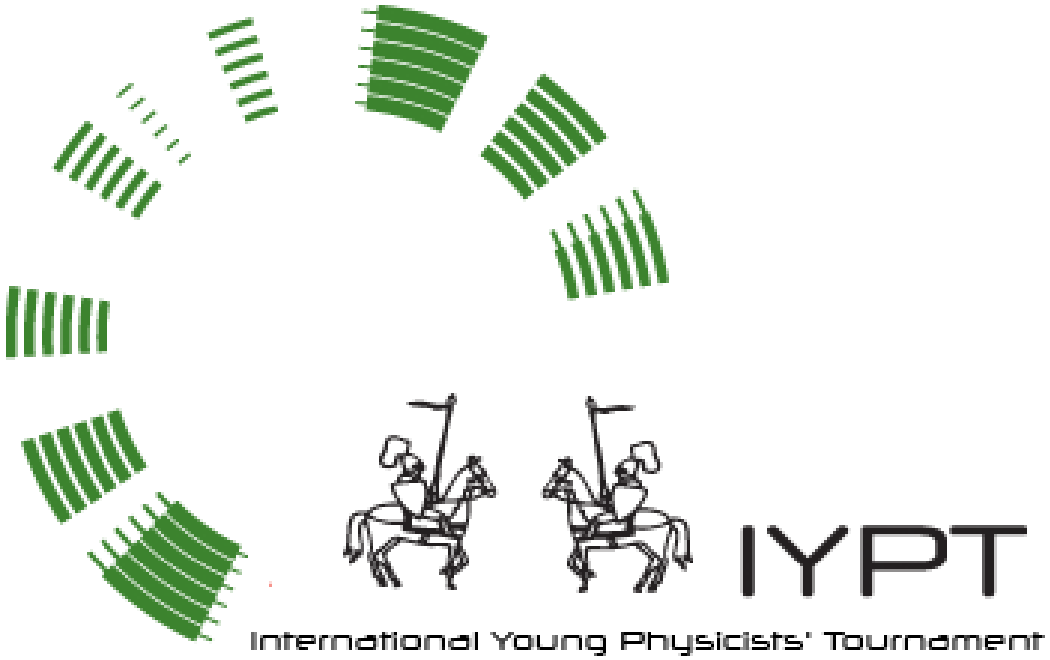
Development of Soft Skills via IYPT

How does YPT participation lead to soft-skill development?



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The relationship between inquiry-based learning in YPT and the development of soft skills

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REPORT

This intellectual output is concerned with the question how inquiry-based learning relates to the development of soft skills in high school students. To this end, three research activities were conducted. First, we investigated how students perceive the role of YPT participation in their development of soft skills. Second, we investigated how students' teachers assess the contribution of YPT participation to students' soft skills development. Third, we link self-reported soft-skill development to performance in research tasks, as assessed by international panels of experts in the context of a physics competition. Taken together, the three steps, by triangulating the relationship between inquiry-based learning and soft-skill development, allow building inference about how inquiry-based learning helps students build soft skills, and how these soft skills influence student performance in research tasks. The data for the three stages includes 308 student responses for stage one, 33 teacher responses for stage two, and 794 expert (teachers, researchers, and university professors) assessments of student performance for stage three. Condensing the detailed findings from our analysis, we suggest thirteen guidelines for developing soft skills in students below. In the supplementary materials that complement this report, we present our findings in full detail. These supplementary materials consist of three sections. The first section shows survey results on students' assessment of soft-skill development through regular physics classes, YPT-related activities, and other extracurricular activities. The second section present results from a survey of teachers' assessment of soft-skill development through these three types of activities. In section three, we present result from an expert evaluation of the relation between soft skills and performance in inquire-based learning. This analysis was conducted as part of two master theses that are included in Appendix B (separate documents). Throughout the report, we refer to the respective sections in the supplementary materials.

