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Teaching and Learning Science in Hungary, 1867–1945: Schools, Personalities, Influences

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Abstract The article provides an overview of the development of teaching science in Hungary during both the time of the dual monarchy and the newly established independent Hungary after 1920. The integration of Hungary into the Austro-Hungarian Monarchy (1867–1918) strengthened the effect of German speaking European science, the results of which were quickly channelled into the Hungarian school system at all levels. The Hungarian Academy as well as the University of Budapest (today Eötvös Loránd University) played a leading role in the „nationalization" of European science in the educational system. Scientific developments in Hungary strengthened the position of rational and secular thinking in a highly religious society and contributed to the erosion of the mental power of the church tradition, particularly that of the Roman Catholic Church. Toward World War I, influenced by the Protestant Churches, the Jewish tradition, and agnosticism, the public picture of science became more international, occasionally ready to consider challenges of the accepted world view, and sometimes less dogmatic. Leading Hungarian figures with an international reputation who played a decisive role in making science part of Hungarian thinking included the physicists Baron Loránd Eötvös and Sándor Mikola, the mathematicians László Rácz and George Pólya as well as a host of others in related fields. Emigration, mostly Jewish, after World War I, contributed to the curtailment of efforts to teach science effectively as some of the best people left Hungary for, mostly, Germany, Britain, and the United States. However, the interwar school system, the Hungarian version of the German *Gymnasium*, continued to disseminate scientific thought in Hungarian education. Much of the information was foreign and appeared simply in translation—but an impressive array of indigeneous scientific results paved the way to a larger educated middle class then in the making.

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1 The Making of Modern Hungarian Mind

The emergence of the relatively large number of excellent mathematicians and scientists in Hungary rising at the turn of the 19th and 20th centuries and after was often explained in very different terms.[1] The Hungarian-American mathematician George Pólya answered, "[a] general reason is that mathematics is the cheapest science." (Arvai Wieschenberg 1984, 86–87).

This was, indeed, important in a relatively underdeveloped country. As to specific reasons, Pólya listed the *Középiskolai Mathematikai Lapok* [High School Papers in Mathematics], the Eötvös Competition, and the personality of the mathematician Lipót Fejér. To all this we may add a number of social factors such as Hungarian creativity, the Liberal nature of Hungarian politics in much of the era of the Austro-Hungarian Monarchy, and massive German influence.

1.1 Hungarian Creativity

Hungarian creativity is embedded in a complex tradition. Two aspects have to be particularly emphasized: the almost constant entanglement with internal and international conflicts, wars, revolutions and the long coexistence with German culture and civilization. Often in a cross-fertilizing way, both left a lasting imprint on the Hungarian mind, its ways to solve problems, create new ideas, and organize thoughts.

The standard joke about Hungarians is that they are the ones who can enter a revolving door behind you but leave ahead of you. A back-handed compliment, to be sure, but if there is such a thing as national character, then it can be taken as a sign of sneaking respect for a certain shrewdness, ingenuity, originality, and an uncommon approach to problem solving. Through the long centuries of Habsburg rule and beyond, German philosophy, science, literature, education, music shaped and harnessed the intellectual energies and talents of subsequent Hungarian intellectual generations.

The social history of the Hungarian cast of mind—indeed the way of thinking across much of East-Central Europe—is deeply rooted in war and conflict, abetted by a foe of an entirely different nature: poverty.

This blend of national quirks has made problem solving a natural, permeating all aspects of life, from the most mundane to the highly abstruse. Much of this came from the multiethnic, multicultural, multilingual nature of Hungarian and Austro-Hungarian society, which constantly provided problems to be solved—economic, social, political, and cultural. Hungarians have been ready to accept whatever solutions they could find or devise, even if that has meant flying in the face of received yardsticks or devising new, unorthodox approaches—provided, of course, that these served their purpose. One may conjecture that this call for problem solvers contributes to explaining the country's longstanding abundance of brilliant mathematicians and scientists, to mention János Bolyai, Lipót Fejér, John von Neumann, George Pólya, and Paul Erdős as merely the best-known of outstanding talents which spills over, beyond the realm of pure mathematics, into physics, chemistry, engineering, and many other fields.

A potent factor in maintaining that record of achievement lay in the manner secondary schooling was reorganized after the Austro-Hungarian Compromise of 1867. In 1870–1872,

[1] This article has partially drawn upon the author's 2007 Budapest ICAS/POAK conference paper (unpublished), his 2008 San Marino *Euresis* symposium lecture (forthcoming), as well as his recently published book (Frank, T. 2009).

the educationist Mór Kármán, father of aviation pioneer Theodore von Kármán, was commissioned by the minister of education Baron József Eötvös (1813–1871), to undertake a first-hand study of Germany's acclaimed high-school system. This laid the ground for ensuring that the best Hungarian schools consistently had access to first-class teaching resources capable of encouraging students to standards of attainment that compare favorably with many (and not just lower-tier) colleges in the United States today. On the German model, the high school, or *Gymnasium*, placed heavy emphasis on the Classics, Hungarian language and literature, and universal culture, without neglecting mathematics and the natural sciences. These were unashamedly élitist institutions, with a student intake drawn typically from a rather narrow upper-middle section of Hungary's than still relatively conservative, even feudalistic society. However, they could attract teaching staff of a very high caliber; many of them recognized scientists and scholars in their own fields, as reflected in their subsequent membership of the Hungarian Academy of Sciences and appointment to university professorships. As a result, the country's top schools, such as the Lutheran high school in Pest or the *Mintagimnázium* (The 'Model') of the University of Budapest, succeeded for several decades in cultivating an astonishingly consistent succession of brilliant young minds, of whom John von Neumann, Eugene Wigner, Edward Teller, and Theodore von Kármán, were only a few of the more prominent, many of whom ended up in the United States.

Of course, there was also animosity to innovation: Conservatism prevailed in much of the Austro-Hungarian Monarchy. Although Hungary was in several ways an ideal creative spawning ground, many of its achievements were made in the face of official Austrian and Hungarian disapproval. For the greater part of the nineteenth century the national tradition was conservative and the mentality hostile to innovation—not least due to the obverse side of German and Austrian culture, with its authoritarian insistence on strict and often antiquated rules and standards, established patterns of thinking, and unalterable methods. The general ambiance favored preserving the *status quo* rather than supporting new ideas, and accordingly the ruling conservative forces of the pre-1867 period ignored or spurned many reform-minded Hungarians, which more often than not led to exile, the lunatic asylum or to suicide. There is of course a contradiction here between conservatism and renewal, which was seen and shown in many different occupations and life styles.

After the Austro-Hungarian Compromise of 1867, however, Franz Joseph I, Emperor of Austria (1848–1916) and Apostolic King of Hungary (1867–1916), whether he liked it or not, presided over a tide of change during the half a century of his 'Dual' Monarchy. Innovative spirits flourished in many walks of life; big industrial firms sprang up and in their search for competitive edge founded product-oriented experimental laboratories in fields as diverse as telephony, lighting, pharmaceuticals, armaments, and electric locomotion, to name just a few. Later generations were to look back on these as the "good old days" of peace and prosperity.

The economic advance that occurred under the Austro-Hungarian Monarchy, however, did spur further development of the Hungarian language to furnish it with an adequate technical vocabulary to serve as a continued vehicle for professional communication and understanding—again reflecting the willingness of the culture to adapt itself to the modern world. This was particularly notable at the universities, where Hungarian gradually displaced German as the main language of tuition. Latin ceased to be a state language already after 1844.

1.2 Fin-de-Siècle Budapest

After the unification of Buda, Pest, and Old-Buda into one municipality in 1873, the newly constituted Monarchy had two capital cities: Vienna and Budapest. While Vienna was the old imperial capital city of the Habsburgs, Budapest emerged astonishingly quickly, basically by the end of the 19th century, as a beautiful, modern city to serve as the administrative and economic center of the Hungarian part of the Monarchy. In some ways it was designed to impress the many different ethnic minorities of the country by the visible ability of the *Magyar* ruling élite to govern their land. Overlooking the Danube across the Royal Palace, the building of Parliament dominated the landscape as a symbol of constitutionalism and political power.

Soon after the creation of the Austro-Hungarian Monarchy (1867) and the unification of Buda, Pest, and Óbuda into the representative and impressive Hungarian capital city of Budapest, a new, complex and modern, Hungarian intellectual élite emerged. Centered in the city of Budapest, this modernizing group came partly from the decaying landed gentry of feudal origins and partly from intellectually aspiring members of the assimilating (predominantly German and Jewish) middle class. While creating metropolitan Budapest in the intellectual sense, they constituted themselves as a group through what proved to be a completely new and unique social and psychological experience.

Before the unification of Buda, Pest, and Óbuda, the population of Pest-Buda was 269,293 (1869). Between 1890 and 1910, the population grew from 492,227 to 880,371, with additional growth in the suburbs (from 61,289 to 217,360) (Vörös, K. szerk. 1978, 185, 577).

