return your kindness with some support of my own, worthy of your consideration, but I am deserving only to grovel on the ground and place my little matters before your Lordship's superior understanding with the sole purpose of gaining illumination and improvement."[35]

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[33] J. RICCATI, *Annotations* to Agnesi's manuscript *Instituzioni*, *Del Calcolo Differenziale* [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 186a]. These notes were inserted in work, with little modifications [Agnesi, 1748, 434-442 and 456-457].

[34] J. Riccati to M.G. Agnesi, 10 May 1748 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 183]: «Eccomi colle mie insulse annotazioni sopra i dottissimi scritti della Sig.ra Contessa mia riveritissima Padrona. Esse sono poche perché non ce n'era bisogno di maggior numero; mi sono però esteso alquanto sulla natura e sull'uso delle prime ed ulteriori differenze, onde il lettore potesse formarsene una distinta e sincera idea e crederò d'aver fatto assai se mi riuscirà di guadagnarmi il di Lei benigno compatimento. Deggio poi chiedere umilmente perdono della mia lunga tardanza …. Darò subito dietro al metodo inverso delle tangenti e spero in breve di venirne a capo; avvegna che avendolo scorso dal principio al fine, osservo che ci è poco da dire: se pure, siccome accade, nel lavorarci sopra non mi si presenterà qualche vista.»

[35] M.G. Agnesi to J. Riccati, 19 August 1748 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 188]: «Ho ricevuto l'ultima parte delle mie Istituzioni illustrata dalle dottissime annotazioni di V.S. Ill.ma degne certamente della di Lei gran mente, alle quali l'opera mia deve tutto quel pregio, che è per acquistare a cagione di esse presso gli Intendenti; onde non mancherò di approfittarmene subito… Provo sommo rossore del grande incomodo recato a V.S. Ill.ma fra le molte domestiche, e letterarie sue occupazioni, e tanto più che non ho espressione che corrisponda alla interna mia riconoscenza per degnamente ringraziarla. Oh quanto le sarò obbligata se mi farà l'onore di comunicarmi le sue scoperte! Oh quanto sospiro di veder compiuta l'Opera sua intorno ai principj e metodi della

> "I offer my utmost thanks to you and to Count Jacopo for the goodness and trouble you have had over this long and most bothersome matter of looking over so much stuff, and I redouble my thanks knowing that I have been the cause of your trouble and bother."[36]

4. *Progress and Completion*

From the dialogue that emerges in this exchange of correspondence, we can glean some features of Agnesi's style of reasoning and her character. The young woman was not only a diligent student able to work out problems and exercises correctly, but also the possessor of critical faculties regarding the rigor required in mathematical demonstrations. As proof of this we can examine her observations on the study of the cubic equation in the problem of the trisection of the angle written by Giuseppe Suzzi in 1747, about which Agnesi expresses her perplexities in letters from January, February and March 1748.[37] Giordano Riccati had suggested to her to include Suzzi's method in her text, but following the young woman's demonstration of the presence of errors and vicious circles in this method, Jacopo Riccati was led to concur that it should not be inserted.[38] Agnesi did not passively accept advice, but rather ascertained whether it was fitting or not, and also expressed the doubts and thoughts that arose from the methods and erroneous applications of other authors. In her letters there often appears a clear awareness of the precise logical procedures to follow and the objective she was trying to achieve: a clear, simple explanation that would help beginners and young pupils, even those without a particular gift for the subject. Having paid attention right from her adolescence to her siblings' education and to the difficulties and particular needs of young girls with disabilities, Agnesi had the happy gift of being able to identify obstacles and facilitate learning [Frisi, 1799, 81, 92].

Her *Instituzioni analitiche* was not aimed at a readership formed of expert mathematicians. This adds meaning to the fact that the author neither, as was the custom at the time, focused heavily on all her original deductions and results obtained, nor included examples of curves linked to problems in mathematical physics, a burning topic of the day. This indicates her awareness that these problems would require other principles and methods, while her main aim was to teach analysis and its application to geometry:

> "concerning the quadrature of various curved lines your Lordship mentioned, in truth I had not considered many of these, but those that depend on a knowledge of physical matters I deliberately left alone because, as your Lordship noted, I did not wish to embroil myself in

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Fisica!, quale sarà il profitto e piacere mio!, quale ne risulterà vantaggio alla Repubblica letteraria! Così fossi io capace di corrisponderle con alcuna cosa mia, che fosse degna di Lei; ma io non posso che rader terra, e sottoporre le piccole cose mie al superiore intendimento di V.S. Ill.ma a solo fine di trarne lume e profitto.»