Guidelines for Developing Soft Skills through Inquiry-Based Learning in YPT

I. YPT participation reinforces soft-skill development

In our survey, students responded that they consider participation in YPT-related activities as beneficial to the development of soft skills (see 1.2.1). Although we observed some variation between different types of soft skills, the median evaluation of the usefulness of YPT-related activities for soft-skill development was 4 (out of 5). Broadly speaking, this intellectual output (IO) therefore shows that inquiry-based learning—a core tenant of YPT—is positively associated with the development of soft skills. The perceived usefulness of YPT-related activities for the development of individual types of soft skills is strongly correlated. We consider this as an indication that YPT-related activities have a holistic impact on soft skills.

Students also evaluated their regular physics classes as useful to develop soft skills. In the survey, we observed similarly high evaluations for the usefulness of regular classes as of YPT-related activities. Hence, we applied a t-test on the differences in students' self-reported usefulness. Our results show minor differences in the perceived usefulness. Only in the case of "Debating skills", we find that students perceived YPT-related activities as significantly more useful than regular physics classes. For all other types of soft skills, we did not find statistically significant differences ($p \leq 0.10$).

For teachers, these findings imply that participation in YPT-related activities helps students to develop their soft skills. This means, that YPT participation should complement regular physics classes. Additionally, at least for specific soft skills, benefits from participation in YPT-related activities even exceeded the benefits from regular physics classes. Yet it appears as if students, on average, do not consider participation in YPT activities as substantially more useful than their regular physics classes. Hence, teachers must communicate to students how YPT complements regular physics classes.

Usefulness of regular classes vs. YPT activities

Soft Skills	**t**	**df**	**p**
Teamwork	-0.845	97	0.400
Ability to loc. and use information	1.145	92	0.255
Creativity	0.223	91	0.824
Presentation skills	-1.104	95	0.272
Debating skills	**-2.188**	**99**	**0.031**
English skills	0.520	94	0.604

Note: Student's t-test, coefficients with $p \leq 0.10$ highlighted bold.

II. Linkage between inquiry-based learning and extracurricular activities

As part of the survey (see 1.2.1), students also evaluated the usefulness of other extracurricular activities (e.g., Physics Olympiad, IJSO, EUSO, or Project Science Competition). Overall, students considered these extracurricular activities as useful to develop their soft skills. We find that, based on students' self-evaluation, extracurricular activities had a significantly stronger impact on soft skills than regular physics classes. In comparison to YPT-related activities, we observe greater perceived usefulness for extracurricular activities for all types of soft skills, with the notable exceptions of "Presentation skills" and "Debating skills".

An important caveat applies regarding the perceived usefulness of other extracurricular activities. Since students choose these activities themselves, they might be somewhat biased towards them. This may partially explain the greater perceived usefulness of other extracurricular activities in comparison to YPT-related activities.

For teachers, these findings imply that YPT-related activities and other extracurricular activities may complement each other. As a result, we suggest that teachers reinforce inquiry-based learning activities in regular physics classes and encourage the participation in YPT-related activities. In addition, teachers should link these activities to students' other extracurricular activities in order to maximize soft-skill development through both types of activities.

Usefulness of YPT activities vs. other activities

Soft Skills	**t**	**df**	**p**
Teamwork	**-3.946**	**92**	**0.000**
Ability to loc. and use information	**-6.046**	**90**	**0.000**
Creativity	**-4.887**	**89**	**0.000**
Presentation skills	-1.273	91	0.206
Debating skills	-0.102	94	0.919
English skills	**-4.661**	**90**	**0.000**

Note: Student's t-test, coefficients with $p \leq 0.10$ highlighted bold.

III. Inquiry-based learning builds on existing soft skills

Self-reported usefulness of participation in YPT-related activities by students show differences contingent on the number of years that students had to complete until their final exam (see 1.2.2). In our regression analysis, we find that students that still had some time until their final exam considered the participation in YPT-related activities as less useful than students who were in their final or last-to-final year. Only in the case of "Teamwork" and "English skills", we find no differences in the perceived usefulness. We observe no such differences in the case of other extra-curricular activities.