By 1930, the city had 1 million people, and by 1941, it reached 1,2 million. In the meantime, the suburbs grew from 311,000 in 1920 to 560,000 in 1940 (Horváth, M. szerk. 1980, 418).

Several economic and social factors contributed to the emergence of this gifted and creative professional group at the time of the rise and fall of the Austro-Hungarian Monarchy (1867–1918). In a country where the long decay of feudalism had become visible and the political and social system based on huge landed estates had come under sharp attack, the beginnings of a new, capitalist society stimulated work in science, technology and the arts. The transformation of the Habsburg Monarchy and the creation of a “Hungarian Empire” contributed to an economic prosperity that brought about a building and transportation boom, the advancement of technology, and the appearance of a sophisticated financial system. The rise of a new urban middle class affected the school system. Around 1900, there was a creative spirit in the air throughout Europe, permeating literature, music, the arts, and sciences. In Hungary, the poet Endre Ady, the editors of the new literary journal *Nyugat* (West) (1908), the composers Béla Bartók and Zoltán Kodály, the artistic group The Eight, philosophers such as Georg Lukács and Karl Mannheim, art historians such as Charles de Tolnay, Arnold Hauser, Lajos Fülep, and Frederick Antal, offered a new and stimulating agenda for artistic and social discourse and later became internationally recognized. This creative atmosphere set the tone for a generation that included the many celebrated scientists born in the early years of the new century.

From assimilated Jewish-Hungarian upper middle-class families, prospective scientists such as Theodore von Kármán, John von Neumann, Leo Szilard, Eugene Wigner, and Edward Teller were born into this challenging intellectual atmosphere of Budapest, which bred provocative questions and pioneering answers. Paradoxically, the approaching decline of the Austro-Hungarian Monarchy seemed to have generated unusual sensitivity and creativity (Mátrai, L. 1976; Nyíri, K. 1980; Nyíri, J. C. 1988; Hanák, P. 1998; Vörös, K. szerk. 1978, 321–723; Lukacs, J. 1988; Gluck, M. 1985; Hargittai, I. 2006, 3–31). In many ways, the political and social decline of the monarchy created a special opportunity for Hungarian Jewry, which had grown and flourished throughout the fifty years of the Monarchy. The result was a professionally defined middle class, instead of a feudally-defined one in Hungary. Whereas the first generations of assimilating middle class

Hungarian Jews concentrated on amassing material wealth, subsequent generations were destined to focus their activities on accumulating knowledge (William O. McCagg, Jr. 1986). Their often-strong financial background enabled them to concentrate exclusively on their studies and eventually join the various scholarly or scientific groupings such as the *Társadalomtudományi Társaság* [Society for the Social Sciences], the *Galilei Kör* [Galileo Circle], or the journal *Huszadik Század* [Twentieth Century] where the critical social issues were often debated with a highly politicized focus. These circumstances provided a good schooling for this generation of prospective émigré intellectuals.

The period that ended with World War I saw a relatively peaceful cooperation and often-true friendship between Jew and Gentile in Hungary. What historian Raphael Patai described as "the love affair […] between the Jews and Hungary" (Patai, R. 1980, 68; cf. Terao, N. 1997) often resulted in intermarriages and other forms of close social ties and networking. For those opposing the influx of Jews into Hungary, however, Budapest seemed a special, "un-Hungarian" case, out of line with Hungarian tradition. The popular conservative author Ferenc Herczeg expressed this sentiment in a straightforward manner when he spoke about "foreign elements in [the] chemistry" of Budapest (Horváth, Z. 1961, 205–206; quoted by Lukacs, J. 1988, 202).

Assimilation was the by-word of the period: religious conversion, the dropping of German, Slavic, and particularly Jewish family names, and ennoblement were all standard practice (Gerő, J. szerk. 1940). The tortuous process of Jewish assimilation in Budapest was (often ironically) documented by the Hungarian novels of the period (Molnár, F. 1901, 1917; Kóbor, T. 1901; Bródy, S. 1902; Herczeg, F. 1903; cf. Marianna Birnbaum 1989, 331–342). Nevertheless, the full social history of Magyarization at all levels is yet to be fully researched and written. The capital city of Hungary played the role of a Hungarian melting pot through the four decades preceding World War I. It attracted a vast number of migrant workers, professionals, and intellectuals from all quarters of the kingdom of Hungary and beyond. It became an energized meeting ground for a multitude of ethnic and religious groups with varying social norms, modes of behavior and mental patterns. The mixing and clashing, fusion and friction, of such diverse values and codes of behavior created an unparalleled outburst of creativity, a veritable explosion of productive energies. In this exciting and excited ambiance, a spirit of intellectual competitiveness was born, which favored originality, novelty and experimentalism. Budapest expected and produced excellence and became deeply interested in the secret of genius. For many of those who were later to be known both nationally and internationally as geniuses, Budapest seems to have been the natural place to have been born.

1.3 Hungary and the German Cultural Tradition

The German influence during this era also reached more widely, with Hungary in many ways constituting itself an outpost of German culture, whose icons—from writers Goethe and Schiller or philosophers Kant and Schopenhauer, through composers Beethoven, Brahms and Wagner, or painters Kaulbach and Piloty, to scientists Gauss, Haeckel and Brehm—were held in unparalleled esteem. Even news of the wider world outside the German universe usually reached Hungarian aristocratic libraries or the coffeehouses and salons of Budapest's middle classes refracted through the medium of the German language and, inevitably, cultural paradigms.

The influence of German culture and Germany as a civilization was so strong in Hungarian history that we must address it in a variety of contexts. Their early learning experiences in Germany also made a huge impact on many Hungarian scientists such as Loránd

Eötvös, Leo Szilard, Edward Teller, and Lipót Fejér through their entire life. Both as a language and as a culture, German was a natural for upper- and middle class Hungarians up to World War II. The *lingua franca* of the Habsburg Empire and of the Austro-Hungarian monarchy, German was used at home, taught at school, spoken on the street, needed in the army (Deák, I. 1990, 83, 89, 99–102). This was more than a century-old tradition: the links between Hungary and both the Austrian and the German culture went back to the eighteenth century. For a considerable time in the 18th and 19th centuries, Hungary (or large parts of it) in many ways used to be on the fringes of the greater realm of German culture. We should emphasize again that the average middle-class "Hungarian" was typically German ("Schwab") or Jewish by origin and for him it was German culture and civilization that connected Hungary and the Austro-Hungarian Monarchy with Europe and the rest of the World. Middle-class sitting rooms in Austria, Hungary, Bohemia, Galicia, and Croatia typically boasted of the complete works of Goethe and Schiller, the poetry of Heine and Lenau, the plays of Grillparzer and Schnitzler (Illyés, Gy. [1938], II, 239).

Not only was German literature and German translations read throughout the Empire: German was the language of the entire culture. When Baron József Eötvös, the great liberal statesman, man of letters and Hungarian Minister of Religion and Education, visited his daughter in a castle in eastern Hungary, he noted: "What contrasts! I cross Szeged and Makó, then visit my daughter to find Kaulbach on the wall, Goethe on the bookshelf and Beethoven on the piano" (Sőtér, I. 1967, 314).

Throughout the entire Austro-Hungarian Monarchy and beyond, Hungarians looked to Germany to import modern theories and establish modern practices. The study of the German school system had a great tradition throughout the nineteenth century. For generations of Hungarian lawmakers, the German school provided the finest example in Europe. Two widely spaced examples are characteristic. When young Bertalan Szemere, a future Prime Minister of Hungary, went in 1836 to Berlin to study "what was best in each country, [he] tried to consider schools in Germany, the public life in France, and prisons in Britain…" (Journal entry from Berlin, October 31, 1836, cf. Szemere, B. 1983, 59). A generation later, the ideas and know-how of modern teacher training were studied in, and imported from, Germany by Mór Kármán in the early 1870s.

As late as December 1918 Cecilia Polányi, the mother of Michael and Karl Polányi and grandmother of Nobel laureate John C. Polányi, intended to study the curricula and methods of German institutions in the field of "practical social work" and for this planned visits to Berlin, Frankfurt am Main, Mannheim, Hannover, Düsseldorf, Cologne, Augsburg, Munich, Heidelberg, Königsberg, and a host of other places where the various *Soziale Frauenschulen, Frauenakademie, Frauenseminare* were the very best in Europe.[2]

Efforts to study and imitate what was German were also natural because German was then the international language of science and literature: in the first eighteen years of the Nobel Prize, between 1901 and 1918, there were seven German Nobel laureates in chemistry, six in physics, four (and one Austro-Hungarian) in medicine, and four in literature (*The World Almanac* 2010, 295–298; Hargittai I. 2002; Schirrmacher, A. 2010, 8–10). Scholars and scientists read the *Beiträge,* the *Mitteilungen*, or the *Jahrbücher* of their special field of research or practice, published in some respectable German university town such as Giessen, Jena, or Greifswald. The grand tour of a young intellectual, artist, or professional would unmistakably lead the budding scholar to Göttingen, Heidelberg, and

[2] Cecilia Polányi to the Minister of Religion and Public Education, Budapest, December 11, 1918 and enclosures. (Hungarian and German) Michael Polányi Papers, Box 20, Folder 1, Department of Special Collections, University of Chicago Library, Chicago, Ill.

increasingly Berlin. Artists typically went to Munich to study with art professor Karl von Piloty (Lyka, K. 1982, Balogh, L. 1988).