[36] R. Rampinelli to G. Riccati, 21 August 1748 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 189]: «Io rendo al Sig.re Conte Jacopo, ed a lei somma grazia della bontà e sofferenza, che hanno avuto in questo lunghissimo, e nojoso affare di esaminare tanta robba, e molto più le rendo grazie perché io sono stato la causa del loro incomodo e disturbo.»

[37] Cf. M.G. Agnesi to J. Riccati, 31 January 1748, 28 February 1748 and 20 March 1748, [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letters 177, 178 and 179].

[38] J. Riccati to M.G.Agnesi, 10 May 1748 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 183].

questions of physics; therefore I ignored all the problems related to that subject in order not to extend the work beyond pure Analysis and its applications in geometry."[39]

Nonetheless, from the exchange of letters we can perceive a hint of her desire to broaden her horizons and study works that had recently been published, such as Leonhard Euler's *Introductio in Analysin Infinitorum* and the articles by Vincenzo Riccati and Gabriele Manfredi published in the *Commentarii* of the Bologna academy of sciences. As she was unable to consult these works, Agnesi proposed inserting a final note inviting her readers to approach these areas of advanced research:

"Lastly, as I myself did not manage to make use of the dissertations written by your most worthy son Father Vincenzo and Mr. Manfredi in time, I hold that it is my duty to add the following note at the end: «The method in n°. 47 discovered some time ago by Count Jacopo Riccati was known to me before now, while the extension of it found here above, as well as the second inverse problem of the osculating radii I have only now apprehended, upon being able to consult the second volume of *Commentarii* from the Bologna Institute. It is certainly too late for me as, finding myself as I do at the end of my labours, I am no longer able to avail myself of other learned dissertations by both Father Vincenzo Riccati, son of the aforementioned Count Jacopo, and Mr. Gabriello Manfredi published therein. Moreover I have been unable to profit from the doctrines and insights, which must surely be many, in the analytical work of Mr. Leonhard Euler, which, it has come to my knowledge, has recently been placed before the public, but I have not yet had the good fortune to peruse. I hope it may be sufficient to have directed the Reader towards these works for him to profit from them.»"[40]

The library Agnesi had at her disposition was rather well-stocked [Mazzotti, 2007, 93-104] and she had the ability to select the most appropriate examples from each author to refine the more difficult concepts, adding her own personal remarks. Fitting proof of this is Sylvestre F. Lacroix's comment on the order of infinitesimals, where he underlined that "In Miss Agnesi's treatise on Differential Calculus, this ordering is based on quite satisfactory geometrical reasoning" [Lacroix, 1810, 1, §258, 489].

5. *Further Stimuli and Conclusions*

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[39] M.G. Agnesi to J. Riccati, 1 October 1746 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1746, letter 164]: «riguardo alle quadrature di varie curve da V.S. Ill.ma accennate, a molte di esse veramente non ho pensato, ma quelle che dipendono dalla cognizione delle cose fisiche le ho lasciate a bella posta, perché come V.S. Ill.ma ha veduto, non ho voluto impegnarmi in cose fisiche ed ho lasciati tutti quei Problemi che da esse dipendono per non estendermi oltre la pura Analisi e l'applicazione di essa alla geometria.»

[40] M.G. Agnesi to J. Riccati, 4 September 1748 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1748, letter 190]: «Finalmente non essendo io stata in tempo di fare uso delle disertazioni del P. Vincenzo di Lei degnissimo Figlio e del Sig.r Manfredi stimo mio dovere l'aggiungere in fine la seguente avvertenza: «Il metodo del n° 47 ritrovato già tempo fa dal Sig.r Conte Jacopo Riccati prima d'ora mi era noto, ma la qui sopra scritta estensione, siccome il problema secondo inverso de' raggi osculatori ora solamente gli ho appresi che mi è capitato il secondo tomo de' Commentarj dell'Instituto di Bologna, e certamente troppo tardi per me, poiché ritrovandomi al fine dell'impressione di questa mia fatica non sono più in tempo di prevalermi d'altre dottissime disertazioni e del P. Vincenzo Riccati Figlio del suddetto Sig.r Conte Jacopo, e del Sig.r Gabriello Manfredi ivi inserite. Così non ho potuto far uso delle dottrine e lumi che certamente saranno moltissimi nell'opera analitica del Sig.r Leonardo Eulero, che, per quanto mi vien riferito, poco fa è arrivata al pubblico, ma che io non ho ancora avuta la sorte di vedere. Basterà adunque l'aver indicati al Lettore questi luoghi, acciò voglia trarne profitto.» This note will be published in her work [Agnesi, 1748, 1018].