These findings are even more revealing, when considering them in comparison to the perceived usefulness of regular physics classes contingent on time to final year. In this analysis, we see the opposite picture. Students that were in their early years considered their regular physics classes as more useful than students in their final year. This further underlines the complementarity between regular physics classes and YPT-related activities.

For teachers, these findings imply that participation in YPT-related activities may constitute a "capstone" element in student education. It seems as if teachers need to ensure sufficient levels of skills for students to make the most from participation in YPT. Teachers should therefore build on existing soft skills (as well as hard skills) in students in order to maximize soft-skill development in the last year(s) before students graduate. For students that are still some time from their final exams, and thus presumably have a shallower skill pool than more senior students, these findings point at additional need for guidance by teachers. In this case, teachers should ensure that students get sufficient preparation and support for YPT-related activities in order to avoid feeling overwhelmed by the events' requirements. This step will help to allow junior students to maximize their benefits from YPT-related activities.

Differences in usefulness of YPT activities based on years to final exam

Soft Skills - YPT	**1**	**2**	**3+**	**R^2**
Teamwork	0.086	-0.113	-0.239	0.017
Std. Error	0.205	0.213	0.247	
p-value	0.677	0.596	0.336	
Ability to loc. and use information	-0.024	**-0.476**	**-0.498**	0.053
Std. Error	0.234	**0.247**	**0.288**	
p-value	0.919	**0.057**	**0.086**	
Creativity	-0.164	**-0.493**	-0.146	0.038
Std. Error	0.220	**0.236**	0.275	
p-value	0.458	**0.039**	0.596	
Presentation skills	-0.029	**-0.408**	-0.108	0.036
Std. Error	0.202	**0.215**	0.257	
p-value	0.886	**0.060**	0.675	
Debating skills	0.021	-0.310	**-0.383**	0.046
Std. Error	0.183	0.192	**0.228**	
p-value	0.911	0.109	**0.096**	
English skills	-0.002	0.017	-0.271	0.015
Std. Error	0.181	0.191	0.232	
p-value	0.990	0.931	0.246	

Note: Linear regression, baseline: year of final exam, coefficients with $p \leq 0.10$ highlighted bold.

IV. Inquiry-based learning builds on existing physics skills

In our survey, students indicated that they consider participation in YPT-related events the more useful, the more regular physics classes per week they attend (see 1.2.3). Only for "Presentation skills" and "Debating skills", we do not observe this relation. Although results differ by type of soft skill, it appears that students that took 4 hours of weekly physics classes perceived YPT-related events as most useful. Findings for the self-reported usefulness of regular physics classes resemble those for YPT activities—the more hours of class the students take, the more useful they consider them. For other extracurricular activities we do not find comparable effects.

For teachers, these findings imply that basic physics skills are important contingencies for soft-skill development from YPT-related activities. Seen differently, students with solid foundations in physics will benefit most in terms of soft-skill development from YPT participation. This outlines two suggestions for teachers to enhance the benefits from inquiry-based learning. First, teachers need to consider class's progress in physics before employing inquire-based learning methods or joining YPT-related activities. Teachers may employ inquiry-based learning activities particularly in groups of advanced students who have a heavy physics course load in order to maximize soft-skill development. Second, teachers must ensure that students develop the necessary foundations in physics before joining YPT-related activities. Otherwise, this may result in adverse effects due to a feeling of being overwhelmed—a point already raised above. As a positive side-effect, building foundations in physics will also enhance the development of soft skills during regular physics classes.

