Robert H. Goddard: The Proto-Plan WPI Student

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ABSTRACT

The goal of this project was to compare and contrast Robert Goddard's program of study while enrolled at Worcester Polytechnic Institute with the various components of the educational philosophy of the WPI Plan. Materials regarding both Robert Goddard and the WPI Plan were thoroughly examined, including the original reports of the WPI Planning Committee titled *The Future of the Two Towers*, Robert Goddard's journals and diaries, as well as various primary source materials held in the archives from Robert Goddard's residency at WPI. The ultimate result this report aims to achieve is to paint Robert Goddard as a prototype for the WPI Plan's objectives, and to affirm that WPI is going in the right direction for the education of modern scientists and engineers.

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1. INTRODUCTION

Ever since 1971 Worcester Polytechnic Institute (WPI) has been committed to a long term and rather extensive educational experiment titled the WPI Plan. In the previous one hundred years of the schools existence the faculty and students developed a feeling that WPI was becoming no more then a trade school. The graduates were becoming career mechanics and construction specialists, even the physicists and chemists would only go as far as teaching and never going on to become distinguished researchers. The only exception to this fact seemed to be the distinguished graduate of the class of 1908, Robert Goddard, and the WPI Plan was created to fix the problems of the first one hundred years. The problem then is to look at what was different between Goddard's experiences and those of his fellow classmates, and to look at the educational system now under the WPI Plan along with Goddard's education, to see if WPI is on its way to producing more distinguished graduates. In a way, was Robert Goddard the prototypical WPI Plan student and what, if anything can be done to make the Plan better equipped for its mission?

Everyone loves a hero, everything and everyone that can be seen as successful always seems to have one. As for locations, the heroes are the people who hailed from those locations and became successful, people who defeated all of the odds and distinguished themselves above the rest. For example in Boston it may be a baseball player who went to pitch the Red Sox to a Championship or an MIT graduate, in Hollywood you might find an actor who was born and raised where you live and grew up who actually made it. For Worcester, MA and Worcester Polytechnic Institute there is Robert Hutchings Goddard, the man who was made famous by laying the foundation for

modern day rockets and arguably laid the foundation for recent developments in space travel. The question is, what was peculiar about this citizen of Worcester that distinguished him, and increasingly important is what about Worcester Polytechnic Institute prepared Robert Goddard to be the legend he became.

Worcester Polytechnic Institute is an engineering college in Worcester, MA that was founded in 1865 by two local donors John Boynton and Ichabod Washburn based on the ideals of theory and practice (Lehr und Kunst). This was unlike other colleges of the time because conventional colleges only taught theory and left out the practical aspects of education. On the other hand, the traditional apprenticeship system for tradesmen only taught practicality and not the theory behind their trades. This combination of theory and practice was unheard of at the time in education and was revolutionary with the vast improvements to come within industry. However, along with revolutionary ideas often comes a certain level of error, and the new Worcester Tech had its fair share.

2. BACKGROUND TO ROBERT GODDARD

2.1 EARLY LIFE

Before Worcester Polytechnic Institute and rockets or space travel, Robert Goddard was an everyday child born in Worcester, MA on 5 October 1882. "The Heart of the Commonwealth" as it was and still is known, Worcester was a busy, urban city that characterized the Industrial Revolution of the time. The hills of Worcester were covered with the factories of the Washburn wire companies, or the Norton and Heald machine tool companies; Worcester produced countless products important in everyday life. However, the mind was certainly never neglected, there were six colleges in Worcester while Goddard grew up, and several concert halls, and Boston was only a short car or train ride away with its own wealth of history. If there existed a city on the rise during the Industrial Revolution it was Worcester, and young Robert Goddard was born right in the middle of it. (*The Rocket Man*, pp. 6-7)

Goddard grew up in the household of Nahum and Fannie Goddard, initially in Worcester and then to Roxbury for a short period before returning to Worcester. Robert Goddard's father Nahum was a bookkeeper and later a machinist for several prominent machine knife companies in Central Massachusetts. In the various materials for a potential autobiography written in 1927, Goddard mentions how he and his father would go hiking and shooting and that it was his father who introduced Goddard to photography (*Papers of R.H. Goddard Vol.1*, Pg. 4). Later on Goddard would go on to credit his father's efforts with his own love of nature (*The Rocket Man*, Pg. 8).

In his early years of schooling there was never any real mention of Goddard being a spectacular student. Despite being overwhelmed with a curiosity about the natural

world, in his "Material for an Autobiography" Goddard mentions he took the entrance examinations to Roxbury Latin School with his friends solely because of the boredom he faced in grammar school—an examination which Goddard had not passed. However, one note that was made of this examination was that Goddard had an aptitude for arithmetic, an aptitude which Goddard believed to be an average ability at best. Arithmetic would be a foundation for his later problem solving skills, as he noted arithmetic "…had merely been a subject in which I had continually made mistakes, and achieved poor or unsatisfactory grades" (*Papers of R.H. Goddard Vol.1*, Pg. 5). This early run in with learning the hard way would later be testament to the physicist he would become, someone who tried often and failed but continued trying.

2.2 DREAM OF SPACE TRAVEL

In future years Goddard's interest in science would erupt; his interest in science fiction would spark an interest that would eventually set his entire career in motion. In January of 1898 Goddard was introduced to H.G. Wells' "War of the Worlds", an event that Goddard would later describe by saying "Wells' wonderfully true psychology made the thing very vivid, and possible ways and means of accomplishing physical marvels set forth kept me busy thinking" (*Papers of R.H. Goddard Vol.1*, Pg. 7). This interest would set forth multiple experiments in reaching the heavens, including his balloon experiments later on in the same year. In his autobiographical materials Goddard mentioned how in the spring of 1898, "…perhaps because the sky appeared so attractive", he tried a rather ordinary experiment for a young man in attempting to fly a balloon. However, this balloon was not a rubber one filled with helium; Goddard instead wanted a self-sufficient aluminum balloon filled with hydrogen like the space vessels in his science fiction books.

Despite the failure of this experiment, rather than quitting Goddard discovered the problem was the weight and thickness of the aluminum and strove to correct it.

Experiments would ensue as everyday life continued. In 1899 Goddard's mother became extremely sick and he was also withdrawn from school. Among all other playthings a boy might have come up with back then, Goddard had a cherry tree in his back yard. On October 19, 1899, while cutting off limbs of the tree to no doubt build a tree-house of some sort, he looked patiently off to the fields in the east, "imagining how wonderful it would be to make some device which had even the possibility of ascending to Mars, and how it would look on a small scale, if sent up from the meadow at my feet" (*Papers of R.H. Goddard Vol.1,* Pg. 9). This event would later be memorialized by Goddard in his calendars and journal entries as "Anniversary Day", in which he decided to devote his life to the attainment of space travel.

2.3 ILLNESS

Something that altered Goddard's entire way of life came around the same time as his initial interest in space travel. Throughout his youth Goddard was always a thin and frail child, constantly recorded as getting sick. Since his younger brother Richard died of a spinal deformity at less than a year old, his family paid particular attention to any signs of ailment among their only remaining child. In 1898, when his mother came down with tuberculosis, and young Robert complained of stomach pains, the family was not going to take the risk of losing their son to tuberculosis and the stressful environment of schooling—so they withdrew Goddard from school in the fall of 1899.

Once again Goddard proved incapable of being discouraged, instead of taking his illness and using it as an excuse to give up; he used it to reinvigorate his interests. It was

during his withdrawal that his "Anniversary Day" occurred, and that Goddard wrote several inquiries to the Harvard Observatory regarding satellites and projecting apparatus as well as investigated centrifugal force and Newton's Laws. Though not in school, Goddard was certainly never idle, always keeping busy with new ideas for research and study.

Goddard spent two years out of school when he decided he had been away for to long. In his "Material for an Autobiography" he mentions that at the end of his sabbatical he came to the conclusion that he did not have enough mathematical or physical knowledge to solve the problem of space travel and was determined to go back to school (*Papers of R.H. Goddard Vol.1,* Pg. 10).

Just before his nineteenth birthday Goddard enrolled in South High School of Worcester in the sophomore class in 1901, much older than his fellow classmates, he was also much more mature. His interests and his experiences with illness gave him a much deeper understanding of the importance of an education. Early on in his sophomore year at South Goddard wrote an essay titled "The Navigation of Space". Unlike previous experiences where Goddard tried to solve the problem, this time he knew he could not solve the problem, but brainstormed the problem itself including what it would take to propel an object into space (*Papers of R.H. Goddard Vol.1,* Pg. 57). Goddard submitted this article to *Popular Science News,* and though the article was not accepted it certainly set Goddard on the right track (*Papers of R.H. Goddard Vol.1,* Pg. 10).

Propulsion became a topic of high interest that occupied a lot of Goddard's time for his next years at South High School. He experimented with various machine gun types of devices along with studying gyroscopes, even researching the semicircular

canals of the human ear, as they maintain the human body's equilibrium and are strongly related to balance. On a social front, young Robert took to seizing the day, he was elected class president twice, played piano, was a member of the debate team, and even started dating a young girl named Miriam Olmstead. After his experience of being deprived of his desire of knowledge by ailment, Goddard took full advantage of his education at South. This is proven by him being chosen to speak at his graduation ceremony, and he did so by delivering a speech titled "On Taking Things for Granted" (*Papers of R.H. Goddard Vol.1*, Pg. 63). In this speech Goddard examines the history of science to show that the errors of the past were caused by taking things for granted and closed with the thought that it is difficult to say what is impossible, for the "dream of yesterday is the hope of today and the reality of tomorrow" (*The Rocket Man*, Pp. 18-19).