Some of the observations contained in Agnesi's correspondence and work were incitements to other mathematicians to further study certain problem areas. For this reason, the mathematicians of the Riccati family dedicated a number of studies to her and cited her remarks. Vincenzo Riccati's writings on the indeterminate forms of differentials and on the way to separate variables in first-order differential equations took inspiration from some observations of Agnesi's sent to him by his brother Giordano Riccati [41] while others derived from the general method published in the fourth book of her *Instituzioni* [Agnesi, 1748, 887-890], which he considered to be worthy of note for its elegance of style [Riccati, V., 1762, 21-22]. The same method was to be appreciated also by J. Hellins in his preface to the English version of Agnesi's work, edited by John Colson [Colson, 1801, IX-X].

In 1751, Jacopo and Giordano Riccati came back to the problem of trisecting the angle, which had been broached in the first book of Agnesi's *Institutions* [Agnesi, 1748, 339-350] and had also been the subject of their Annotations on her Cartesian algebra section, sent to her in the winter of 1746.[42] The results of their analysis on this problem would only be published in 1780, in the form of a collection of letters addressed to Agnesi.[43] This homage was paid above all to the author of the most successful treatise on analysis of the first half of the century in Italy, one which even caused a stir abroad, as reviews and announcements appearing in various journals testify [*Journal des sçavans*, May 1750, 309-310; *Acta Eruditorum* 1750; *Giornale de' Letterati pubblicato in Firenze*, VI, 1, 1750, 7-22].

To conclude this illustration of the events that saw Agnesi at the centre of a lively exchange of scientific ideas that developed in the Lombardy and the Veneto in the years 1745-1753, I would like to draw the reader's attention to a few of the features that emerge from the epistolary exchange between Agnesi, Rampinelli and the Riccatis, in my view the most interesting.

The extraordinary intellectual fellowship that was formed with the aristocratic family from Castelfranco in order to enhance the composition of the *Instituzioni* can be compared with the 'singular pact' stipulated between the Marquis G.F. de l'Hôpital and Johann Bernoulli in Paris in 1691 that gave rise to the successful work *Analyse des infiniment petits* (1696). In this case as in ours, the intense exchange of letters between the two mathematicians served to clarify doubts, suggest examples, supply comments and dispense advice that enriched and improved the work [Spiess, 1955, 173, 187, 199, 226 and 235].

As an example we need look no further than the 'de l'Hôpital' rule on indeterminate forms expounded in art. 163 of the *Analyse* [L'Hôpital, 1696, 145-146], which in reality was the brainchild of Johann Bernoulli, as can be seen in the letter of 22 July 1694 he sent to the Marquis [Spiess, 1955, 235-236]. The only clear difference between these two events was the fact that the Riccatis made a free gift of their annotations to Agnesi's manuscript, while de l'Hôpital shelled out considerable sums to receive lessons from the Swiss mathematician. In

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[41] V. Riccati to G. Riccati, 26 September 1752 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1752, letter 215a]; G. Riccati to R. Rampinelli, 6 October 1752 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1752, letter 215]; G. Riccati to R. Rampinelli, 10 November 1752 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1752, letter 218].

[42] See note 30 above.

[43] Riccati, J., Riccati, G., 1780; Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1751, letters 210-211-212a, 210-211-212b]

all other areas we can find similarities in the behavior of the elderly Marquis and that of his young student, in particular in their organization of the materials and the clear explanations of concepts and methods based on specific examples. This *modus operandi* became a characteristic of analysis textbooks in the 18th century.