Differences in usefulness of YPT activities based on regular physics classes per week

Soft Skills - YPT	**1**	**2**	**3**	**4**	**5+**	**R^2**
Teamwork	0.500	**1.052**	**1.067**	**1.350**	0.750	0.076
Std. Error	0.654	**0.507**	**0.518**	**0.530**	0.580	
p-value	0.446	**0.040**	**0.042**	**0.012**	0.198	
Ability to loc. and use information	1.083	**1.048**	**1.126**	**1.233**	1.083	0.034
Std. Error	0.773	**0.600**	**0.614**	**0.627**	0.686	
p-value	0.164	**0.084**	**0.069**	**0.052**	0.117	
Creativity	0.167	0.500	0.381	0.767	0.667	0.032
Std. Error	0.720	0.559	0.573	0.584	0.638	
p-value	0.817	0.373	0.507	0.192	0.299	
Presentation skills	0.167	0.649	0.598	0.857	0.792	0.036
Std. Error	0.675	0.524	0.536	0.546	0.598	
p-value	0.805	0.218	0.267	0.119	0.188	
Debating skills	-0.167	0.333	0.398	0.633	**1.000**	0.079
Std. Error	0.601	0.466	0.476	0.487	**0.525**	
p-value	0.782	0.476	0.405	0.196	**0.059**	
English skills	-0.083	0.648	**0.770**	**1.000**	**0.917**	0.092
Std. Error	0.571	0.444	**0.454**	**0.462**	**0.507**	
p-value	0.884	0.147	**0.092**	**0.032**	**0.073**	

Note: Linear regression, baseline: no weekly physics classes, coefficients with $p \leq 0.10$ highlighted bold.

V. Recent participation in YPT enhances soft-skill development

As part of our survey, we analyse how students' self-reported benefits from YPT-related activities vary contingent on their most recent participation in YPT (see 1.2.4). Students had either participated "Never", "Earlier than this year", or "This year". With the exception of "English skills", we find no statistically significant differences contingent on the most recent participation. Yet it appears that a recent participation in YPT has a stronger effect than participation that dates some time back. We make similar observations about the perceived usefulness of regular physics classes. With the exception of "Presentation skills", our results show a more positive impact of regular physics classes on the development of soft skills for students that recently participated in YPT-related activities than for students who participated in YPT at an earlier point in time. A potential explanation for this relation might be that participation in YPT-related events empowers students in a way that motivates them to make the most out of opportunities to improve their soft skills during regular physics classes.

For teachers, these findings imply that students should participate in YPT-related activities and employ inquiry-based learning methods on a regular basis. Not only will they directly benefit from their participation in YPT, but students will also generate indirect benefits from YPT through greater usefulness of regular physics classes. It may appear as if this recommendation runs somewhat against the result that YPT participation is particularly relevant for soft-skill development in the last year of high school. However, the two findings can be reconciled by seeing participation in YPT-related activities in early years of high school as an investment into maximizing the effect of later-year YPT participation for soft-skill development. Yet, as mentioned above, our findings also suggest that students will require support and guidance by teachers during such early participation to avoid unintended consequences for the students' soft-skill development.

Differences in usefulness of regular classes based on most recent participation in YPT activities

Soft Skills - RPC	**Earlier**	**This year**	**R^2**
Teamwork	**-0.954**	-0.954	0.078
Std. Error	**0.284**	0.981	
p-value	**0.001**	0.333	
Ability to loc. and use information	**-0.966**	1.117	0.081
Std. Error	**0.295**	0.982	
p-value	**0.001**	0.257	
Creativity	**-0.856**	0.298	0.060
Std. Error	**0.288**	0.993	
p-value	**0.003**	0.765	
Presentation skills	-0.406	1.209	0.024
Std. Error	0.291	1.005	
p-value	0.166	0.231	
Debating skills	**-0.620**	1.380	0.038
Std. Error	**0.320**	1.065	
p-value	**0.055**	0.197	
English skills	**-0.538**	0.000	0.023
Std. Error	**0.300**	1.033	
p-value	**0.074**	1.000	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

VI. Recent participation in YPT increases benefits from extracurricular activities

Analogous to our analysis above, we investigate differences in the perceived usefulness of extracurricular activities based on students' most recent participation in YPT-related activities (see 1.2.4). Our results suggest, that students who recently participated in YPT activities consider other extracurricular activities more useful than students that participated in YPT some time back. As above, a potential explanation might be that participation in YPT-related activities motivates students to take benefit from other extracurricular activities.