The Hungarian middle-classes often read local papers published in German, which were available everywhere in the monarchy until its dissolution and even beyond. Founded in 1854, the authoritative *Pester Lloyd* of Budapest, for example, continued as one of the most appreciated and well-read papers of the Budapest middle-class until almost the end of World War II (1944). German in language but committed to Hungarian culture (Kiss, J. 1969, 275–297), this part of the press helped bridge the gap between the two cultures. In much of the eighteenth and nineteenth centuries, German novels and poetry written and published in Hungary were just as integral a part of the Greater German *[Gesamtdeutsch]* literature as anything written in Königsberg or Prague (Tarnói, L. 1998, 203–322, Monsberger, U. R. 1931). The Jewish population of the Empire/Monarchy, particularly its educated urban middle-class, embraced German primarily as a new, common language and contributed to making the Austrian realm a part and not just an outskirt of German civilization (Szalai, Gy. 1974, 216–223; Osztern, R. 1930). For socially aspiring Jewish families, German was the language of education and upward mobility.

With all this infusion of German blood into Hungarian musical life and education, Budapest in the early 1900s still was not comparable to Berlin. Young and gifted pianist and composer Ernő (Ernst von) Dohnányi considered the Hochschule für Musik in Berlin a much greater challenge. "To choose Budapest instead of Berlin would have been such a sacrifice on my part which, considering my youth, the fatherland cannot demand and, considering my art, I cannot make," he wrote to the director of the Budapest Music Academy around 1905. "Berlin is unquestionably the center of the musical world today. Budapest, we must admit, does not play even a small role in the world of music. Even if it is true that the Hochschule of Berlin is simply the center of a clique, that clique is enormous and has played a role for decades whereas the musical world doesn't even notice whether or not I take a dominant position in Budapest." (Vázsonyi, B. 1971, 67–68). Dohnányi stayed in Berlin until World War I and, as *Ernst von* Dohnányi, became one of the internationally most distinguished professors of the Hochschule für Musik.

Berlin in the early prewar era proved to be an irresistible magnet for the new Hungarian intellectual and professional classes. Many of the young Hungarians who frequented Berlin around the turn of the century were Jewish. The Jewish-Hungarian middle-class felt at home in imperial Germany and sent their sons and daughters there to study. After completing their courses in Budapest before World War I, Hungary's up-and-coming mathematicians saw Göttingen and Berlin as the most important places to study. As a very young man, the celebrated mathematician Lipót Fejér spent the academic year 1899–1900 in Berlin where he attended the famous seminar of Hermann Amandus Schwarz. In 1902–1903 he studied in Göttingen and in subsequent years returned to both universities (Szegő, G. 1960, 346–347). A gifted student of Fejér, Gábor Szegő, also followed his path and went to study in prewar Berlin, Göttingen, and Vienna, and later became professor of mathematics at Stanford (Szegő, G. n.d. Lebenslauf).

2 The Legacy of Teaching

2.1 Baron Loránd Eötvös

The key personality in late 19th century Hungarian science and mathematics was Baron Loránd Eötvös (1848–1919). Son of the author, philosopher, and statesman Baron József

Eötvös, young Loránd was not only a major physicist in his own right, but also one of the truly great organizers of Hungarian science. He was three times (1911, 1914, 1917) nominated for the Nobel Prize (Beck, M. 2009; cf. Beck, M. 1995, 531–535). Young Loránd Eötvös was greatly influenced by the ideas and personality of his father, a leading Liberal before and during the 1848 revolution, a dedicated critic of the Hungarian nobility and the political system upheld by it. Still surviving in Budapest, his rich personal library shows him as a man of immense erudition and sophisticated culture, with an avid interest in world history (Gábor Gángó, Hrsg. 1985). As Arthur J. Patterson, a contemporary British observer put it, Baron József Eötvös was a witness who cannot be accused of partiality to this class since "his novel, *The Village Notary*, was written to satirize the very institutions to which they were especially attached" (Patterson, A. J. 1869, I, 271; cf. Frank, T. 2004, 47–62).

Loránd Eötvös studied Chemistry, Physics, and Mathematics at the [Ruprecht-Karls] University of Heidelberg in 1867–1870 with the chemist Robert Bunsen as well as the physicists Hermann von Helmholtz and Gustav Kirchhoff.[3] These were the heydays of natural sciences in Heidelberg, a centre for Liberal thought and openmindedness. Eötvös, Sr. maintained regular contact with his son Loránd. Written in loving care, the correspondence between father and son reflected their strong devotion to 19th century ideals such as rationalism, the idea of progress, enlightened thinking, and the openness of mind. A touch of social responsibility permeates the letters which were partly published.[4]

Loránd benefited of the intellectual and political legacy of his father as well as that of his uncle, Ágoston Trefort who for 16 years continued József Eötvös's great Liberal work as Hungarian Minister of Religion and Education (1872–1888) as well as President of the Hungarian Academy of Sciences (1885–1888) (Mann, M.). It is important to notice that, though for a very limited time, that Loránd Eötvös himself became Minister of Religion and Education (1894–1895), in addition to his long and distinguished service as President of the Hungarian Academy of Sciences (1889–1905). It is no exaggeration to claim that the Eötvös-Trefort family dominated Hungarian science and education policies between 1866 and 1905.

As a scientist, Loránd Eötvös is best remembered today for the Eötvös Law in surface tension and for his gravitational torsion balance measurements which opened up pioneering ways to identify new sources of energy and particularly of natural gas (Loránd Eötvös 1912, I, 427–438; cf. Tóth, Gy. and Völgyesi, L. 2003; Eötvös, L. 1953); Mikola, S. and Renner, J. szerk., Irodalom" [Bibliography], in: Fröhlich, I. szerk. 1930), 287–317; Környei, E. szerk. 1964, 379–421). His educational achievements, are, however, just as important.

With his German (Heidelberg, Königsberg) educational background and inspiration, Eötvös created a small, private Mathematics Circle in Budapest, in the fall of 1885, to build an informal network among university professors and high school teachers and their best students (Radnai, Gy. 1991, 349). As of 1891, this circle continued as the *Mathematikai és Physikai Társulat* [Society of Mathematics and Physics] with some 300 members (including three women). Loránd Eötvös served as the first president of the *Társulat*, which launched *Mathematikai és Physikai Lapok* [Mathematical and Physical Papers]. In his

3 Promotionsakten von Roland von Eötvös, Ruprechts-Karls-Universität, Universitätsarchiv, Heidelberg, UAH H-IV-102/72; copies in the custody of the University Archive, Eötvös Loránd University, Budapest. Cf. Rosta, I. 2008, 11.

4 Benedek, M. szerk. (1988). I have also studied Loránd's letters originally in the custody of the Patrona Hungariae Gyakorló Általános Iskola, Gimnázium, Diákotthon, Zene- és Szakiskola, Budapest, copies of which are today in the Archives of Eötvös Loránd University, Budapest. I am grateful to Dr. László Szögi, Director of the University Library and Archives of Eötvös Loránd University for kindly providing access to the Eötvös-documents in the custody of the Archives.

inaugural address, Eötvös expressed his hope that "we will do great service to the general cultural development of the country, because undoubtedly, the success of teaching in both higher and secondary schools depends above all on the scientific preparation of the teachers." (Loránd Eötvös, L. 1892, 1, quoted by Árvai Wischenberg, Á. 1984, 23). The special emphasis on the training of mathematics and physics teachers and on the achievement of the secondary school student in Hungary can thus be traced back to Loránd Eötvös. Hungarian-born Mathematics Professor Peter Lax of the Courant Institute of Mathematical Sciences at New York University remembered Eötvös as a professor of his parents who were joined by a host of students in "the lecture room just to be able to hear him lecture." (Interview with Peter Lax, May 3, 1983, quoted by Árvai Wischenberg, Á. 1984, 56).

In his 1891 inaugural address as the newly installed Rector of Budapest [today: Eötvös Loránd] University, Loránd Eötvös emphatically argued for independent research and independent thinking: "I do not call a scientist someone who knows a lot, but someone who does research in science. … Independence in thinking can only be fostered by a teacher who thinks independently himself, and it is this very independence that is most necessary for the scientist as a man of practice." (Eötvös L. 1891, in Környei E. szerk., 201–202).