Agnesi's independence of thought and judgment is notable; although she assessed and often approved others' comments and clarifications, she displayed resoluteness, determination and constancy in her organization of the material, in her selection of the most appropriate examples, in her ability to glide over thorny and as yet unresolved questions, in her attempt to find methods suited for beginners, her desire for clarity, rigor and precision and lastly her great intellectual honesty. Agnesi explicitly acknowledged the merits and results of others in her treatise and often stated what sources she had consulted taking care to acknowledge the paternity of the methods, in accordance with the suggestions made by Riccatis in their letters. Being self-taught, she was aware of the difficulties encountered in the books and articles in circulation at the time, because of their often complex and obscure style, their lack of concrete demonstrations and their excessive heaping together of information of little use for students. This led Agnesi to adopt a clear, simple style and to write the work in Italian rather than Latin. What is more Italian had been the language chosen by Galilei to diffuse his results and by editors of the *Giornale de' Letterati d'Italia* and of the *Opuscoli scientifici e filologici*, current in public libraries and academies [Roero, 2011; Roero 2012, 72-75].

Her simple yet elegant style of writing won her the appreciation of her teachers and also of numerous Italian and foreign contemporaries.[44]

Giordano Riccati wrote the following to his friend Rampinelli on 6 October 1752:

> "Her *Instituzioni analitiche* is now found in the hands of everyone, and the young now learn Algebra by studying the work of Her Ladyship Countess Agnesi."[45]

One of the most illustrious names to use the *Instituzioni analitiche ad uso della gioventù italiana* was that of Giuseppe Luigi Lagrange (1736-1813), who mentioned it in his correspondence with Giulio Carlo Fagnani [Fagnani, 3, 1912, 203-204; Roero, 2008, 21] and also used it in 1755 in his lessons on Analysis given at the Academy of Artillery and Military Engineering in Turin [Borgato, 1987, 154, 177 and 187].

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[44] See R. Rampinelli to G. Riccati, 2 December 1749 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1749, letter 195]. In Milan, Ambrosiana Library, see also the sheaf of manuscripts entitled *Lettere Italiane, Latine, Greche e Francesi di Donna Maria Gaetana Agnesi e di varj Illustri suoi Corrispondenti. Estratto dei Registri dell'Accademia Reale delle Scienze di Parigi del 6 Dicembre 1749 sul merito delle Instituzioni Analitiche della prelodata Donna Maria Gaetana Agnesi*. Among the letters of congratulations and thanks we can mention those by Laura Bassi (Bologna 18 June 1749, f. 10r-v), Jacopo Bartolomeo Beccari (Bologna, 18 June 1749, f. 12r), Francesco Maria Zanotti (Bologna 18 June 1749, ff. 14r-15v), Vincenzo Riccati (Bologna 28 June 1749, f. 16r-v), Giovanni Poleni (Padua 5 July 1749, f. 22r-v), François Jacquier (Rome 13 July 1749, f. 88r-v) and Flaminio Scarselli (Rome 25 November 1750, f. 59r). In the same manuscript, beside the letters of congratulations sent by various French scholars (ff. 108r-118r) , we find the *Extrait des Registres de l'Académie Royale des Sciences du 6.e Décembre 1749* (ff. 106r-107v) in which J.J. Dortous de Mairan and E.M. de Montigny present a report of Agnesi's work, rich of praises and positive remarks. Lastly, we must not forget the letter of praise sent by Pope Benedict XIV on 21 June 1749 (Milan, Ambrosiana Library, ms. O 202 sup., c. 2r-v) published in Frisi, 1799, 53-54 and reprint in Masotti, 1940, 108-109.

[45] G. Riccati to R. Rampinelli, 6 October 1752 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1752, letter 215].

Moreover, Agnesi's work was so well received in France and Great Britain that versions in French and English were made and the book was printed in Paris 'under the privilege' of the Académie Royale des Sciences in 1775.[46] A French translation was prepared by da Pierre Thomas Antelmy (1730-1783), under the guidance of Charles Bossut. It was related to books II, III and IV dedicated to the differential and integral calculus and did not include Cartesian algebra, widely known in France. An English version, edited by John Colson (1680-1760) and revised by John Hellins, was published posthumously in two volumes in London in 1801, with the financial support of baron Francis Maseres.