It is interesting to note that, in our data, we do not observe the same moderating effect for other extracurricular activities (see 1.2.5). Neither in the case of regular physics classes, nor in the case of YPT-related activities, we find that a more recent participation in other extracurricular activities leads

to greater perceived usefulness. It appears as if students cannot transfer learnings or motivation from other extracurricular activities to regular physics classes or YPT-related activities, as in the case of YPT.

For teachers, these findings imply the existence of a positive interaction effect between participation in YPT-related activities and other extracurricular activities. Yet we do not find such an interaction effect in the opposite direction—i.e., from other extracurricular activities on participation in YPT. As a result, we suggest teachers to include particularly students with substantial extracurricular activities in their YPT preparation. Thereby, teachers will allow their students to directly benefit from their participation in YPT as well as to benefit indirectly through greater soft-skill development in other extracurricular activities.

Differences in usefulness of other activities based on most recent participation in YPT activities

Soft Skills - Other	**Earlier**	**This year**	**R^2**
Teamwork	**-0.609**	0.622	0.057
Std. Error	**0.222**	0.765	
p-value	**0.007**	0.418	
Ability to loc. and use information	**-0.491**	0.600	0.039
Std. Error	**0.229**	0.730	
p-value	**0.034**	0.413	
Creativity	**-0.527**	-0.427	0.044
Std. Error	**0.220**	0.673	
p-value	**0.018**	0.526	
Presentation skills	**-0.527**	1.056	0.032
Std. Error	**0.296**	0.983	
p-value	**0.077**	0.285	
Debating skills	**-0.620**	0.017	0.036
Std. Error	**0.280**	0.892	
p-value	**0.028**	0.985	
English skills	**-0.610**	0.556	0.051
Std. Error	**0.237**	0.787	
p-value	**0.011**	0.481	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

VII. Teachers take positive perspective on YPT participation

In a second survey, we analyse teachers' evaluation of the usefulness of YPT-related activities to develop students' soft skills. Teachers generally considered YPT-related activities as highly beneficial for students' soft-skill development (8 out of 10, see 2.2.2). This result is particularly strong when compared to the usefulness ascribed to regular physics classes: 5 out of 10 (see 2.2.1). Results from a paired t-test (see 2.3.1) confirm these differences. Across all types of soft skills, we observe greater perceived usefulness for YPT-related activities than for regular physics classes.

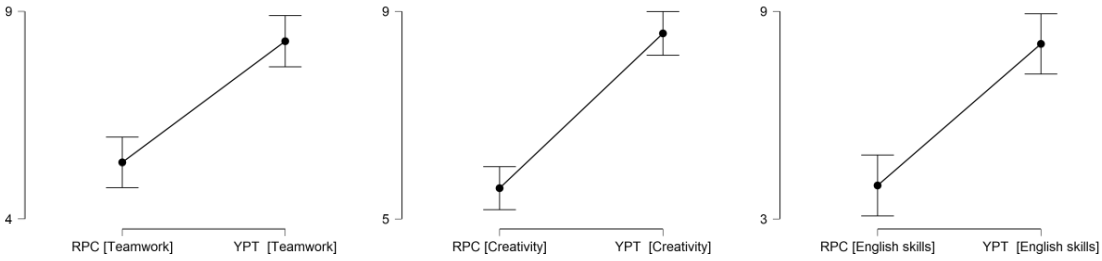
While this finding attests to the usefulness of YPT-related activities to develop students' soft skills, an important caveat applies. Only teachers who have some experience with YPT activities participated in the teacher survey for IO2. Therefore, we have to consider the possibility of a self-selection bias by teachers. This may explain the differences in the perceived usefulness of YPT-related activities by