As students were expected to be challenged in regular national interschool competitions in mathematics and science, the *Mathematikai és Physikai Társulat* honored Eötvös by launching an annual mathematics and physics contest "in order to discover those who are exceptional in these fields." (Értesítő 1894, quoted by Árvai Wischenberg, Á. 1984, 26). Appropriately named the Eötvös Competition, a first and a second prize (the Eötvös Prize) were awarded to the best secondary school graduates. As only secondary school material was included in the test, no additional study was necessary for the exam. Results were reported directly to the Ministry of Religion and Education, along with the names of the teachers of the winners, and were published in the *Mathematikai és Physikai Lapok.*

To support preparations for future contentions, the same year, 1894, also saw the inauguration of *Középiskolai Mathematikai Lapok* [High School Papers in Mathematics], edited by Dániel Arany, an outstanding high school mathematics teacher from the West Hungarian city of Győr. László Rátz (1863–1930), the future teacher of mathematics of John von Neumann and Eugene Wigner, continued Arany's editorial work, between 1896 and 1914. The problems to be solved included a wide variety of fields such as algebra, calculus, combinatorics, geometry, number theory, and trigonometry, and the problems always required creative thinking. Pride, rather than money was the reward of the best students.

The organizational structure of these competitions, along with the related new publications, provided a well-structured and carefully regulated framework of preparation for future professional challenges these students would face.

The idea of founding awards and contests was not restricted to the Eötvös Prize alone. For example, it was at the personal instigation of Loránd Eötvös that Andor Semsey, a rich patron of the Hungarian National Museum, established fellowships and prizes in various scholarly and scientific fields to inspire talented young people to do research (Fröhlich, I, 1930, 47–48). Also, upon the death of the reputable high school mathematics teacher Adolf Prilisauer (1859–1913), his provincial city of Kaposvár in Western Hungary along with his former teaching colleagues, established a prize for the best student (or, later, students) in mathematics (Kovács-Sebestény, Gy. and Pongrácz, K. 1913, 177–178).

The *Középiskolai Matematikai és Fizikai Lapok* [Highschool Papers in Mathematics and Physics], the *Eötvös Loránd fizikai verseny* [Eötvös Loránd Competition in Physics] and the *Arany Dániel országos matematika verseny* [Arany Dániel National Competition in Mathematics] have survived until today and maintain the living tradition of an excellent mathematics education based on early training, competitive spirit, and the recognition of talent (Győri J. G., Halmos, M., Munkácsy, K., Pálfalvi, J. szerk. 2007).

2.2 The Eötvös School Exported: George Pólya

In a pioneering inquiry into the nature of problems and the solution of a problem, Michael Polányi defined one of the most crucial questions of his generation. "To recognize a problem which can be solved and is worth solving is in fact a discovery in its own right," Polányi declared the creed of his generation in his 1957 article for *The British Journal for the Philosophy of Science* (Polányi, M. 1957, 89). Polányi spoke for, and spoke of, his generation when discussing originality and invention, discovery and heuristic act, investigation and problem solving.

Hungarian-born mathematician George Pólya (1887–1985) was one of those who channeled the Hungarian and, more broadly speaking, Central European school tradition into American education in a series of books and articles, starting with his 1945 book *How to Solve It* (Pólya, G. 1945).[5] Among other ideas, Pólya transplanted the Eötvös Competition to post-World War II Stanford University which makes it important to discuss his career at this point. In 1944, Pólya remembered the time when, at the turn of the century in Hungary,

> he was a student himself, a somewhat ambitious student, eager to understand a little mathematics and physics. He listened to lectures, read books, tried to take in the solutions and facts presented, but there was a question that disturbed him again and again: "Yes, the solution seems to work, it appears to be correct; but how is it possible to invent such a solution? Yes, this experiment seems to work, this appears to be a fact; but how can people discover such facts? And how could I invent or discover such things by myself?" (Pólya, G. 1945, vi).

Pólya came from a distinguished Jewish-Hungarian family of academics and professionals. His father, Jakab, an eminent lawyer and economist, provided the best education for his children. They included George's brother, Jenő Pólya, the internationally recognized Hungarian professor of surgery and honorary member of the American College of Surgeons (Milkó, V. 1948, 1). George Pólya first studied law, later changing to languages and literature, then philosophy and physics, to settle finally on mathematics, in which he received his Ph.D. in 1912. Just like most prospective scientists, medical doctors and mathematicians, he was a student of Loránd Eötvös in Physics. He also studied with the mathematician Lipót Fejér (Mathematics), whom he considered one of the people who influenced Hungarian mathematics in a definitive way (Pólya, G. 1961, 501).

For emancipated Jews in Hungary who received full rights as citizens in 1867, it was the Hungarian Law 1867:XII that made it possible, among other things, to become teachers in high schools and even professors at universities. This is one of the reasons that lead to the explosion of mathematical talent in Hungary, just as it happened in Prussia after the emancipation of Jews in 1812. (Hersch R. and John-Steiner, V. 35–37).[6] John Horváth of

[5] *How to Solve It* has never been out of print and has sold well over 1 million copies. It has been translated into 17 languages, probably a record for a modern mathematics book, cf. Alexanderson, G. L. 1987, 563, 603.

[6] I received a copy of this article from Professor Gerald L. Alexanderson of the Department of Mathematics, Santa Clara University, Santa Clara, CA. .

the University of Maryland was one who pointed out that the overwhelming majority of mathematicians in Hungary were Jewish in the early 20th century. Pursuing scientific professions, particularly mathematics, secured a much desired social position for (in most cases) sons of Jewish-Hungarian families, who longed not only for emancipation, but for full equality in terms of social status and psychological comfort. Thus, in many middle class Jewish families, at least one of the sons was directed into pursuing a career in academe.[7]

Culture in the second half of the 19th century became a matter of high prestige in Hungary, where the tradition of respect for scientific work started to loom large after the *Ausgleich,* the Austro-Hungarian Compromise in 1867 between Austria and Hungary. For sons of aspiring Jewish families, a professorship at a Budapest university or membership in the Hungarian Academy of Sciences promised entry into the Hungarian élite and eventual social acceptance in Hungarian high society, an acknowledged way to respectability.

Distinguished scientists such as Manó Beke, Lipót Fejér, Mihály Fekete, Alfréd Haar, Gyula and Dénes Kőnig, Gusztáv Rados, Mór Réthy, Frigyes Riesz, and Lajos Schlesinger belonged to a remarkable group of Jewish-Hungarian mathematical talents, who, after studying at major German universities, typically Göttingen or Heidelberg, became professors in Hungary's growing number of universities before World War I. A few of them, like Gyula Kőnig and Gusztáv Rados, even became university presidents at the Technical University of Budapest. There were several other renowned scientists active in related fields, such as physicist Ferenc Wittmann, engineer Donát Bánki and some others. Mathematicians were also needed outside the academic world: just before the outbreak of World War I, George Pólya was about to join one of Hungary's large banks, at the age of 26, with a Ph.D. in mathematics and a working knowledge of four foreign languages in which he already published important articles.[8]

Despite what we know about the social conditions which nurtured and even forced out the talent of these many extraordinary scientists, how this occurred still remains somewhat mysterious. Stanislaw Ulam recorded an interesting conversation with John von Neumann when describing their 1938 journey to Hungary in his *Adventures of a Mathematician*.

> I returned to Poland by train from Lillafüred, traveling through the Carpathian foothills […] This whole region on both sides of the Carpathian Mountains, which was part of Hungary, Czechoslovakia, and Poland, was the home of many Jews. Johnny [von Neumann] used to say that all the famous Jewish scientists, artists, and writers who emigrated from Hungary around the time of the first World War came, either directly or indirectly, from these little Carpathian communities, moving up to Budapest as their material conditions improved. The [Nobel Laureate] physicist I[sidor] I[saac] Rabi[9] was born in that region and brought to America as an infant. Johnny used to say that it was a coincidence of some cultural factors which he could not make precise: an external pressure on the

[7] John Horváth compared the explosion of Jewish talent after the Jewish emancipation to the surprising number of sons of Protestant ministers entering the mathematical profession in Hungary after World War II, "Those kids would have become Protestant ministers, just as the old ones would have become rabbis […] mathematics is the kind of occupation where you sit at your desk and read. Instead of reading the Talmud, you read proofs and conjectures. It's really a very similar occupation." Hersch R. and John-Steiner, V. n.d., 37.

[8] György Pólya to Baron Gyula Madarassy-Beck, Paris, February 23, 1914. I am grateful to Professor Gerald Alexanderson for showing me this document.

[9] Nobel Prize in Physics, 1944.

> whole society of this part of Central Europe, a feeling of extreme insecurity in the individuals, and the necessity to produce the unusual or else face extinction. (Ulam, S. M. 1976, 111).[10]

An interesting fact about the turn of the century Jewish-Hungarian mathematicians and scientists was that several of them could multiply huge numbers in their head. This was true of von Kármán, von Neumann and Edward Teller. Von Neumann, in particular, commanded extraordinary mathematical abilities. Nevertheless, there is no means available to prove that this prodigious biological potential was more present in pre-World War I Hungary than elsewhere in Europe (Macrae, N. 1992, 9; Rosenberg, J. M. 1969, 155. ff.; Teller E. and Brown, A. 1962, 160; cf. McCagg, W. O., Jr. 1986, 211).