2.4 WORCESTER TECH

After graduating from South High School, Goddard enrolled at the Worcester Polytechnic Institute to major in general science, focusing on physics in hopes of achieving his dreams of space travel. Although, one of the first things Goddard produced while at Tech actually had nothing to do with physics, instead it was a paper for an English class titled "Who I Am and Why I Came to the Institute". In the essay Goddard did just as the title entailed, discussed where he came from and why he had decided to go to Worcester Polytechnic Institute (*Papers of R.H. Goddard Vol.1*, Pp. 67-68). The most peculiar thing written in the essay was that Goddard juggled around multiple career ideas including biology and even literature, but the deciding factor for physics was the field's social implications and his intention on becoming "as useful a unit as possible in the community."

Considering his dream of space travel, the next four years were full of opportunities to work on the various problems and suggestions Goddard had previously worked out. He wrote several papers for Science classes as well as English regarding these various suggestions. These included "The Use of Gyroscopes in the Balancing and Steering of Airplanes" which regarded the obvious problems of balancing vessels during space travel (*Papers of R.H. Goddard Vol.1,* Pp. 77-80). Others included an English theme titled "On the Possibility of Navigating Interplanetary Space" in which he analyzed space travel focusing on observations made of the planet Mars, a paper which only missed being published by *Scientific American* due to its vast length (*Papers of R.H. Goddard Vol.1,* Pp. 81-87). However, the quest for the means to solving the space travel mystery did not come without doubts. After an abstract Goddard wrote titled "On the Utilization of Atomic Energy" was rejected by his advisor Professor Duff, Goddard wrote in his journals that he "decided that space navigation is a physical impossibility" on March 4, 1906 in his sophomore year at Worcester (*Papers of R.H. Goddard Vol.1,* Pg. 74). Goddard wrote in his "Material for an Autobiography" that he gathered all of his notes and burned them. However, Goddard's interest in the topic was far greater then his self-doubt, as inside of two months he caught himself making notes of further suggestions (*Papers of R.H. Goddard Vol.1,* Pg. 11).

Not everything was work though with the young Robert Goddard. Early journal entries in his freshman year he vocalized his anything is possible philosophy with entries such as "February 2. If there is no law against it, why-- 'twill happen some day" and "February 16. We should not be original for originality's sake" (*Papers of R.H. Goddard Vol.1,* Pg. 69). Goddard certainly kept busy socially, pledging at the Sigma Alpha Epsilon

fraternity and being elected to student government all four years including two years as vice-president and one as president. Even when he was working, his career at Worcester was a very broad and well rounded education. While Goddard very well could have gone in and focused entirely on mathematics and physics, Goddard knew the meaning of an education and took advantage of engineering courses as well as English and German classes. He also knew of the necessity for social sciences in education of a scientist because he fit courses in economics and political science.

At the end of his four years at Worcester, Goddard was highly focused on advanced classes in mathematics, physics, and chemistry. Focusing on his major field after three years of broad preparation afforded Goddard with the opportunity to polish his abstract writing skills and focus on his senior thesis on the conductivity of the element selenium. At his graduation of from Worcester Polytechnic Institute in the Spring of 1908 Goddard was initiated into the Sigma Xi research honor society and thereafter graduated with a B.S. degree in General Sciences, prepared to go on to graduate school and one day become the father of modern rocketry.

3. BACKGROUND TO THE WPI PLAN AND ITS PHILOSOPHY

3.1 ORIGINAL PLAN

While the idea of learning theory and then practicing was a revolutionary idea, it was far from a radical idea. Instead, the new Institute developed a reputation of being extremely rigid and strict with its scheduling and rules. This rigidity eventually developed the college into what seemed to be a glorified technical school, going on to produce excellent engineers but they would never become distinguished among their colleagues. In *The Future of the Two Towers*, it was pointed out that "WPI's reputation in industry is based on the technical competence of its graduates…not in the technical competence of its graduates in theoretical fields or in high level administrative posts" (*The Future of the Two Towers Vol.1,* Pp. 9-10). Regarding the job search for graduates, over the first 100 years of the college's history the Institute developed a great reputation for assisting graduates in job placement. However, students were never quite assisted in pursuing graduate study in their fields. One could almost say that WPI was developing its "practice" much more then its "theory".

These problems and many others persuaded the faculty at WPI to question what was wrong and how they could improve. Planning groups started meeting and discussing what could be done to make their good school into an excellent one and their notes were compiled into a report titled *The Future of the Two Towers*. The problems outlined in the initial report analyzed various factors including the fact that WPI up until that point had only graduated one outstanding alumni since its founding—Robert Goddard. WPI graduates were often extremely hard working and good at their jobs, but had very poor communication skills and never cared much for the social implications of their work. It

was noted in the fourth volume of *The Future of the Two Towers* that "Neither the WPI curricula nor campus life seem adequate for informing students about the modern problems or how the students must soon be participating in solving them" (Pg. 28), a problem which the faculty was intent on solving.

In 1970 the planning committee gave their recommendations for changes, denoted as the WPI Plan. The traditional idea of about 50 hours of work per week was kept for the coursework to ensure WPI graduates remained hard working, and this was noted as a single unit of work. However, there were no longer requirements for what courses a student had to be enrolled in. Instead, the student's graduation relied upon a series of projects and examinations, the students simply had to take courses in preparation for the examination and apply what they learned to real world projects. This plan required an examination in the student's major field of study to ensure the student was deeply prepared for whatever field they go into after graduating. Then there was also another examination to qualify for a minor field of study called the Sufficiency Examination, which was most often in an area of the humanities and arts as most students were science and engineering majors. This sufficiency examination was put in place to ensure the students covered a broad program of study, were more aware of the world around them, and rounded out a more complete four year education. This component was a redefinition of the original WPI tower of theory.

In addition to the examinations, students were required to complete two projects, each comprising one unit of work. The first project was to be in the student's major field of study to ensure a real world application of a student's major coursework. The second project was to be an activity relating science or technology to the society, in response to

the WPI graduate not having enough social aptitude. This would become the redefinition of the original portion of the Two Towers philosophy of Theory and Practice.

In 1971 the redefinition of the Two Towers philosophy went into effect and students began their transition into the new WPI program of study. The program had its pros and cons as students greatly enjoyed the lack of course requirements, but seemed to find the examinations difficult and rather terminal, since graduation depended on passing them. One particular difference was also the new grading system; instead of a numerical system there were only the three grades of Unacceptable, Acceptable, and Distinguished. Whether the new system was accepted or unaccepted by the campus community, it was certainly different, and required close attention in the first years of its implementation.

3.2 CURRENT PLAN

Over the next decade the Plan was closely watched to pick out any discrepancies or loose ends, and along the way changes were made. One of the first changed had been to the projects themselves, by giving them titles and restructuring the way they were completed. The first project that was done in a student's major field of study was titled the Major Qualifying Project (MQP) and these projects were done as though they were a miniature Master's thesis in a student's senior year. The second project in which a student was required to relate science or technology to the society was certainly a work in progress.

A key component to the new plan was instilling the importance of society into the students of WPI, yet the only put in place for this was a project and an under-developed social science department. However, then President of the Institute George W. Hazzard saw this as an excellent opportunity for pushing the Plan and raising funds for the school.

As most academic grants at that point were given to Liberal Arts schools, President Hazzard argued that WPI was the 'new liberal arts school' (*Engineering as a Liberal Education*). In this argument Hazzard pointed out that WPI students had a complete university education with science, mathematics, humanities, arts, and also a component forcing the student to interact with society. In addition though to the traditional liberal arts educations, WPI had something extra in that its graduates had an applied technical background to contribute to society. The only problem that President Hazzard faced though was that this revolutionary argument hinged on a much more developed social science program.

Hazzard saw this problem and charged the new Dean of Undergraduate Studies, William R. Grogan, with the duty of polishing the social science component of the WPI Plan. In fulfilling this duty Grogan called on the National Science Foundation, which was the largest supporter of the new educational system at WPI. The NSF sent an advisory panel headed by Dr. David Riesman, who was at the time a Professor of Sociology at Harvard University, with the duty of giving suggestions to WPI for improvement of their social science program and then coming back to investigate and report on the status of the schools program. After this report (The Final NSF-WPI Report-Riesman), the second project was changed drastically, being titled the Interactive Qualifying Project (IQP), and in order to better prepare students for this as well as attract more social science faculty, a course requirement of two social science courses was implemented.

Concerning the grading policy, with the grades of Acceptable and Distinguished the community had to much of a Pass/Fail resemblance simply with two varieties of passing. While the idea of not failing a student and not relying on GPA was widely

accepted as it provided the student with the opportunity to experiment without too high of a risk, almost all felt that the student's success had to be gauged more thoroughly, this brought in the current system of A, B, C, and NR. The A, B, and C grades gave students a thorough gage on how well they understood the material, while the NR (No Record) allowed students to make up for their shortcomings without the depressing grade of F or the obscure grade of D.