students (see 1.2.1) and teachers. While teachers considered YPT-related activities as more useful for all kinds of soft skills, we find a difference in the students' perception only in the case of "Debating skills". In an additional analysis (see 2.5), we investigate how students compare the usefulness of their regular physics classes to develop their soft skills to the usefulness of YPT-related events and how teachers compare the two activities. We observe that teachers perceive YPT-related activities as significantly more useful across all types of soft skills. Students, on the other hand, took a more differentiated view and reported YPT-related activities as more useful for only 4 out of 6 soft skills.

For teachers, these findings imply regular reflections on students' soft-skill development in their inquiry-based learning activities. This will help teachers to better assess whether YPT-related activities actually contribute to students' soft-skill development in the extent that teachers expect. On the other hand, the findings also suggest that teachers need to ensure that students recognize the benefits of participation in YPT-related activities. Unless the differences between students' and teachers' perceptions are the sole outcome of a selection bias, the question remains why teachers consider YPT more positively than students. Thus, teachers should motivate students to participate in YPT and should explicate how YPT-related activities and inquiry-based learning complement regular physics classes—rather than being a redundancy.

Paired sample t-test: Soft skill in RCP vs. YPT

Measure 1	Measure 2	Test	Statistic	df	p
RPC [Teamwork]	- YPT [Teamwork]	Student	-6.503	31	< .001
RPC [Creativity]	- YPT [Creativity]	Student	-10.225	31	< .001
		Wilcoxon	0.000		< .001
RPC [Debating skills]	- YPT [Debating skills]	Student	-7.126	32	< .001
RPC [Ability to loc. use inf.]	- YPT [Ability to loc. use inf.]	Student	-7.742	31	< .001
		Wilcoxon	0.000		< .001
RPC [Presentation skills]	- YPT [Presentation skills]	Student	-6.040	32	< .001
RPC [English skills]	- YPT [English skills]	Student	-6.759	31	< .001



VIII. Teachers favour YPT participation over other extracurricular activities

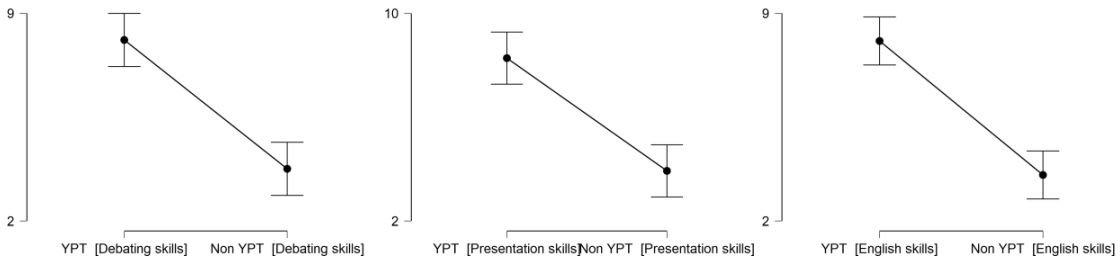
As part of the survey, teachers also evaluated the usefulness of other extracurricular activities (e.g., Physics Olympiad, IJSO, EUSO, or Project Science Competition) for the development of students' soft skills. With some variation between the different types of soft skills, on average, teachers evaluated other extracurricular activities similarly to regular physics classes (5 out of 10, see 2.2.3). Since this evaluation is below the score for YPT activities, we compare the evaluation of teachers' for YPT-related activities and other non-curricular activities. As in the case of regular physics classes, teachers reported that the considered YPT-related activities as more useful to develop students' soft skills than other activities (see 2.3.2).

