COOPERATION BETWEEN UNIVERSITIES AND HIGH SCHOOLS: A CASE STUDY AND A PERSONAL REFLECTION

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This is a personal note about a cooperative project between Jagiellonian University and August Witkowski High School in Kraków, Poland (V Liceum Ogólnokształcące im. Augusta Witkowskiego) from the perspective of a teacher.

Jagiellonian University is the second largest university in Poland and one of the oldest universities in Eastern Europe, founded in 1364. August Witkowski High School is one of the leading Polish high schools, known in particular for its focus on the teaching of mathematics and computer science. For example, during each of the past six years, August Witkowski High School sent 6-15 students to the final stage of Olimpiada Matematyczna, the oldest Polish mathematical competition. This means that 5–12 % of all qualifying students in the competition were from this one high school.

Jagiellonian University and August Witkowski High School have been cooperating for a number of years. According to a programme established in 2010, faculty members from Jagiellonian University's Department of Mathematics and Computer Science give courses to a selected group of high school students.

High school education in Poland takes 3 years. Students are usually organized into classes of 30–35 students, called klasa in Polish. These classes take most of their courses together, and a specific class's curriculum often has some particular emphasis. Our programme involves two courses, offered each year to a class which specializes in mathematics and computer science. One is a general course in mathematics, and the other focuses on algorithms. Both courses are required in the first year, and students can choose between the two courses during their second and third year. The precise content of these courses is decided by the university teachers and varies considerably from year to year depending on the teacher's preference. Some teachers focus on mathematical competition problems while others give lectures on topics from undergraduate mathematics.

I taught such a course to first year students in 2010/11, and I've been teaching another course for three years since 2014/15 for the same class of students (that, however, became much smaller after a year). During the first year, I taught mostly elementary number theory and combinatorics with a rather standard set of topics: congruences, diophantine equations, permutations, enumeration, recurrence relations, methods of summation, Stirling numbers, etc. I put particular emphasis on teaching students how to write a formal proof. While many students hardly needed any training (mostly due to substantial mathematical competitions experience), some chose the high school solely because of their interest in

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computer science. These students often had almost no prior experience in having to write down a formal proof and many struggled.

After the first year many students opted to take only the algorithms course which led to substantially smaller groups of students (even as a few students from other classes started to attend the course as well). I decided to essentially follow the book of V.B. Alexeev Abel's Theorem in Problems and Solutions based on the lectures of V.I. Arnold for high school students in Moscow in 1963-64. We moved at a much slower pace than Arnold did (what he did in half a year took us almost three times as much time to cover) and I included some extra topics. We discussed basic group theory (supplementing the beautiful geometric approach of Arnold with a more algebraic one) and then proceeded to discuss basic facts about complex numbers, analytic continuation, and monodromy groups, trying to preserve the geometric and intuitive flavour of Alexeev-Arnold's approach. Occasionally, I would break the flow of the course to discuss some other topics, often at students' request.

Let me end on a personal note. I had an opportunity to teach a selected group of very bright and ambitious high school students whose knowledge and talent for mathematics exceeded those of many undergraduate students. It was thus sometimes only too easy to forget that they were nevertheless much younger than undergraduate students and should be approached accordingly. Compared to undergraduate students, high school students spend a much larger proportion of their time in class, often having up to forty hours of courses and extracurricular activities per week. It is unrealistic to expect them to spend as much time working on homework problems as undergraduate students do and a teacher needs to take this into account. Furthermore, high school students, even the best ones, are used to relying heavily on their teacher for precise instructions and organisation of their studies and are less independent than their older counterparts.

The partnership between Jagiellonian University and August Witkowski High School is only directed at a small, selected group of students. However, for these students it provides a valuable supplement to the regular education, one which complements students' involvement in mathematical competitions and is well adapted to their interests and abilities. As such, it partially addresses a quite common problem of many bright students with a lot of olympiad training who experience trouble in their early undergraduate studies in shifting to more abstract, research-oriented mathematics that involves fewer technical tricks and more structural ideas. A university-high school partnership intends to bridge the gap between high school education and research. Only time will tell whether this particular programme achieves this aim.

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