Similarly, heuristic thinking was also a common tradition that many other Hungarian mathematicians and scientists shared. John von Neumann's brother remembered the mathematician's "heuristic insights" as a specific feature that evolved during his Hungarian childhood and appeared explicitly in the work of the mature scientist (Vonneuman, N. A. 1987, 44). Von Neumann's famous high school director, physics professor Sándor Mikola, had made a special effort to introduce heuristic thinking into the elementary school curriculum in Hungary by the 1900s (Mikola, S. 1911, 57–73).

Fejér drew a number of gifted students to his circle, such as Mihály Fekete, Ottó Szász, Gábor Szegő and, later, Paul Erdős. His students remembered Fejér's lectures and seminars as "the center of their formative circle, its ideal and focal point, its very soul." "There was hardly an intelligent, let alone a gifted, student who could exempt himself from the magic of his lectures. They could not resist imitating his stress patterns and gestures, such was his personal impact upon them." (Szegő, G. "[Lipót Fejér]). George Pólya remembered Fejér's personal charm and personal drive to have been responsible for his great impact: "F[ejér] influenced more than any other single person the development of math[ematic]'s in Hungary…"[11]

Pólya, however, soon went to Vienna where he spent the academic year of 1910–1911, after receiving his doctorate in mathematics in Budapest. In 1912–1913, he went to Göttingen, and later to Paris and Zurich, where he took an appointment at the *Eidgenössische Technische Hochschule Zürich* [Swiss Federal Institute of Technology Zurich]. He became full professor at the ETH in 1928.

A distinguished mathematician, Pólya drew on several decades of teaching mathematics based on new approaches to problem solving, first as a professor in Zurich, Switzerland, and later at Stanford, California. It was in Zurich that Pólya and fellow Hungarian Gábor Szegő started their long collaboration by signing a contract in 1923 to publish their much-acclaimed joint collection of *Aufgaben und Lehrsätze aus der Analysis* [Problems and theorems in analysis] (Pólya, G. – Szegő, G. 1925). Considered a mathematical

[10] Cf. Tibor Fabian, "Carpathians Were a Cradle of Scientists," Princeton, NJ, November 16, 1989, *The New York Times,* December 2, 1989.—George Pólya's nephew John Béla Pólya had an even more surprising, though cautious proposition to make. He suggested that through George Pólya's mother, Anna Deutsch (1853-1939), Pólya was related to Eugene Wigner and Edward Teller, "who are thought to have" ancestry originating from the same region between the towns of Arad and Lugos in Transylvania (then Hungary, today Romania). Though this relationship is not yet documented and should be taken at this point merely as a piece of Pólya family legend, it is nonetheless an interesting reflexion of the strong belief in the productivity of the Jewish community in North-Eastern Hungary and Transsylvania in terms of mathematical talent. John Béla Pólya, "Notes on George Pólya's family," attached to John Béla Pólya to Gerald L. Alexanderson, Greensborough, Australia, July 28, 1986.—I am deeply grateful to Gerald L. Alexanderson of Santa Clara University, Santa Clara, CA, for his generous and highly informative support of my research on George Pólya in 1988 and after. The Pólya papers in the custody of Prof. Alexanderson were transferred to the George Pólya Papers, Department of Special Collections and University Archives, Stanford University Libraries, Stanford, CA.

[11] Pólya, G., Lecture outline, n.d. Unpublished MS. George Pólya Papers, SC 337, 87-034, Box 1.

masterpiece even today, *Aufgaben und Lehrsätze* took several years to complete, and it continues to impress mathematicians not only with the range and depth of the problems contained in it, but also with its organization: their grouping of problems, not by subject but by solution method, was a novelty (Alexanderson, G. L. 1987, 562).

In the United States after 1940, and at Stanford as of 1942, Pólya became the highest authority on the teaching of problem solving in mathematics.

> With his arrival at the United States, Pólya started a new career based on his new-found interest in teaching and heuristics. He developed several new courses such as his "Mathematical Methods in Science," which he first offered in the Autumn 1945 quarter at Stanford, introducing general and mathematical methods, deduction and induction, the relationship between mathematics and science, as well as the "use of physical intuition in the solution of mathematical problems." (Alexanderson, G. L. 1987, 563, 566–570).[12]

He surveyed all aspects of a problem, general and specific, restating it in every possible way and pursuing various courses that might lead to solving it. He studied several ways to prove a hypothesis or modify the plan, always focusing on finding the solution. He compiled a characteristic list of "typical questions for this course," which indeed contained his most important learnings from a long European schooling.[13]

In a course on heuristics, he focused on problems and solutions, using methods from classical logic to heuristic logic. Offering the course alternately as Mathematics 110 and Physical Sciences 115, he sought to attract a variety of students, including those in education, psychology and philosophy.[14] The courses were based on Pólya's widely used textbook *How to Solve It*.

In due course, Pólya published several other books on problem solving in mathematics such as the two-volume *Mathematics and Plausible Reasoning* (1954), and *Mathematical Discovery,* in 1965. Both became translated into many languages. Towards the end of his career his "profound influence of mathematical education" was internationally recognized, as suggested by the words of Sir James Lighthill.[15]

Pólya's significance in general methodology seems to have been his proposition for interpreting heuristics as problem solving, more specifically, the search for those elements in a given problem that may help us find the right solution (Pólya, G. 1964; Pólya, G. (n.d.) L'Heuristique). For Pólya, heuristics (*Erfindungskunst)* equaled an inventive or imaginative power, the ability to invent new stratagems of learning, and it bordered not only on mathematics and philosophy but also on psychology and logic. In this way, a centuries-old European tradition was renewed and transplanted into the United States where Pólya had tremendous influence on subsequent generations of mathematics teachers well into the 1970s. In 1971, the aged mathematician received an honorary degree at the University of Waterloo, where he addressed the Convocation, calling for the use of "heuristic proofs":

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[12] Paul Kirkpatrick, Acting Dean, School of Physical Sciences, Stanford University, Course outline, September 4, 1945, George Pólya Papers, SC 337, 87-137, Box 2.

[13] G. Pólya, "Elementary Mathematics from a Higher Point of View," Survey of Typical Questions, George Pólya Papers, SC 337, 87-137, Box 3.—Pólya was indeed very well read and liked to show his erudition by quoting Socrates, René Descartes, Gottfried Leibniz, Immanuel Kant, Herbert Spencer, Thomas Arnold, J. W. von Goethe, Leonhard Euler and his famous colleagues such as Albert Einstein, and many others. George Pólya Papers, SC 337, 87-034. Box 1&3, 87-137, Box 2, Department of Special Collections and University Archives, Stanford University Libraries, Stanford, CA.

[14] Untitled course description, n. d. George Pólya Papers, SC 337, 86-036, Box 1, Folder 3.

[15] A good example was the Second International Congress on Mathematical Education at the University of Exeter, England. Cf. the invitation sent to Pólya by the Chairman of the Congress, Professor Sir James Lighthill, FRS, June 23, 1971. [Cambridge] George Pólya Papers, SC 337, 87-034, Box 1.

> In a class for future mathematicians you can do something more sophisticated: You may present first a heuristic proof, and after that a strict proof, the main idea of which was foreshadowed by the heuristic proof. You may so do something important for your students: You may teach them to do research. (Pólya, G. 1971)

"Heuristics should be given a new goal," Pólya argued, "that should in no way belong to the realm of the fantastic and the utopian." (Pólya, G. 1964, 5).

Throughout his career as a teacher, he strongly opposed believing in what authorities profess. Teachers and principals, he argued, "should use their own experience and their own judgment."[16] His matter-of-fact, experience-based reasoning has been repeatedly described in books and articles. He even made two films on the teaching of mathematics (*Let Us Teach Guessing,* an award winner at the American Film Festival in 1968; *Guessing and Proving,* based on an Open University Lecture, Reading, 1962).[17]

Pólya had lasting influence on a variety of thinkers in and beyond mathematics. The first curriculum recommendation of the [American] National Council of the Teachers of Mathematics suggested that "problem solving be the focus of school mathematics in the 1980s" [in the U.S.]. The 1980 NCTM Yearbook, published as *Problem Solving in School Mathematics,* the Mathematical Association of America's Compendia of Applied Problems and the new editor of the *American Mathematical Monthly,* P. R. Halmos, all called for more use of problems in teaching.[18] Pólya was an integral part of the "problem solving movement" that cut a wide swath in the 1980s (Schoenfeld, A. H. 1987, 595. Cf. Groner, R. et al. 1983; Brown, S. I. and Walter, M. E. 1983). Philosopher Imre Lakatos, a fellow-Hungarian who described mathematical heuristics as his main field of interest in 1957, acknowledging his debt to Pólya's influence, and particularly to *How to Solve It,* which he translated into Hungarian.[19]

Critics, however, like mathematician Alan H. Schoenfeld, pointed out that while Pólya's influence extended "far beyond the mathematics education community," "the scientific status of Pólya's work on problem solving strategies has been more problematic." (Schoenfeld, A. H. 1987, 595). Students and instructors often felt that the heuristics-based approach rarely improved the actual problem-solving performance itself. Researchers in artificial intelligence claimed that they were unable to write problem solving programs using Pólya's heuristics. "We suspect the strategies he describes epiphenomenal rather than real." (Schoenfeld, A. H. 1987, 596). Recent work in cognitive science, however, has provided methods for making Pólya's strategies more accessible for problem solving instruction. New studies have provided clear evidence that students can significantly improve their problem-solving performance through heuristics (Schoenfeld, A. H. 1985). As suggested by Alan H. Schoenfeld, "[i]t may be possible to program computer knowledge structures capable of supporting heuristic problem-solving strategies of the type Pólya described." (Schoenfeld, A. H. 1987, 596).