For all these reasons, the opinions of Gino Loria and Clifford Truesdell on Agnesi's mathematical skills and the importance of her work are too severe and also limited to a simple identification of new and original results. The following statement made by Loria is particularly flawed:

> "But at the time when the praise and encouragement … should have spurred her on to walk the path she had laid out for herself, it was a painful surprise to see her set down the studies she had held so dear and dedicate all her time and energy to religious practices and works of charity … Let us only observe how … the fate of Gaetana Agnesi appears similar to the destiny of the unlucky mountain climber who believes he has reached his longed-for goal, but when he looks anxiously around him finds that he is separated from it by an enormous abyss, which makes him lose all hope of going higher; in that moment he realizes – with useless and all-too-late regret – that another easier, shorter and hazardless road would have surely led him to the top."[47]

Life choices similar to that made by Maria Gaetana Agnesi after her father's death in 1752 were made by other famous mathematicians, for example Blaise Pascal, to whom Loria failed to attach similar blame for having abandoned his studies and scientific research.

The example cited by Truesdell to prove that Agnesi was an amateur, *i.e.* her quizzing Riccati about the study of extremal points, should be viewed given the background of that time and also compared with the similar questions put to Johann Bernoulli by de l'Hôpital [Spiess, 1955, 195-197, 203-207 and 214-226]. If we look carefully, we can see that on this matter Agnesi asked specifically about Nicomedes' conchoid, a curve presenting maximum, minimum, flexion, cusps and double points, presentations of which were hard to come by in the texts available at that time and scattered here and there, as Rampinelli wrote to Giordano Riccati on 20 January 1745.[48]

The fact that Agnesi failed to include applications to rational mechanics and mathematical physics – the subject of the most advanced research of her day – should be viewed in relation to her purpose (as mentioned above) and her desire not to overlap with her tutor's production of didactic materials: he had been busy for years writing introductory texts

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[46] The mathematicians who delivered their report to the Paris Académie on 30 August 1775 were J. d'Alembert, M.J. Condorcet and A.T. Vandermonde. The report is printed in [Frisi, 1799, Table VIII].

[47] Loria, 1936, 453-455: «Ma nell'ora appunto in cui gli elogi e incoraggiamenti … dovevano spronarla a percorrere la strada che essa stessa aveva spianata, con dolorosa sorpresa la si vide porre in disparte gli studi già caramente diletti e consacrare tutto il suo tempo e tutta la sua attività a pratiche religiose ed opere di carità. … Osserviamo soltanto come … la sorte di Gaetana Agnesi appaia simile al destino dell'alpinista disgraziato che giunto tutto intriso di sangue, estenuato, palpitante al termine di una pericolosa ascensione, crede di avere raggiunta la sospirata mèta; ma, girando attorno ansiosamente lo sguardo, se ne trova invece separato da un abisso profondo, che gli fa perdere la speranza dell'altezza; e riconosce, con tardivo e sterile rimpianto, come un'altra strada più comoda, più breve e scevra di pericoli avrebbe potuto guidarlo sicuramente a raggiungerla».

[48] R. Rampinelli to G. Riccati, 20 January 1745 [Mazzone, Roero, Luciano, 2010, http://bibdig.museogalileo.it/Teca/Viewer?an=000000990843, 1745, letter 141].

on mechanics and hydrostatics for his pupils, works in which he made use of analytical methods, as can be seen from some of his unpublished manuscripts conserved in Padua and Udine, and from his correspondence with Riccati. The same attitude was behind the note Agnesi placed at the end of her work, which in my opinion should be interpreted as advice to young scholars of analysis to study the 'artifices' used

> "by famous mathematicians in the problems of the Elastic curves, the Catenaries, the Velaria, in that of Isoperimetric Curves and in others of this kind … in order to acquire such skill and dexterity as will be very beneficial to him." [Agnesi, 1748, 1020]

On the following assertions made by Truesdell:

> "Maria Gaetana Agnesi may be the only renowned mathematician who never breathed the air of a mathematical environment" [Truesdell, 1989, 135]
>
> "… those facts do not prove that her book was read or studied." [Truesdell, 1989, 136]
>
> "… Lagrange recommends Agnesi's second volume … this reference … is the only one made by a great mathematician of the 18th century" [Truesdell, 1989, 136]

all I can say is that they demonstrate the point of view of a professional mathematician who sees the historic development of his profession as marked only by the most innovative and original contributions and who fails to take into consideration the importance of transmitting knowledge through books, journals, face-to-face teaching and correspondence.