Lastly, regarding the examinations the faculty and administration eventually threw out the idea entirely. Initially the exams were to be framed on the Graduate School Qualifiers, testing the student's overall theoretical knowledge in a field. The first exam being the Sufficiency Examination, which was taken as a logistical hindrance, was thrown out in preference to the students taking two units (6 courses) in a minor field of study with a capstone humanities and arts project composing one of these six courses, which eventually composed the modern day Humanities and Arts component of the curriculum, where a student takes five humanities and arts courses and completes a sufficiency. The Competency Examination on the other hand was much more controversial. This exam ensured that students were not required to take specific courses and had free reign of their course of study, but still ensured the student's were competent in the theoretical knowledge of their major. However, the exam became a logistical nightmare, professors had to take a good amount of time and effort to compose a comprehensive examination that would cover the knowledge a student graduating in that field should know, whether they took a course in it or not.

The problem arising with dismissing the Competency Examination was that the students would then require course requirements, something contradictory to the WPI

Plan. The way the school found around this was to implement distribution requirements, in which there were no course requirements for everyone as a whole. Instead, requirements were worked out within each department, and instead of being the one size fits all distribution like before the Plan, the distributions were created closely with an advisor and tailored for each student's individual interests. This ensured the WPI education remained a personal experience, while also making certain each student had the basic requirements they might need in their field.

With these various changes the school finally came upon its current WPI Plan. Under the current Plan, in order to graduate the students of Worcester Polytechnic Institute are required to take a personalized distribution of courses in their major field of study capped by a Major Qualifying Project. They are also required to take two social science courses along with their Interactive Qualifying Project, and they are required to do the Humanities and Arts component that rounds off a complete four year university education.

3.3 PHILOSOPHY

Along with the change to the current Plan also came skepticism. Many people interviewed for this project had made the comment "The WPI Plan is dead", at least once, whether by a slip of the tongue or deliberate statement. Well if one states the revolutionary ideas behind the change back in 1971 were indeed a "Plan", then one could say that Plan is dead because a plan is a solid structure and the original Plan was changed. However, if the ideals of the original plan are taken to be a philosophy, the WPI Plan is still very strong and will be affirmed by this paper.

The Philosophy of the WPI Plan is that the true modern day education is that of an engineering education. An education where students go to school, gain a broad university educations from humanities and arts to social sciences and mathematics, yet deepen themselves in a major field of study with a technical background and the practical project experience to back it up. In this world technical background among the educated are more and more important as we live in an age run by technology. This is all wrapped together by the student's investigation into how science and technology interacts with society, as not only does WPI graduate brilliant scientists and engineers, it now graduates brilliant scientists and engineers that are prepared to take on the problems of society.

4. CUSTOMIZED CURRICULUM

4.1 GENERAL SCIENCE PROGRAM OF STUDY

Upon entrance into Worcester Polytechnic Institute, Robert Goddard chose to follow the General Science course of study. In the WPI catalog corresponding to Goddard's freshman year (1904-1905), the General Science course is described as being "intended to meet the needs of young men who expect to take non-technical positions in commerce and manufacturing, to become teachers, or to enter upon professional study later". This course of study was a much broader program than any of the other majors, one in which the first year and half of the second year was rigid with the exact same curriculum as a Chemistry major, and the remainder of the schedule was to be filled in conference with the President of the Institute.

This course of study allowed Goddard to specialize in Physics as there was no Physics major at the time, and allowed an extremely large range of work compared to other programs of study. Had he chosen Mechanical Engineering or Chemistry for example, Goddard would have been required to focus entirely on mathematics and shop work in which the young Robert Goddard would have spent all four years applying math and science to his technical specialty. Instead, Goddard chose to focus on the theoretical background of the mathematics and science courses and their application to society as a whole and his own personal goals of space travel. General Science allowed this in many was such as the individualized curriculum set up personally with an advisor (in this case the President of the Institute).

The description of the General Science program also states that "courses in History, Economics, and Political Science are offered, in the belief that to the business

man in non-technical positions, to the merchant and manufacturer, as well as the journalist and teacher, the study of society and of development of institutions furnishes a training more practical and useful than the study of technical processes". This suited Goddard's wishes very well as he states in his freshman English essay *Who I Am and Why I Came to the Institute* how a practical education should develop a man to be as useful a unit as possible in the community and how he ultimately wished to enter professional study in space travel and physics. The coincidence however, comes in the fact that this very description also suits the wishes of the original planning committee of the WPI Plan in the ideal system of an engineering education.

4.2 COMPARISON BETWEEN GODDARD'S COURSEWORK AND PLAN REQUIREMENTS

In *The Future of the Two Towers*, the planning group analyzed several concerns about where education at WPI had been over its first century of existence, concerns of which were outlined in Chapter 3 earlier in this report. At the end of the first report in which the problems were laid out and objectives considered, two of the possible objectives stood out in later reports, the first being "to provide high quality pre-graduate education in engineering and science" and the second "to educate for leadership and decision-making in a technological society".

The first of these two objectives was to provide a high quality pre-graduate education in engineering and science. In Goddard's time, there were no graduate degree programs at WPI and the only outlet for a pre-graduate program was that of General Science. All other courses of study were highly technical and assumed the student would graduate to go directly to work in a technical capacity. This posed a problem in that WPI

wished to have more distinguished graduates and to boost its reputation, and for a university that partially meant achievement in research which could be identified with WPI. In the years preceding the WPI Plan, engineering and science had evolved into fields where a Bachelor's Degree was no longer sufficient formal education. Goddard's course of study, General Science, was the major that was intended for student's interest in just that, non-technical positions allowing for entrance into professional study later.

This objective however did not mean a lesser quantity or quality of work required. Something Goddard had in common with his fellow students regardless of the program was that they were all required to do a minimum of 50 hours of work per week between lectures, recitations, laboratory/shop work, and personal study. Using the course catalog and Robert Goddard's transcripts it can be seen that Goddard enrolled in a program that required a minimum of 51 hours per week up to 58 hours of work per week to ensure success in his studies. This is also something the old system has with the WPI Plan, which called for a term of work to be called a "unit", which was defined as a minimum of 50 hours of work per week. This similarity brings up the question of rigidity; just how different is the WPI Plan from the old vocational school system and how does this difference apply to Robert Goddard?

To understand the difference between the WPI Plan and its predecessor and part of the reason Goddard was an exception to the WPI of his time, one must first consider the difference between rigidity of tradition and rigidity of purpose. To provide a quality education in fields as important as engineering and science there must be a rigid structure of some sort to ensure the engineers and scientists of the world are fully prepared. The difference is that the old system of WPI was a rigidity of tradition, not accepting a

departure from the old apprenticeship system and putting more emphasis on training tradesmen then educated technical and scientific experts. The new system and the system followed by Goddard in the General Science program called for a rigidity of purpose, the rigidity that requires structure and hard work but has a specific purpose in the field of study. Goddard came to WPI with the purpose of gaining the knowledge to put a vessel into space, this purpose which was the future of physics at the time, framed Goddard's individual curriculum as a General Science major. Likewise, the WPI Plan calls for a personalized curriculum educating the individual student in their own technical interests, through a rigid program of project based experience.

The second objective continuously mentioned by the planning group was to educate for leadership and decision making in a technological society. This was something that was of high demand for the planning committee as they were worried WPI's reputation was based on the technical competence of its graduates but their leadership abilities were lacking. Additionally, one of the gravest concerns for the faulty in the 1960's was that the WPI curriculum never seemed adequate for informing students about societies problems and how they would soon be participating in solving them (*The Future of the Two Towers Vol. IV*, Pg. 28). This makes Goddard's General Science curriculum almost hand tailored as a prototype as the broad range of study was meant to include various courses in Humanities as well as Social Sciences to gain an understanding of society, which was thought more practical to scientists then the study of technical fields. This range allowed Goddard to understand both the theoretical background to his goals in space travel as well as how to implement those goals as a leader in society. This sentiment carried over into the new WPI Plan with an emphasis on

the social science course requirements as well as the project requirement relating science and technology to society which later became the Interactive Qualifying Project (IQP). This connection will be discussed in further detail in the chapter dealing with the IQP.

5. HUMANITIES AND ARTS

5.1 BREADTH OF A FOUR YEAR EDUCATION

Before the industrial boom of the late nineteenth century, technical experts were mechanics, construction workers, architects, and other tradesman who were taught their professions using the traditional apprenticeship system. In this system an apprentice would learn the technical expertise from a master of the field and go on to establish their own practice. While extremely personal, this system became out of date regarding the demands of the Industrial Revolution as tools and machines had to be mass produced and now technical expertise had broad implications beyond a tradesman-customer transaction. It was the opinion of many industrialists in the mid to late 1800's that there should be a university like the liberal arts schools of England and the Ivy League that would educate scientists and engineers to meet the demands of a technical society. Two of them were right here in Central Massachusetts—John Boynton and Ichabod Washburn.