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[16] George Pólya to Robert J. Griffin, Stanford, June 12, 1962. George Pólya Papers, SC 337, 87-034, Box 2.

[17] George Pólya to Anthony E. Mellor, Harper and Row, Stanford, March 11, 1974; Stanford University News Service, February 17, 1969. George Pólya Papers, SC 337, 87-034, Box 1.

[18] [Untitled MS, n.d. The organizers' choice of George Pólya]. George Pólya Papers, SC 337, 87-034, Box 2, —Cf. P. R. Halmos, 1980, 519–524. .

[19] Imre Lakatos to Dr. Maier (Rockefeller Foundation), Cambridge, England, May 5, 1957. George Pólya Papers, SC 337, 87-137, Box 1.—In turn, Pólya expressed his admiration for Lakatos's "Proofs and Refutations," and recommended him as Professor of Logic at the London School of Economics and Political Science, "with special reference to the Philosophy of Mathematics." George Pólya to Walter Adams (LSE), Stanford, CA, January 13, 1969, George Pólya Papers, SC 337, 87-034, Box 1.

3 Schooling

The outstanding success of education, and mathematics education in particular, underlines the significance of the Hungarian school system from the turn of the century until World War II. The secret of Hungary's émigré geniuses is partly the secret of Hungarian high schools before World War II and the result of a systematic effort in Hungary to develop an educational system along German lines. The Hungarian *gimnázium* was modeled upon the German *Gymnasium* and this was a studied effort on behalf of the new Hungarian government established after the Austro-Hungarian Compromise of 1867.[20]

3.1 The *Gymnasium* Imported

The architect of this admirable knowledge transfer was Mór Kármán (1843–1915), one of Hungary's most renowned educational experts, a pedagogical reformer and the father of Theodore von Kármán. Kármán, Sr. (originally Kleinmann) came from a distinguished Jewish-Hungarian background, studying philosophy and classical philology at the University of Vienna and receiving his Ph.D. in Budapest in 1866. In 1869, the able young educational philosopher was commissioned by Minister of Religion and Education Baron József Eötvös (1813–1871) to Leipzig, Saxony (in Germany), to study pedagogy and the modern theory and methods of training high school teachers, under the philosopher Professor Tuiscon Ziller (1817–1882), founder of the pedagogical seminar at Leipzig.[21] Upon returning from Germany in 1872, Eötvös's immediate successor, Tivadar Pauler, helped him introduce the German system in Hungary and found the Institute for Teacher Training at the University of [Buda]pest, as well as the "Practicing High School," or *Model-gimnázium,* for prospective teachers, thus profoundly influencing Hungarian education in a German spirit and tradition (József Eötvös to Mór Kleinmann, *loc. cit.* 1–2; cf. Sőtér, I. 1967; Mann, M. 1982). Mór Kármán himself became director of the school, which all four of his sons, including Theodore, attended.

Becoming Hungary's foremost expert on education, Mór Kármán was elevated to the Hungarian nobility in 1907,[22] and became a full professor at Budapest University in 1909. He belonged to the assimilated Jewish upper-middle class of Hungary, and married into a well-connected family through which he was distantly related to the titled Jewish aristocracy of Hungary.[23] Mór Kármán felt himself close to Hungarian culture, and studied Hungarian literature.[24]

Some of the high schools developed under Kármán's oversight were connected in various ways with the University of Budapest. Graduating university students were

[20] There were three types of *gimnázium* in Hungary: the regular *gimnázium* [high school] spanned over 6 years, the *algimnázium* [lower high school] 4 years, the *főgimnázium* [main or full high school] 8 years. .

[21] B. József Eötvös, Minister of Religion and Education to Mór Kleinmann, Buda, July 20, 1869. No. 12039, Theodore von Kármán Papers, 142.10, California Institute of Technology Archives, Pasadena, CA.

[22] Mór Kármán had some responsibility for planning the education of one of the Habsburg Archdukes and he received his title partly for this reason. Cf. McCagg, W. O., Jr. 1972, repr. 1986, 209, note 46—it was this title that Theodore von Kármán used in a Germanized form.

[23] Theodore von Kármán, Untitled note on Mór Kármán, Theodore von Kármán Papers, 141.6, California Institute of Technology Archives, Pasadena, CA. Cf. Gerő, J. ed., 100, McCagg, W. O., Jr. 1972, repr. 1986, 209; Újváry, P. szerk. 1929, 453–454.

[24] Mór Kármán, Az Ember Tragédiája. Elemző tanulmány [The Tragedy of Man. An analytic study] (*Budapesti Szemle*, 346, 1905).—It is interesting to note that *The Tragedy of Man* was also a source of inspiration for other Hungarian émigré scientists such as Leo Szilárd.

expected to do their practice teaching in “model” high schools. High school teachers themselves were expected to do original research and be published regularly, both in- and outside of Hungary. The most eminent teachers were invited to give university courses; some even became professors and were elected members of the Hungarian Academy. The faculty of the best high schools in Budapest enjoyed a privileged position and high social prestige.

Defined by the act 1924:XI, high schools in Hungary were of three kinds: the *gimnázium*, the *reálgimnázium,* and the *reáliskola*. The *gimnázium* provided an all-round humanistic education, based primarily on studies in Latin and Greek language and literature. The *reálgimnázium* added modern languages and literatures to Latin, while the *reáliskola* gave a careful introduction to arithmetic and natural sciences and focused on modern languages alone.

The *gimnázium* was an élitist school for the select few. In Budapest, there were 38 high schools with around 16,000 students in 1914–1915, 46 high schools with 21,356 students in 1929–1930, and 81 high schools with 32,111 students in 1942–1943. In 1929–1930, there were only 7 *gimnázium*s with 3,482 boys and another 7 with 2,907 girls, 14 *reálgimnázium*s with 8,167 students, and 7 *lycée* type schools for girls with 3,262 students. Altogether, 3,250 students attended the seven *reál*schools. Even in 1941–1942, there were only twentysix g*imnázium*s for boys and seven for girls, with ten *lycée*s, while the other twentyfour schools were industrial, agricultural, commercial, and business in nature (Horváth, M. szerk. 1980, 480; Illyefalvi [sic], L. I. 1931, 426–427; Illyefalvy, L. szerk. 1943, 346–347).

Most high school students came from the sheltered and privileged social background of a narrowly defined middle class. For many years, these schools were all-male domains: the first *gimnázium* for girls was not opened in Austria until in 1892 and 1896 in Hungary. For socially aspiring Jewish students in particular, these schools acted as social equalizers, a much sought-after opportunity to integrate, emancipate, and assimilate into the emerging Hungarian “gentlemanly” middle class. Upon reaching the age of eighteen, the state-controlled, uniform system of Hungarian final examinations brought high school studies to a demanding, challenging conclusion, and catapulted young men into the Hungarian élite. (Karády, V. 1997, 169–194).

The choice by many Jewish students (or their parents) to attend various Christian denomination high schools in the early twentieth century was related to the phenomenon of religious conversion. Though these schools were of exceptionally high quality (Lukacs, J. 1988, 142–146), sending children of Jewish origin to them expressed a willingness to assimilate. The Lutheran high school at Városligeti Fasor in Pest was a case in point, with dozens of extremely capable Jewish boys among the students every year. Notable examples were John von Neumann and prospective Nobel laureate Eugene P. Wigner. Teachers in these schools excelled in their field, as well as in the art of teaching, and several were recognized members of the scientific and scholarly community of Hungary (Kovács, L. 1995).

The number of Jewish students in the *gimnázium*s was 1,022 (out of the 2,806 who actually graduated and in the *reálgimnázium*s there were 1,956 (out of 7,806). Altogether, 3,408 boys and 2,122 girls were Jewish out of the total of 14,142 boys and 6,384 girls who completed high school of some sort. By 1941–1942, the number of Jews who attended *gimnázium*s was 3,742 (out of 21,369), altogether totaling 4,365 Jewish students from an overall high school student body of 30,730 (Illyefalvi, L. I. szerk. 1931, 426–427; Illyefalvy, L. szerk. 1943, 346–347).

3.2 The Model High School

The *Mintagimnázium* [model high school], founded and first directed by Mór Kármán, was best described by his son Theodore von Kármán, himself a student of this school.