Furthermore, Truesdell's remarks underestimate the role played by Jacopo Riccati in educating teachers, pupils, fellow scientists and journalists about mathematics. The cultural circle that formed between 1709 and 1750 in Veneto around the Riccatis, Hermann, the Bernoullis – Nicolaus I, Nicolaus II and Daniel – Poleni and Zendrini constituted a real turning point for Italian mathematics as they moved towards analytical methods and advanced research [Mazzone, Roero, 1997; Roero, 2012].

The fact that Agnesi's work was sold in both Italian and foreign bookshops and was in circulation in Europe has been documented by recent studies and by the numerous reviews it received.[49]

Among her readership of mathematicians we can name – as well as J.J. Dortous de Mairan and S. de Montigny – the academicians J. d'Alembert, J.A. Condorcet and A.T. Vandermonde, the translators and revisers P.T. Antelmy, C. Bossut, J. Colson and J. Hellins, the commentators S.F. Lacroix and T. Simpson, and in Italy – as well as Jacopo, Giordano and Vincenzo Riccati of course – R. Rampinelli, J.L. Lagrange and G.C. Fagnani, S. Canterzani, F.M. Zanotti, G. Poleni, F. Jacquier, P. Frisi and many others.

The cultural operation set in motion by Rampinelli, with the aid of the Riccatis, that culminated in the publication of *Instituzioni analitiche ad uso della gioventù italiana* can be seen as following in the wake of the grand traditions of transmitting mathematical knowledge that arose, for example, in France, in the circles of Marin Mersenne and later Nicolas Malebranche [Costabel, 1979; Costabel, Peiffer, 1988, 9-14, Peiffer 1992]. The latter of these found a way to accept the invitation Leibniz made to de l'Hôpital to 'train' pupils when he

[49] In Milan it was sold at the bookshop run by G. Cairoli and its availability in Europe has been well documented [Mazzotti, 2007, 120-122]. I would also add that in the *Extrait du Calogue des Livres*, found at the end of the first edition of S.F. Lacroix's *Traité du Calcul differential* … [Lacroix, 1797], both the Italian and French editions of Agnesi's *Instituzioni analitiche* had been itemized.

was working on the draft of his treatise *Scientia Infiniti* (which he never managed to complete):

> "To complete my plans of a Science of the infinite, one would have to be able to find some young man capable of easing my pain in the calculations, and if I knew of one I would maintain him gladly. You, Sirs, in France might dream of bringing forth some such, to have assistance, as much to save you work in which the mind has a lesser part as to save time, which is the most precious of all things, for our time is our life."[50]

Rampinelli and the Riccatis achieved the same aim by educating and supporting Maria Gaetana Agnesi, well aware of the importance of transmitting basic knowledge to raise the cultural level in their land and to provide a springboard for cutting-edge mathematical research. The seeds they sowed and the association they formed bore the hoped-for fruits. In fact, no other Italian book on analysis had the honor of receiving two European translations in the 18th and early 19th centuries.

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[50] G.W. Leibniz to G.F. L'Hôpital, 3/13 October 1697 [Gerhardt 1971, vol. 2, 329] «Pour achever mes projets de *Scientia infiniti*, il faudroit pouvoir trouver quelque jeune homme capable de me soulager dans les calculs, et si j'en sçavois, je luy donnerois volontiers l'entretien. Vous autres Messieurs devriez songer en France à en faire élever, pour en avoir de l'assistance, tant pour vous épargner des travaux où l'esprit a moins de part que pour gagner le temps, qui est la plus précieuse de toutes les choses, car nostre temps est nostre vie.»

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Abstract

The intense correspondence that developed between Rampinelli, Agnesi and the Riccatis from 1745 to 1752 documents with a wealth of details the exchange of scientific ideas that developed around the writing and printing of *Instituzioni analitiche*. Reconstructing the history and significance of this undertaking can help us understand the role that Agnesi's work played in the mathematics and general culture in Italy at the time, as well as the farsightedness of her tutors and supporters. It can also help demonstrate why today we no longer consider valid the judgments that Loria and Truesdell passed on this exemplar of a female intellectual.