The choice that these two industrialists made to establish a technical school in Worcester had many implications. One of the most important implications would be that this was a university for technical education, not a campus full of masters and apprentices, and that meant the students coming through were to come out as educated engineers. The graduates were expected to be able to communicate their ideas through speaking and writing as well as keep up with findings in foreign countries by studying French and German, the major languages of the time. For these reasons, departments in English, French and German were added to the Engineering and Science departments. In order to ensure a broad 'liberal' education in addition to a technical education, elective courses were added over the years in such disciplines as History and Art. However, it was

later noted several times that these departments in the humanities were underdeveloped at best. For years the three language departments (English, French, and German), were run by a single professor, and Stephen Salisbury who had given a large sum of land and money to the school often 'cringed' at the graduation exercises as the seniors spoke because of what he called 'atrocious English' (*The Two Towers*, Pg. 52). In the years that proceeded Salisbury established a fund for the development of the Humanities at the new school, developing the subjects as a high priority by the time Goddard enrolled.

This breadth carried on in the WPI Plan as the Sufficiency, whereby the students majoring in a scientific or engineering field would complete coursework and a culminating project in the humanities and arts. *The Future of the Two Towers* states that the role of the humanities was an extension to the goal of "developing in a student an understanding of himself and of his responsibility to society" (*The Future of the Two Towers Part IV*, Pg. 25). The argument was that the humanities all have an interface with society and that the WPI Plan would fail at its goals if it did not instill sensitivity for the beauty, truth, and human values as well as an appreciation of great minds through their writings (*The Future of the Two Towers Part IV*, Pg. 26). The writers of the Plan were ultimately concerned that they would produce technocrats, following orders blindly like the engineers of Nazi Germany rather then 'humane technologists'.

No matter which time period at WPI one looks at, the humanities were always viewed as important for a well rounded university education, whether the importance is explicitly noticed or not. However, one student at WPI who certainly noticed the importance of humanities in a technical education was Robert Goddard. Goddard took several courses in German as well as a few courses in English totaling six courses in the

humanities, coincidentally the same number of courses required for the sufficiency in the WPI Plan.

5.2 ENGLISH THEMES AND ABSTRACTS

While at WPI Goddard took two courses in English: 'Advanced Rhetoric' and 'Argumentation'. In 'Advanced Rhetoric', Goddard studied how to communicate his ideas through writing and practiced with theme-writing. All throughout his early life Goddard enjoyed writing in his journals, but when Goddard got to WPI he seemed to use the themes written in his English classes as a chance to polish the communication of his ideas. Some of the themes he wrote were "The Use of Gyroscopes in the Balancing and Steering of Airplanes" and "On the Possibility of Navigating Interplanetary Space", where he took the chance to think further about his ideas of space travel while testing his ability to communicate his ideas to people with no extraordinary scientific understanding such as an English professor. We even start to learn through his journal and theme writing during these Advanced Rhetoric classes that it was actually through Goddard's appreciation for great minds through their writings that he came to dream of space travel as he did. This we later learn was largely due to Goddard's intense love for the science-fiction of H.G. Wells, and the inspiration of Wells' book *The War of the Worlds*.

In the 'Argumentation' course students studied how to argue through both written and oral debate, more than likely because of the importance of being able to argue one's thoughts and ideas. In this course Goddard learned to verbally express his ideas against opposition, re-visiting the theme "On the Possibility of Navigating Interplanetary Space" with the idea of arguing his idea in addition to presenting it. He also learned the important human value of disappointment through a theme titled "A High Speed Bet"

where he presented an argument for magnetic levitation trains, an argument in which he proved himself wrong. Both courses managed to instill in Goddard an understanding of how to communicate and argue his scientific ideas as if speaking to a society with no scientific knowledge. Concerning communication with the scientific world, starting in his sophomore year Goddard took courses called 'Abstracts'. In these courses students were instructed on how to research and write articles for scientific journals gearing their ideas toward a technically oriented crowd. This, in addition to the English courses, rounded out a broad education in which Goddard learned to write and speak his ideas.

5.3 SPRECHEN SIE DEUTSCH?

The humanities courses that Goddard took the most of were German courses, in which he took four. Of the four courses, two were Elementary German courses and two were Advanced German courses, whereby the student learned anything from basic grammar and structure up to reading and interpreting technical articles in the German language. Just as the Two Towers tradition has always been theory and practice, everything learned theoretically was applied to some purpose. In this case science and engineering students were taught how to read, write, and speak German in order to apply it to understanding scientific and technical articles in the language, which happened to be the primary language of the technical world at the time.

Just as WPI offers foreign languages today for the reason of understanding cultures outside of the United States, it was certainly the same during Goddard's time. According to the WPI website, "Language is the heart of human existence. We communicate our thoughts and feelings, our dreams and way of life through words. Learning a new language always introduces us to a new way of life." (WPI Department

of Humanities and Arts, Foreign Language Mission). Just as the WPI Plan emphasized the humanities in order to develop 'humane technologists' to prepare them to understand their responsibility to society, Goddard learned an important language and this gave him insight into a thriving European power—the Germans. This insight weaved in very nicely with Goddard later work with rockets during both World Wars, work which had immense social implications concerning Nazi Germany.

5.4 INQUIRY SEMINARS

As described in section 5.3, the original goal of the Sufficiency was to gain an "appreciation for great minds through their writings", to develop initial communication skills and to introduce the students to projects. For about 35 years the Sufficiency was a paper about 20 pages in length written by a single student advised by a professor. While this approach was indeed very personalized and effective, it could strain the student working alone and did not emphasize one of the most important lessons found in a project: teamwork. Thus, over the past few years the Sufficiency evolved into what is now called an Inquiry Seminar, where one professor holds a class of approximately one dozen students in order to achieve the goals of the Humanities and Arts requirement on a larger scale.

While the Inquiry Seminar is not as personalized as the Sufficiency paper, it adds in a wider range of capabilities and takes off the strain of one student doing all of the work. The seminar also adds in one more attainable objective that enhances the requirement as a preparatory requirement for both later project work as well as life in a scientific and technological world. The original Sufficiency had as its results the development of critical inquiry, research and investigation, intellectual independence and

communications and writing. To these the seminar adds in the result of conversation and dialogue, which develops the ability of collaborating with peers that is extremely necessary for any endeavor.

6. INTERACTING BEYOND TECHNOLOGY

6.1 AS USEFUL A UNIT AS POSSIBLE IN THE COMMUNITY

The key change made in the WPI Plan that distinguished the new system from the old was the idea of integrating technology and society. Before the Plan WPI graduates were revered for their technical abilities but that was all they had, they did not have a strong understanding of how their technical work affected society. Graduates were great mechanics and tool makers for local manufacturers but never raised high up in the ranks as leaders. There were brilliant scientists coming out of the schools chemistry programs, but never went on to do cutting edge research in the field.

The very importance of this social component in engineering education can perhaps be displayed best through Nazi Germany during World War 2. Albert Speer, the Nazi Minister of Armaments, argued during the trial at Nuremburg that he was a technocrat, someone who was governed by the technology he worked on. Intrigued by the concept of rockets, Nazi scientist Werner Von Braun took from Goddard's own ideas and made incredible developments in the field of rocketry, not really understanding the impact his research made on society or the millions of deaths in London would result of his research. All brilliant scientists who managed to use their genius in a socially catastrophic way, not because they meant for it to be used that way, but because they were fascinated by the technology that they were working on but did not stop to question the social implications.

Even though WPI without the social component did not produce a Speer or a Von Braun, the only really distinguished pre-Plan graduate was Robert Goddard, and he certainly understood the importance of integrating technology and society. In his

graduation oration, Goddard used scientific history to explain how hopes and dreams frame the history of science as long as it is kept in mind that scientific endeavor affects the world around us, stating "what applies to the mass also applies to the individual". Later, when he first entered WPI, Goddard wrote a theme for his first English course explaining why he came to the Institute. In the theme he finished with the words that would eventually differentiate him from many of his peers at WPI: "…after all, the practical education, from an economic standpoint at least, *should tend to develop what is best in a man and to make him as useful a unit as possible in the community*."

6.2 IMPORTANCE OF THE IQP

After all of the preceding talk it is pretty simple to understand the importance of a project like the Interactive Qualifying Project. However, the question is how is it important for the WPI Plan and how did the idea behind this project apply to Robert Goddard? In the general scheme of things one has to consider how their work interacts with the society, otherwise how can that work be noticed? That is to say, in order for an incredible engineering project or some inspiring research in science to be noticed, the project or research has to be put out into the society and be seen. Before the WPI Plan, the average student at WPI did not consider the social implication of their research or work, as long as hey did a good job at what they were told to do. This implies that students at WPI were highly disciplined and extremely hard workers, but did not care to get involved with the world around them. This kept the students in a box and restricted the level of distinction they could get for their work, because the world cannot give distinction to an idea that it does not know about.

At the heart of this problem in the pre-Plan education at WPI was Robert Goddard, an extremely bright young General Science major who would one day revolutionize rocketry and do key research that would aid in getting space travel on its feet. It is ultimately the goal of this report to answer why Robert Goddard 'launched' into the spotlight while so many of his fellow students were content working as tradesmen and how that connects to the success of the WPI Plan. A major part of the solution would have to be Goddard's interest in the world around him. When Goddard was sixteen years old was when he starting writing his diary entries, and the first entries were about Goddard's concern about the United States declaring war on Spain (Spanish-American War). While most sixteen year olds are working, worrying about school, playing sports, or going out, Robert Goddard carefully observed the news and often expressed his concerns and ideas about world events.