> The Minta, or Model Gymnasium, was the gem of my father's educational theories. It was designed to be directed by a professor at the University but to maintain an independent status. It became the model for all Hungarian high schools and today is quite famous in Hungary, though little known in the West. Recently, however, its high standing over the years was noted by a writer for the London *Observer*, who called the Minta a "nursery for the elite," and compared it with such schools as Eton for Conservative M.P.'s and [the Institut] Le Rosey [in Switzerland] for ex-kings and socialites. The Minta graduated two of Britain's top economists, Dr. Thomas Balogh of Balliol College (a son of one of my cousins) and Nicholas Kaldor of King's, Cambridge. … (Theodore von Kármán with Lee Edson, 1967, 20–21).

As in all the *gimnázium* throughout Hungary, Latin was of paramount importance. Until the end of 1844, Latin was the state language of Hungary and educated people were all expected to read and write classical Latin. The study of Latin was also viewed as being useful for training the mind, strengthening the memory, and introducing the student to a complex system: Latin grammar.

> For me the Minta was a great educational experience. My father was a great believer in teaching everything—Latin, math, and history—by showing its connection with everyday living. In our beginning Latin class, for instance, I remember that we did not start with rules of grammar. Instead we were told to walk around the city and copy the Latin inscriptions on statues, churches, and museums. There were many of these to be found, since Latin was the official language in Hungary until 1848.[25] When we had collected the phrases and brought them to class, the teacher asked us which words we already knew. We usually could recognize a few words among the phrases. If we didn't, we looked them up. Then he asked us if we recognized the same word in different forms. Why were the forms different? Because they showed different relationships to other words in the inscription. We continued in this way until we understood each phrase and why it was placed on the monument. As a result of this practice, we all accumulated a Latin vocabulary which we retained and we deduced some fundamental rules for inflection of the Latin word. We also learned something of Hungary's past (Theodore von Kármán with Lee Edson 1967, 20).

Theodore von Kármán remembered fondly his Mathematics classes which also were based on inductive methods and related to practical life. (Another future celebrity from Budapest, Edward Teller, profited from these same classes.) Von Kármán drew an important parallel between his classes in Latin and in Mathematics, the two cornerstones of Hungarian education in the *gimnázium*.

> Mathematics, which I now studied eagerly, was taught in terms of everyday statistics and it had a fascination for me all over again. For instance, we looked up the figures on the production of wheat in Hungary for several years. We set up tables and then drew graphs, so we could observe the changes and locate the maximum and the minimum wheat production. In the diagrams we searched for correlations, and we learned about "the rate of change," which brought us to the edge of the calculus. We thus learned in a practical way that there was a relationship between quantities that varied, and, as with Latin, we learned at the same time something of the changing social and economic forces in the country.
> At no time did we memorize rules from the book. Instead we sought to develop them ourselves. I think this is a good system of education, for in my opinion how one learns the elements of reasoning in primary school will determine his later capacity for intellectual pursuits. In my case the Minta gave me a thorough grounding in inductive reasoning, that is, deriving general rules from specific examples—an approach that remained with me throughout my life (Theodore von Kármán with Lee Edson 1967, 21–22).

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[25] Until the end of 1844 only. TF.

Mór Kármán was also a pioneer in initiating "practice teaching" in his school, regularly inviting graduating university students from various disciplines to acquire practical experiences for their future careers as high school teachers.

> In addition to introducing what were then novel methods of teaching, my father also started at the Minta the system of practice teaching by university graduate students. Some educators opposed this plan: it would expose us to inexperienced teachers, the *koca* (sows) as we high school students ungraciously called them. My father, on the other hand, firmly maintained that students would find it an advantage to learn as early as possible to distinguish between good and bad teaching.

The *Minta* school also provided a more democratic model, regarding especially teacher-student relations, which in most Hungarian and Austrian schools were traditionally rigidly formal and inpersonal.

> The Minta was the first school in Hungary to put an end to the stiff relationship between the teacher and the pupil which existed in the Empire [the Austro-Hungarian Monarchy] at the time. In the corridors of the Minta the teachers moved constantly among the pupils. Contrary to the practice in other high schools, students could talk to the teachers outside of classes and could discuss matters not strictly concerning school. The charter of the Minta declared in writing for the first time in Hungary that a teacher might go so far as to shake hands with a pupil in the event of their meeting outside class (Theodore von Kármán with Lee Edson 1967, 20–22).

3.3 The Lutheran High School

John von Neumann and Nobel Laureate Eugene Wigner attended the Lutheran *Gymnasium* in Budapest, became two of its top students and in turn made it internationally recognized (Dobos K. et al. 2002, 66–109; Macrae, N. 1992, 61–84).

The origins of the Lutheran *gimnázium* of Pest go back to the late 18th century (Karády, V. 1987, 95–110). The earliest motor behind the school was Lajos Schedius (1768–1847), the enlightened, Göttingen-educated professor of philosophy at the University of Pest whose anonymously published *Die Schule der evangelischen Gemainde A. C. in Pesth* (1816) emphasized the public nature of schools, and the importance of quality training of teachers, and spoke against the practice of mere recitation, calling instead for the emotional development of students. Much of the philosophy behind Lutheran education in Hungary came from the Swiss educator Johann Heinrich Pestalozzi (1746–1827) (Dobos K. et al. 2002, 8–9).

Lutheran schools mushroomed in the country; there were some twenty of them outside the city of Pest. The Pest school was so popular that it had to move to a new building in 1864 and then again in 1904. Erected in the *Városligeti fasor*, an elegant and fashionable street that runs parallel to Budapest's most prominent avenue, Andrássy út, the new building was one of the most up-to-date schools in contemporary Hungary. Designed by architecture professor Samu Pecz, the building was fully equipped with electricity and steam heating, 18 large class rooms, 14 cabinets for teachers and classroom demonstration material, dark rooms for experiments with light, film projection and photography, a six-room library, a five-room apartment for the director, a specially paved gym, and a huge community room for celebrations. By the beginning of the century, there were 12,000 volumes in the library, which subscribed to some 20–30 foreign journals, half of them in German and English. As of 1901–1902, the supervisor of the library was no less a person than Sándor Mikola, the celebrated teacher of physics and prospective director of the school (Dobos K. et al. 2002, 10–13).

The Lutheran Church of Hungary was convinced, however, that it was not the material equipment but the quality of the faculty that defined education. "Good teacher = good school" as the almost mathematical equation suggested in the school's 1922–1923 yearbook. Members of the faculty were near the level of university professors, with fourteen having graduated from the Eötvös Collegium, a Budapest version of the *École Normale Supérieure* in Paris, founded by Loránd Eötvös in 1895 to commemorate his father, Baron József Eötvös.[26]

Many of the best teachers also studied in Germany, among them Károly Bőhm, Gedeon Pecz, János Loisch, Aurél Bászel, Sándor Dietze, Rudolf Weber, and Róbert Fröhlich, who studied with Theodor Mommsen. Several of the teachers went on to become university professors, such as Dezső Kerecsényi, who later taught Hungarian literature in the University of Debrecen, botanist Sándor Sárkány at the University of Budapest, mathematician Ágoston Schultz at the Technical University of Budapest; and the mathematician and physicist János Renner, who became the director of the Institute of Geophysics in Budapest. About two-thirds of the teachers in the *Fasor* regularly published in the most important (typically Hungarian) journals of their own field (Dobos K. et al. 2002, 13–18).

Two important members of the faculty who had a major impact on John von Neumann were the mathematician László Rátz and the physicist Sándor Mikola. It is enlightening to assess the source of their impact.

A member of the *Fasor* faculty for 35 years, László Rátz (1863–1930) studied in the Lutheran *lycée* of Sopron, and the universities of Budapest, Berlin and Strassbourg. He treated all of his students equally and made them love his subject by demonstrating how best they could approach it at their own particular level. This highly individualized treatment brought the subject closer to students, irrespective of the nature of their own individual talent. He documented the practical aspects of mathematics and made its usefulness come alive. As editor of *Középiskolai Mathematikai Lapok* [High School Papers in Mathematics], he turned the school into a national center of mathematics teaching and made problem-solving into a national mathematics education program. He published the material of the first ten volumes in his *Mathematikai gyakorlókönyv* [Problem Book for Mathematics] in two parts (algebra and geometry), which became one of the basic textbooks of mathematical problem-solving worldwide. Many outstanding Hungarian mathematicians and scientists received their basic training in mathematics, and particularly mathematical problem-solving, through the work of László Rátz. As an acknowledgment of his role in modernizing mathematics education in 1909, he became the Hungarian member of the international committee for mathematics education and attended the congresses of Milan, Cambridge, and Paris. He was at his best when discovering, acknowledging, and nurturing talent and making his difficult subject generally well-liked and appreciated (Dobos K. et al. 2002, 27–45).

As a teacher of mathematics, Rátz was a pioneer in introducing the elements of infinitesimal calculus and made the concept of *the function* a central aspect of his teaching. He published his new educational ideas along with colleague Sándor Mikola in 1910 under the title *Az infinitezimális számítások elemei a középiskolában* [Elements of infinitesimal calculus in the high school] (Miklola, S., Rátz L., 1910) which they later published in a new, improved edition as *A függvények és az infinitezimális számítások elemei* [Elements of function and infinitesimal calculus] (Miklola, S., Rátz L., 2nd ed. 1914).