Regardless of his childhood interests, Goddard never quite gave up his interest in the social implications of things when it came to working. Robert Goddard was by no means interested in space travel for the sake of space travel itself, but the possibilities space travel would provide for the world. If one really thinks about space travel from Goddard's point of view, it is rather difficult to think of it as a selfish endeavor in any way. Goddard never actually went to space himself, but he did keep on trying to put mankind into space regardless to whether or not he could go himself. Goddard's dream was to see a *world* with no boundaries, one where society could go to Mars or anywhere else it wanted to go.

One of the major reasons a student at WPI had in the early 1900's for going into General Science was the availability of electives outside of Science and Technology,

including economics and political science. This was obviously something Goddard took advantage of because he sampled both, taking the introductory courses in both economics and political science, and doing fair well in both (receiving an A and a B respectively). As Goddard became a Professor of Physics and entered professional research, according to the course catalog of Goddard's freshman year, …"the study of society and of development of institutions furnishes training more practical and useful then the study of technical processes" (Thirty Fourth Annual Catalogue of the Worcester Polytechnic Institute, Pg. 56). Ironically, Goddard took two social science courses, and WPI students under the current WPI Plan are required to take two courses in social science.

The way in which the WPI Plan amplified this testament was through the Interactive Qualifying Project, a project often completed by students in their junior year in which they relate science and technology to society. In the final report by the NSF-WPI Advisory Panel, the chairman Dr. David Reisman, who was a Professor of Sociology at Harvard University, wrote "…it is clear that what the new Plan aims for at WPI is an engineer with training in the basic sciences who is at the same time conversant with the social and human consequences of what was once assumed to be automatic growth and progress" (*Final NSF-WPI Summary Report (Reisman),* Pg. 16). According to another member of the panel Dr. John Whinnery of the University of California at Berkeley Electrical Engineering Department, when interviewing graduating seniors, the first thing described as being a basis for job offers was the IQP (*Final NSF-WPI Summary Report (Whinnery),* Pg. 11).

In his initial report to this NSF panel, William Grogan, the Dean of Undergraduate Studies who was charged with implementing the WPI Plan, mentioned

that courses in social science have often been required in technical schools such as WPI for a long time. It is also pointed out that while these courses are valuable on their own, "there was no experiential component which brought physical for the student the social, political, or humanistic dimensions of their technological world (*Restructuring Undergraduate Education of Worcester Polytechnic Institute*, Pg. 4). That is to say, while a couple of social science courses may be good to influence a WPI student to connect technology with society, it is not a systematic way of ensuring an awareness of that interaction in every student.

7. MAJOR QUALIFYING PROJECT

7.1 DEPTH OF A FOUR YEAR EDUCATION

When all is said and done in the four years one spends at a college, the ultimate result should be a certain level of expertise in a field. This depth in a certain major field of study is the culmination of coursework and projects over the period of four years, and it is this depth that the Bachelor degree signifies at face value. A question that often plagues universities and colleges around the world however is how does one measure the success of the four years a student spends studying? How can a university issuing a degree know that the graduate has this depth required to go out into the real world and do what the degree says they now have expertise in? Every college has its own methods of measuring this final outcome, and WPI under its new Plan had to choose what it wanted to use as its mechanism.

A frequent and somewhat obvious initial mechanism is the idea of a comprehensive examination to test the student in the knowledge they should have after four years of studying. This was true for both the founding of WPI as well as the establishment of the WPI Plan, where in both cases the first solution the school came to was an examination. At the start of WPI in the 1860's, the senior classes were expected to pass comprehensive examinations the morning of their graduation, which can be observed in the first graduation program of 1871 (*The Two Towers*, Pg. 55). However, as the years went on these examinations diminished, as by 1882 the examinations dwindled down to presentations and oral quizzes of an abstract, and by the time Robert Goddard enrolled there were no examinations at all. The examinations became logistical nightmares even for the considerably small classes of the nineteenth century, and were

eventually replaced by a senior thesis which was to be written and defended upon graduation.

One hundred years later, at the foundation of the new WPI Plan there was an almost identical difficulty. After every term, a week was devoted to Competency Examinations in the major fields of study which the student had to pass once in order to graduate. The examination was meant to test the student's competence in their major through complex problems much like those in which they will be expected to solve as a graduate in a specified major (*Restructuring Undergraduate Education at Worcester Polytechnic Institute*, Pg. 5). These were one or more open problems in which the students were allowed to utilize reference materials, computer facilities, the library, laboratories, and faculty. This would then culminate in the students presenting their findings to the examination board and then discuss the methods and principles of the solution as well as alternative approaches. The problem then encountered with this examination was once again, the logistics.

In his report *Restructuring Undergraduate Education at Worcester Polytechnic Institute*, Dean Bill Grogan stated, "Despite a great deal of effort…much remains to be learned by this type of competency measurement and developmental work continues in this area" (Pg. 6). As every student had to be examined, the test mirrored those of graduate school qualifying examinations, making sure the students are qualified in the field by quizzing them on the material they are expected to know from courses and studying. However, the workload impressed upon the faculty was enormous, as they had to develop a new examination for every year and commit time to coming up with problems and the various solutions to those problems. This was a heavy burden in

addition to the projects the professors were expected to advise, the research they were expected to carry out, and the courses they were expected to teach! Thus, just as the exams 100 years earlier were phased out, the Competency Examination was eventually replaced by course distribution requirements and a heavier emphasis placed on the Major Qualifying Project (*Reflecting on 35 Years of the Plan*).

7.2 MQP VERSUS THE THESIS

No matter what changed, whether it was at the founding of WPI or the implementation of the WPI Plan, the foundation of WPI has always been the projects. The measure of the depth of education one receives at WPI in a major field is now measured by the courses the student takes and the Major Qualifying Project (MQP). In the time Goddard went to WPI, students were to practice what they learned and present a solution to a problem at graduation. Goddard himself wrote a thesis titled "A Study of the Conductivity of Selenium and Allied Anomalous Conductors", in which he took the knowledge a General Science major was to have gained over four years and applied it to the solution of a problem representative of the field. While the engineers were practicing their theoretical knowledge in the machine shops, Goddard was taking what he learned and applied it to gain an understanding for setting up and carrying out research of his own and ultimately communicating the results in a senior thesis.

The MQP is meant to fulfill a very similar objective as the senior thesis. According to the most recent undergraduate catalog (2009-10), the MQP "should demonstrate application of skills, methods, and knowledge of the discipline to the solution of a problem that would be representative of the type to be encountered in one's career" (Pg. 16). Part of this project is also supposed to incorporate a "capstone design"

in which the student is to design a study, test, apparatus, or research into a subject and also display the external influence the topic would have. By doing this, the student takes into account all that they have learned over the four years of schooling including the courses and studies into a specific discipline and the effect on society learned from the social sciences, and they then employ the ability to communicate those ideas that they learned from the humanities. The end result is a report with results which must then be presented and defended, making the MQP a sort of miniature Master's thesis. Though the subject matter of the MQP is not of as much importance as in a Master's thesis, the purpose of doing the research and presenting to one's peers and superiors is very much the same.

8. CONCLUSIONS

8.1 SUMMARY OF RESULTS

Worcester Polytechnic Institute was founded in 1865 on the "Two Towers" philosophy: Theory and Practice. From the very start WPI has been devoted to a complete education in the fields of science and engineering. By teaching the students the theory in mathematics and science and even in the more technical subjects of engineering, students learn the rules and procedures necessary to solving a scientific problem. This theory is then applied to practice in those subjects, in which the students actually use the rules and procedures in a technical application. In the early years of the school these applications were in the fields of mechanics, chemistry experiments, bridge building, railway establishment, and many others. These applications distinguished young engineers who not only had the necessary head work for an engineer, but also the hand work to understand engineering's application in the field. However, as time advances so does technology and what was important in technology at WPI's founding was no longer a priority going into the twentieth century. The world required different advances, and students of science and technology needed to understand what advances the world needed, this is something Robert Goddard understood, and something the WPI Plan aims to ensure.

In the early 1900's when Goddard was a student at WPI, the practice component of the Two Towers was very much the same as it was at the founding. Mechanical Engineers were in the shop designing and building tools and the Civil Engineers were out surveying the railroads of post-Civil War America. Robert Goddard did not come in interested in railroads or tools, he came in with a dream of space travel, something that

the world thought was nothing more then fiction but would one day reach as a reality. From the various diary entries and academic papers Goddard had written up to his graduation from WPI, one can tell that he knew the advances which space travel would one day imply to the entire world.

Thus, we come to the primary difference that distinguished Goddard from the rest of the pre-Plan graduates and ultimately distinguished Goddard among fellow scientists and technologists of his time; Goddard knew that in order to succeed in science and engineering one must look at the broader implications of an idea. Engineers must look at how the project affects the world around them and the scientist must look at what implications their research has on society. What may be extremely interesting research or an outstanding project may simply be of no use to the society, from which the scientist or engineer would not receive any distinction no matter how hard they had worked.

When the WPI Plan was developed it was geared towards making the good school the Institute was into an excellent one. The school wanted the ability to claim more then one distinguished graduate, whether it was in the field of science, engineering, or even management. While no evidence exists to say the WPI Plan was based on its most distinguished graduate up until that point (Robert Goddard), one can surely observe Robert Goddard's education here and it success in later life as an affirmation that the philosophy behind the WPI Plan is indeed at the very least a walk down the correct path. This affirmation is in the incorporation of society into the education at WPI, not just in the IQP, but even in the MQP a student has to include how their research and experimentation affects more then just the project but things such as economics, the environment, politics and others.

8.2 REDEFINITION OF THE TWO TOWERS PHILOSOPHY

There was a good reason why the report given by the Planning Committee was titled “The Future of the Two Towers”. Right in the introduction to the recommended undergraduate degree requirements the planning committee speaks of the Two Towers philosophy as an evolutionary process (*The Future of the Two Towers Part IV*, Pg. 18). The Two Towers philosophy has always been and will always be theory and practice, but what has changed with the WPI Plan is the very definition of those words. The theory is still more or less the same with more Humanities and Social Sciences thrown in, because the school wanted to be more then a glorified trade school and wanted to be able to train engineers who had a well rounded education. The real redefinition is in the word practice, which has always been the component in which students take what they learn in class and apply it in the shop or in the field. In the WPI Plan the practice component was redefined into the projects in which the student had to apply what they learned in the theory to various projects. The application though could not just be technical; it had to include a broader application to society as well.

8.3 RECOMMENDATIONS

As for recommendations there are two for the school, not to better the Plan itself but to enhance the effectiveness of the Plan already in place. The first recommendation would be to increase marketing of the Plan including a logical presentation of the project system and how all of the projects fit together to mold a modern engineer. Goddard was successful in his endeavors because he knew the importance of the big picture, meaning he was intelligent in physics but also knew how important it was to be able to

communicate his ideas through speaking and writing and he also knew that his ideas had a greater impact then a purely scientific influence.

Incoming students and people looking at WPI from the outside need to see the project system on a much more intimate level, they should see how students are introduced to communications and humanities through the Sufficiency. These abilities are then practiced on the Interactive Qualifying Project which also introduces to a student that their work in science and engineering influences the society around them. These projects and the curriculum all converge into a Major Qualifying Project, which should combine academic knowledge, technologies impact on society, and the ability to communicate one's ideas. This project is ultimately what tells the school and the world that the student is now qualified to become a young impressionable scientist or engineer, ready to make a difference in the world. The people that make the decisions as to what scientist or engineers receive that distinction want more then just academic ability, they want to understand the young scientists idea or the engineers project through communications and they also want to know how it affects them. The WPI Plan is hand tailored to do just that with its curriculum and projects, but the school needs to find some logical advertising tool to put all of these projects together in the public eye and show how they all contribute to the resulting well rounded graduate.

The final recommendation is to further analyze the WPI Plan. This report analyzed the events that preceded the Plan and was meant to affirm the philosophy behind the Plan through the school's most successful graduate up until that point, Robert Goddard. The school wanted more distinguished graduates like Goddard was, and managed to pin point the characteristics that made him distinguished in the Plan. Future

analysis should take this research further to observe if the Plan succeeded by looking at WPI graduates from the Plan's implementation up until the present day. Research could include interviews of success stories such as successful researchers or chief executive officers of companies who are alumni under the Plan. This would compound on this report by measuring the actual success of the WPI Plan, and possibly giving recommendations for how to improve the Plan.

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10. APPENDIX

Attached to the end of this report are scans of the following primary source:

- Robert Goddard's Worcester Tech Transcripts beginning with the Second Semester of his Freshman Year. (Starting on Page 48)

In a separate document submitted online as a supplementary document are scans of the following primary source:

- Robert Goddard's senior thesis "A Study of the Conductivity of Selenium and Allied Anomalous Conductors" [Document Title: "goddardthesis[1].pdf"]

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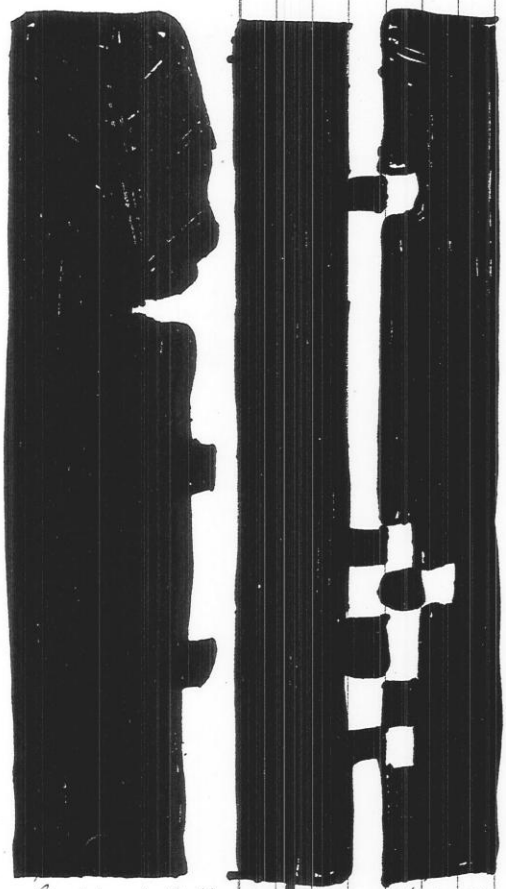
Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) 2nd TERM 1904-1905

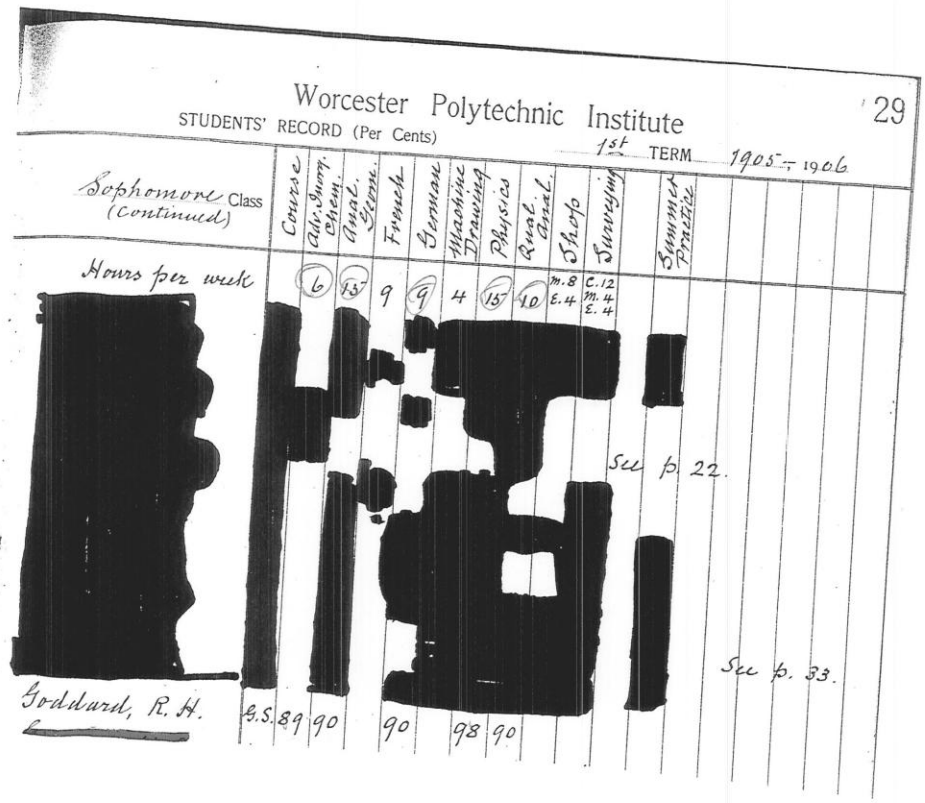
Freshman Class	Chemistry	Dis. Geom.	English	French	German	Shop	Trig.
Goddard, R.H.	95	94	93		86	82	93



Chemistry 95
Descriptive Geometry 94
English 93
German 86
Shop 82
Trigonometry 93

No Hours Given

Freshman 2nd semester



Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents)

29

1st TERM 1905 – 1906

Sophomore Class (Continued)

Course	Adv. Inorg. Chem.	Anal. Geom.	French	German	Machine Drawing	Physics	Qual. Anal.	Shop	Surveying	Summer Practice
Hours per week	6	15	9	9	4	15	10	m. 8 E. 4	C. 12 m. 4 E. 4	
Goddard, R. H.	G.S. 89	90		90		98	90			

See p. 22.

See p. 33.

Sophomore

1st Semester

~~Adv.~~ Inorganic Chemistry 89

Analytic Geometry 90

German 90

Physics 98

Qualitative Analysis (Chem) 90

Hours Spent	
~~6~~	
~~15~~	~~30~~
~~9~~	~~40~~
~~15~~	~~44~~
~~10~~	55

55 hours !

Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) 2nd TERM 1905 – 1906

Sophomore Class (continued)

Course	Abstracts	Calculus	French	German	Hist. Chem.	Machine Drawing	Physics	Qual. Anal. Chem. 7	Qual. Anal. Chem. 5	Quant. Anal. Chem. 8	U.S. Hist.	Surveying	English	P.R. Lumis
Hours per week	6	15	6	6	6	M. 8 E. 8 C. 4	12	4	12	12	M. 8 E. 4 C. 4	7	6	7

Abstracts 95
Calculus 84
German 90
Physics 93
Qual. Anal (Chem) 81

Hours Per Week

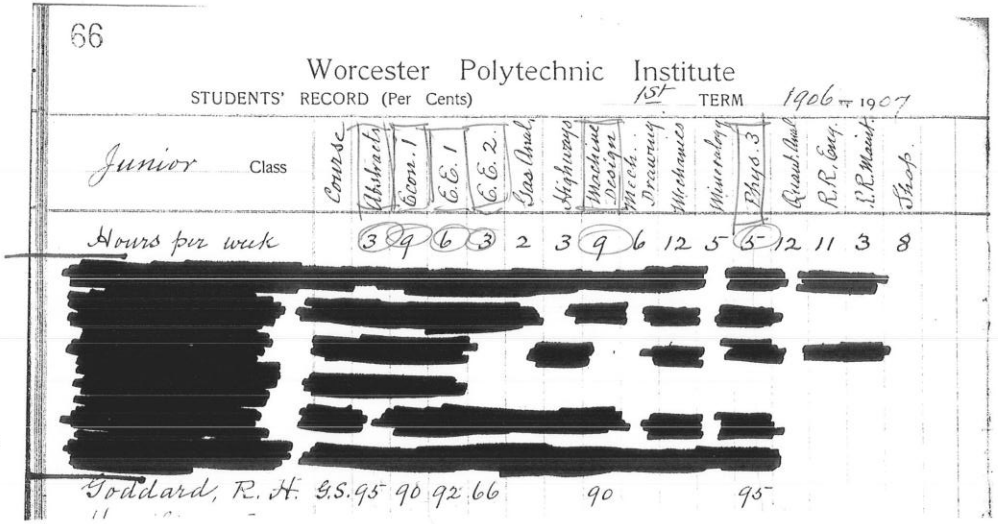
~~6~~
~~15~~ ~~24~~
~~6~~ ~~30~~
~~12~~ 36
~~12~~ 15
(51)

51 hrs per week

Goddard, R.H.	U.S. 95	86	90		93		81

Sophomore
2nd semester

Junior 1st Semester



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Worcester Polytechnic Institute

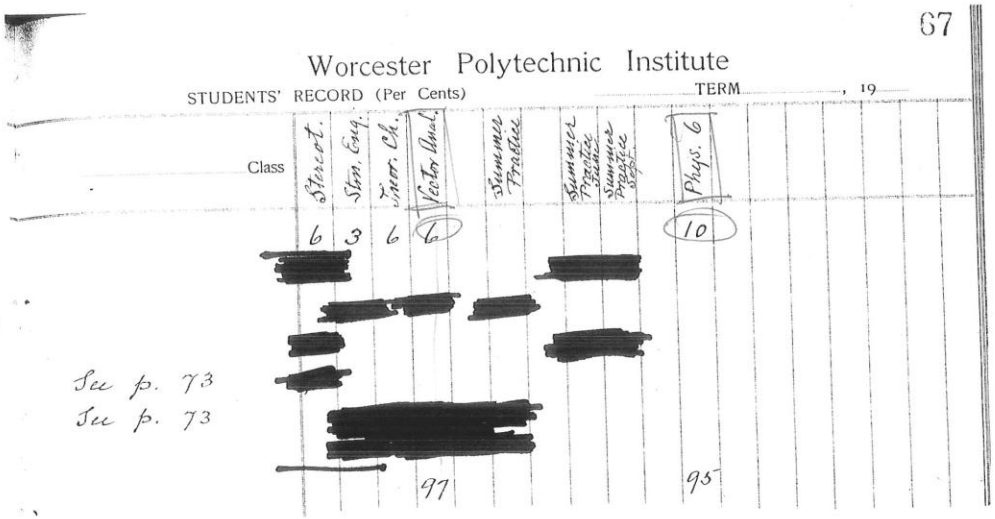
STUDENTS' RECORD (Per Cents) 1st TERM 1906 – 1907

Junior Class

Course	Abstracts	Econ. 1	E.E. 1	E.E. 2	Stes Anal.	Highways	Machine Design	Mech. Drawing	Mechanics	Mineralogy	Phys. 3	Grand Anal.	R.R. Eng.	S.P. Manuf.	Shops
Hours per week	3	9	6	3	2	3	9	6	12	5	5	12	11	3	8
[redacted]															
Goddard, R. H.	95	90	92	66			90				95				

Abstracts 95
Economics I 90
EE 1 92
EE 2 66
Machine Design 90
Physics 3 95
Vector Anal. 97
Physics 6 95

Hrs - 51 per week



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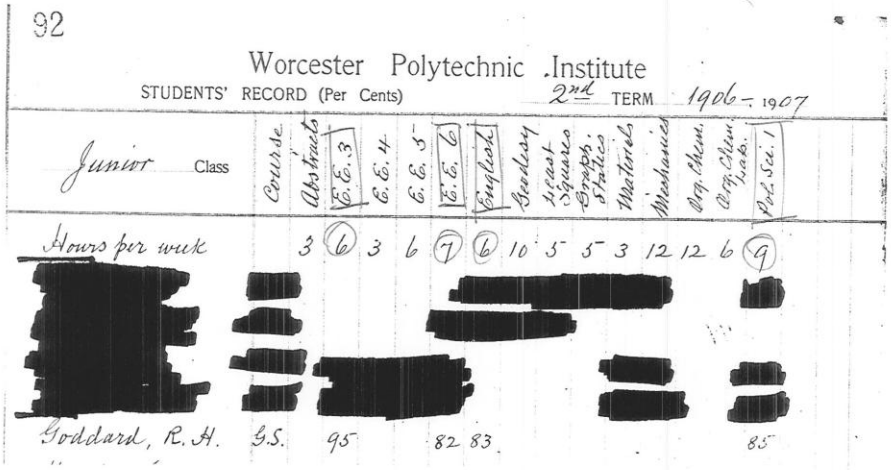
Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) TERM ____, 19____

Class

Stereot.	Stm. Eng.	Junior Ch.	Vector Anal.	Summer Practice	Summer Practice	Summer Practice	Phys. 6
6	3	6	6				10
[redacted]							
See p. 73							
See p. 73							
			97				95

18
30
40
46
51



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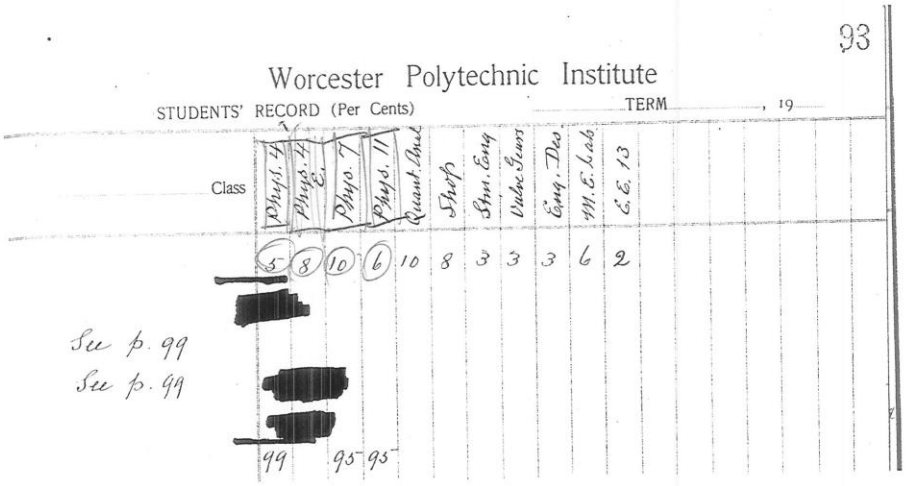
Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) 2nd TERM 1906 – 1907

Junior Class

	Course	Abstracts	E. E. 3	E. E. 4	E. E. 5	E. E. 6	English	Sanitary	Least Squares	Descrip. Statics	Materials	Mechanics	Org. Chem.	Org. Chem. Lab.	Pol. Sci. 1
Hours per week		3	(6)	3	6	(7)	(6)	10	5	5	3	12	12	6	(9)
[redacted]															
Goddard, R. H.	G.S.		95			82	83								85



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Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) TERM , 19

Class

	Phys. 4	Phys. 4	E.	Phys. 7	Phys. 11	Quant. Anal.	Sharp.	Sum. Eng.	Value Surv.	Eng. Des.	M. E. Lab.	E. E. 13
	(5)	(8)		(10)	(6)	10	8	3	3	3	6	2
[redacted]												
See p. 99												
See p. 99												
[redacted]												
	99			95	95							

EE 3 95
EE 6 82
English 83
Political Sci 1 85
Physics 4 99
Physics 7 95
Physics 11 95