[26] The case of the Collegium clearly demonstrated that Hungary's new intellectual élite was rooted not only in the middle- and upper-middle class of Budapest but also in the provinces, thus producing at least two, often competing factions. The Collegium provided a framework for the training of an élite, with its pool of young people coming mainly from the Hungarian countryside. Cf. Karády, V. 1986..

Like his friend László Rátz, Sándor Mikola (1871–1945) was also a student of the Lutheran *lycée* of Sopron and of the University of Budapest where he studied with the Eötvös-student János Renner and met Loránd Eötvös himself. He became a teacher at the Lutheran *gimnázium* in 1897 and remained a member of the faculty until his retirement in 1935. He was director of the school between 1928 and 1935, and co-editor, with Lipót Fejér, of *Mathematikai és Fizikai Lapok* [Papers in Mathematics and Physics] (Kovács, L. 1995, 5–7; Dobos, K. et al. 2002, 46–65). Mikola was an active experimental physicist whose studies on electricity were rewarded with a membership of the Hungarian Academy of Sciences in 1923. He was an enthusiastic teacher and educator, who loved his work as well as his students. He thrived when free to choose his working methods and put into application exact scientific terms such as the notion of development, the use of analogies and the creation of models (Kovács, L. 1995, 21). For him, the notions of physics were born and developed rather than merely existing in a physical form: physical reality is the result of a process and not an existing set of facts. The teaching of physics started with either qualitative or virtual experiments, which helped students to develop their notions of physics (Beke, M. and Mikola, S. 1909). Mikola was enthusiastic about the inductive and heuristic method, which he believed was especially created for physics (Kovács, L. 1995, 22–24).

> By applying appropriate questions the teacher tries to direct the thinking of his students to the subject, to help the subconscious experiences and making their instinctive mechanical notions conscious, to turn the direction of their thinking toward selecting the important, to develop their ability to observe and analyze, to enlighten the development of abstract physical notions and keep their interest in the subject by inspiring the necessary stimuli constantly awake… (Kovács, L. 1995, 25).

He developed his principles of physics over the writing of several books such as *A physikai alapfogalmak kialakulása* [The development of the basic terms of physics] (1911), *A fizika gondolatvilága* [The mind of physics] (1933) and *A fizikai megismerés alapjai* [The basics of physical cognition] (1941), which brought him full membership of the Academy by 1942 (Kovács, L. 1995, 57).

3.4 The University of Hungary

In the 18th and 19th centuries the Central European university was strongly influenced by the Prussian/German model, and particularly by the ideas and activities of Wilhelm von Humboldt (1767–1835). Von Humboldt persuasively argued for a university that the State of Prussia should possess, and his vision of a state-run university had a wide impact not only in the various states of Germany but also throughout Central/East-Central Europe. „The Prussian State," he declared when lobbying for the University of Berlin in 1810, „has no other means, and no state may possess a nobler one to distinguish and honor itself than through the loving support of the sciences and arts." Culturally speaking, East-Central Europe has always been on the fringes of Germany, heavily influenced by German ideas, German art, German science and German scholarship. The Central European university cannot be understood without the proper study of, and a comparison with, its German opposite numbers. Hence their high quality, their competitive edge, but also their strictly hierarchical nature and authoritarian philosophy. Particular forms of teaching such as the seminar as we know it even today spread largely from Germany, particularly from the University of Berlin where famous scholars like the historian Leopold von Ranke (1795–1886) introduced and developed it for an intellectually élitist consumption. The most important university in Hungary has for a long time been Eötvös Loránd University of Budapest, named after the great Hungarian physicist and one time Rector of the University, Loránd Eötvös (1848–1919, son of Baron József) (Kornis Gy. szerk. 1936, 54–57, 121–180). One of the top fifteen universities of the world at the end of the 19th century, this university awarded John von Neumann his doctorate in mathematics in 1926. The oldest Hungarian university currently in service, the university was founded as a Jesuit institution by Péter Cardinal Pázmány (1570–1637) in 1635 in Nagyszombat (today Trnava in Slovakia). At a time when much of Hungary was still under Ottoman occupation, Pázmány expressed his desire to move his University of Hungary *(Universitas Hungariae)* in the future from the small city of Nagyszombat to a more suitable location after the liberation of the country. In the meantime he entrusted the university to the Jesuits of Nagyszombat and designed it as a center of the entire educational system of Hungary. International in its ideological foundations, Pázmány's work was instrumental in preserving Hungarian national culture at a time when Hungary was dominated by a major foreign power. This indeed signaled the recurring double function of higher education in not only Hungary but in many different areas of Europe: it served both cosmopolitan and national functions and interests.

When the Jesuit order was dissolved by Pope Clement XIV in 1773 *(„Dominus ac Redemptor noster")* it was the Empress Maria Theresa (1740–1780) who moved the university to Buda (much later, in 1873, to become a part of Budapest) in 1777 and tried to include it (as well as all other universities of her Empire) into a Habsburg system. The Empress made every effort to make this as well as all the other imperial universities resemble the University of Vienna: *„Universitati Vindobonensi per totum conformentur".* In the history of the university this was one of the many subsequent steps towards centralization. Her son, the Emperor Joseph II went even further when making the University one of his many government offices, which ultimately simply denied the university faculty and the academic leadership any interference in university matters: *„nec decanis facultatum, nec magistratui academico aliquis influxus in res litterarias concedendus est".* These ideas and efforts started a long tradition of state intervention in the entire area that came gradually to replace church governance and have lasted indeed until today. Practically no government in Hungary ever tolerated the autonomy, let alone sovereignty of the universities and tried to place them under the tutelage of the state. This ideology was made into a compact philosophy by the German philosopher Georg Wilhelm Friedrich Hegel (1770–1831) and his vision of the state as an absolute (in the words of Thomas Mann, *„Staats-Verabsolutierung"*) (Mann, Th. 1938, 60). Not even the ministry of the democratic revolution of 1848 restored the autonomy of the university, ordering it under the direct control of the minister of education. One must add that the language of tuition was Latin until the very end of 1844 when it was belatedly replaced by Hungarian.

Without even trying to present the complete history of this one university as a case study, it is imperative to note that all this was done to the University of Hungary centuries before Communism: practically all subsequent (and very different) political regimes took a nearly absolute control over this institution of higher learning. The foundations of centralization, anti-democratic leadership, ideological control, and the direct interference of the state were all there in the early history of this great institution.

This once so famous institution suffered the consequences of merciless state interventions under the Communist regime, particularly between 1949 and 1956. A school that at the end of the 19th century belonged to the top fifteen universities of the world is today in the 301–400 range of the Shanghai academic ranking of the top 500 world universities (provided by the Jiao Tong University), was Nos. 376–377 on the list of *The Times Higher-*

QS World University Rankings 2006, and No. 351 on the *Webometrics* list in January 2007.[27]

3.5 V Fascination with Science

Several economic and social factors contributed to the emergence of the high level in science and science education at the time of the rise and fall of the Austro-Hungarian Monarchy. In a country where the long decay of feudalism had become visible and the political and social system based on huge landed estates had come under sharp attack, the beginnings of a new, capitalist society stimulated work in science, technology, and the arts. The transformation of the Habsburg Monarchy and the creation of a "Hungarian Empire" contributed to an economic prosperity that brought about a building and transportation boom, the advancement of technology, and the appearance of a sophisticated financial system. The rise of a new urban middle-class affected the school system.

Modern Hungarian science was rooted in the highly selective and élitist educational system of fin-de-siècle Hungary's high schools, the competitive spirit introduced in mathematics and science education in the form of high school competitions and journals specialized in high school mathematics and physics. Members of the high school faculties were, at least in the very best schools, outstanding science educators and outstanding scientists themselves, several of them close to the level of university professors. The Liberal spirit of much of the era contributed to the relatively high degree of the freedom of teaching and learning. The denominational high schools played an important role, though usually with a limited role on religious education and a greater emphasis on free thinking.

The strong attraction of some of the best German universites played a major role in Hungary. Berlin, Göttingen, Heidelberg and other German centers of learning lured subsequent generations of outstanding Hungarian students and had a strong impact on Hungarian science and science education. The German cultural and scientific background prevailed throughout Hungary, where German as a language was widely used in the period of the Austro-Hungarian Monarchy. German culture permeated most branches of Hungarian civilization, which developed for a long time, as it were, on the fringes of the great German world of education, science, and culture.

The end of the period came right after World War I. Hungary, within the Austro-Hungary, was one of the loosers of the War and had to suffer the consequences: two revolutions, a counterrevolution, the Peace Treaty of Trianon (1920), and the *Numerus Clausus* act of 1920. Hungarian society underwent momentous changes, loosing vast territories, large groups of ethnic *Magyars*, experiencing decline and initiating the disastrous policy of revisionism which attached the country to Germany and its allies. The golden age of Hungarian development was over.

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