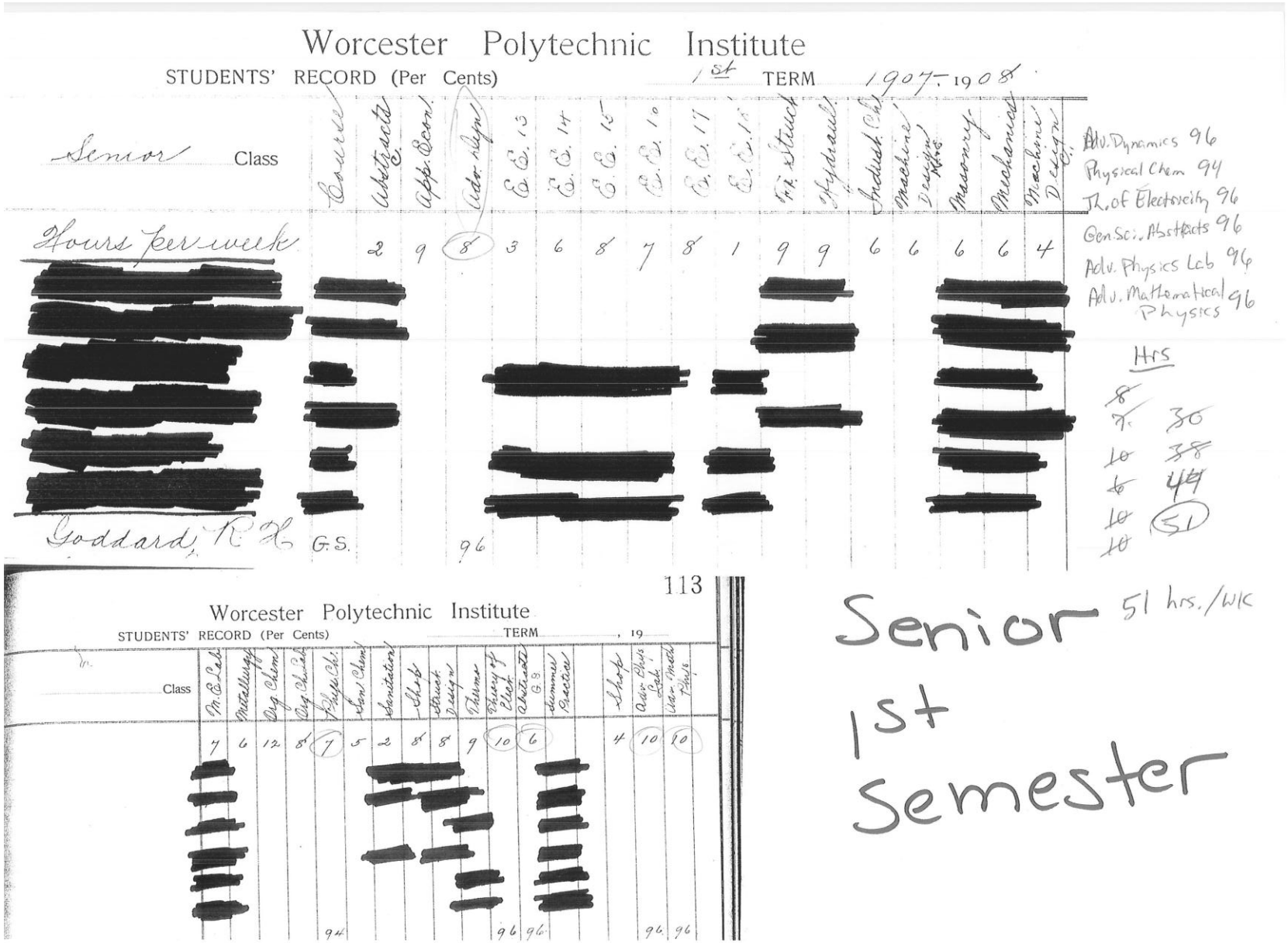
Hrs
16
7
16
9
15
8
10
16

1.8
27
79
49
49
57

Junior

2nd semester

57 hrs per week



Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) 1st TERM 1907-1908

Senior Class

Hours per week: 2 9 8 3 6 8 7 8 1 9 9 6 6 6 6 4

Adv. Dynamics 96
Physical Chem 94
Th. of Electricity 96
Gen Sci. Abstracts 96
Adv. Physics Lab 96
Adv. Mathematical Physics 96

Hrs
8
7. 30
10 38
6 44
10 51
10

Goddard, R. H. G.S. 96

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Worcester Polytechnic Institute

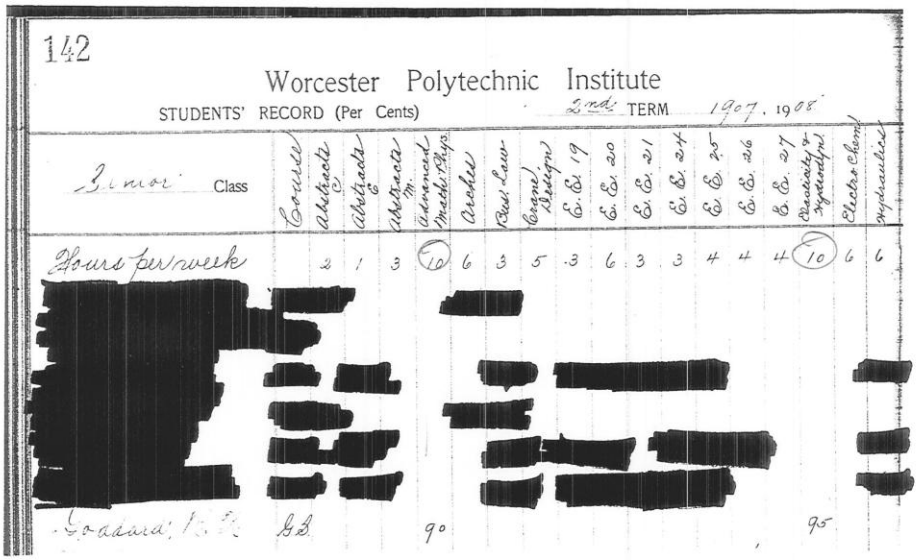
STUDENTS' RECORD (Per Cents) TERM , 19

Class

7 6 12 8 7 5 2 8 8 9 10 6 4 10 10

94 96 96 96 96

Senior 51 hrs./wk
1st
Semester



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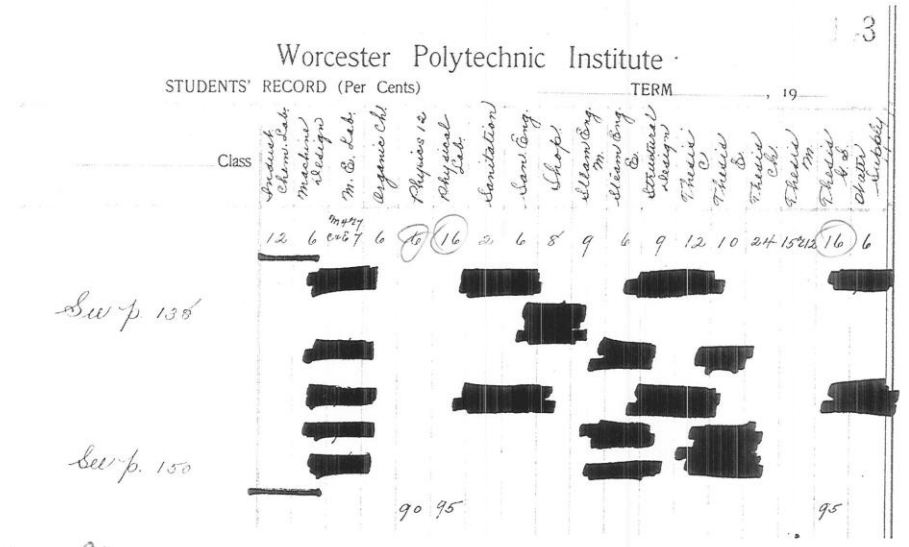
Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) 2nd TERM 1907. 1908

Junior Class

	Course	Abstracts	Abstracts &	Abstracts	Advanced Math & Phys	Arches	Beam Laws	Organ. Design	E. & 19	E. & 20	E. & 21	E. & 24	E. & 25	E. & 26	E. & 27	Elasticity & Hydrodyn	Electro Chem	Hydraulics
Hours per week		2	1	3	10	6	3	5	3	6	3	3	4	4	4	10	6	6
					90											95		



3

Worcester Polytechnic Institute

STUDENTS' RECORD (Per Cents) TERM , 19

Class

	Product Chem. Lab.	Machine Design	M. & Lab.	Organic Chl	Physics 12	Physical Lab.	Sanitation	Steel Eng.	Shops	Steam Eng.	Steam Eng. M	Structural Design	Thesis	Thesis C	Thesis &	Thesis M	Thesis & of Orator	Hydraulics
	12	6	May 27 6	6	10	16	2	6	8	9	6	9	12	10	24	15 12	16	6
Sur p. 138																		
See p. 150																		
					90	95										95		

n Adv. Math. Physics 90

o Elasticity + Hydrodynamics 95

o Physics 12 90

o Physical Lab 95

o General Science Thesis 95

16
3
32

Senior

2nd semester

Hrs	
~~16~~	~~32~~
~~16~~	~~52~~
~~6~~	58
~~16~~	
~~16~~	58 hrs/wk