Again, we want to point to the role of a selection bias as a potential caveat. By their experience and involvement with YPT, teachers may be positively predisposed towards YPT-related activities. Yet the same caveat also applies to students who might be biased towards their individually chosen extracurricular activities (see 1.2.1). This could explain why teachers considered YPT-related as more useful than other extracurricular activities across all types of soft skills, while students, with the exception of "Presentation skills" and "Debating skills" took the opposite view.

For teachers, these findings once more imply regular reflections on students' soft-skill development in their inquiry-based learning activities. In addition, the findings also suggest that teachers need to leverage the benefits of YPT-related activities in combination with those from other extracurricular activities. Neither teachers nor students should consider the two types of activities as substitutes or, worse, at a conflict. Instead, teacher have to make sure that students extend their apparent motivation for other extra-curricular activities to YPT-related activities. Students should see these activities as complementary. This is important, since our student survey indicates potential for positive interactions and cross-fertilization between the two types of activities.

Paired samples t-test: Soft skills in YPT vs. non-YPT

Measure 1	Measure 2	Test	Statistic	df	p
YPT [Teamwork]	- Non YPT [Teamwork]	Student	-6.503	31	< .001
YPT [Creativity]	- Non YPT [Creativity]	Student	-10.225	31	< .001
YPT [Debating skills]	- Non YPT [Debating skills]	Student	0.000		< .001
YPT [Ability to loc. use inf.]	- Non YPT [Ability to loc. use inf.]	Student	-7.126	32	< .001
YPT [Presentation skills]	- Non YPT [Presentation skills]	Student	-7.742	31	< .001
		Wilcoxon	0.000		< .001
YPT [English skills]	- Non YPT [English skills]	Student	-6.040	32	< .001



IX. Soft skills positively influence student performance

In expert evaluations, we analyse how students' perceptions about their soft skills relate to their performance in inquiry-based learning (see 3.3, hypothesis P.2). For analysis, we consider the grades assigned by the jurors at YPT competitions for students' presentations as performance measures. In a first step, we observe that students that attributed greater importance to their soft skills also achieve greater performance. Although this relation may be subject to a bias (e.g., only students with highly developed soft skills deem them important), this finding may point at a motivational effect. If students consider their soft skills important, they are motivated to enhance them, which in turn results in greater performance.

In a second step, we extend the analysis to the students' perceived proficiency in various soft skills and to how such proficiency affects performance. In the test, we consider six different types of soft skills. Out of these, we found that greater proficiency of scientific reasoning skills (prof_post_reasoning), debating skills (prof_post_debating), and English skills (prof_post_english) enhanced performance in inquiry-based learning.

Regression results for importance of individual soft skills

term	estimate	std.error	statistic	p.value
(Intercept)	-8.86	1.41	-6.30	0.00000000
tournamentAYPT2021	1.61	0.25	6.39	0.00000000
roleRep	0.26	0.12	2.07	0.03915244
roleRev	0.67	0.15	4.57	0.00000555
age	0.27	0.07	3.87	0.00011965
importance_teamwork	1.46	0.18	8.00	0.00000000
importance_research	1.99	0.23	8.69	0.00000000
importance_reasoning	0.58	0.18	3.15	0.00171139
importance_presentation	-2.20	0.35	-6.31	0.00000000
importance_debating	1.08	0.25	4.40	0.00001239
importance_english	-0.81	0.11	-7.52	0.00000000

Regression results for proficiency after preparation phase in 2020

term	estimate	std.error	statistic	p.value
(Intercept)	-2.42	1.67	-1.45	0.14684470
tournamentAYPT2021	1.22	0.21	5.73	0.00000001
roleRep	0.29	0.14	2.13	0.03331587
roleRev	0.66	0.17	4.01	0.00006743
age	0.36	0.11	3.31	0.00097471
prof_post_teamwork	-0.14	0.19	-0.76	0.44499886
prof_post_research	-0.01	0.11	-0.06	0.95270594
prof_post_reasoning	0.47	0.23	2.09	0.03661578
prof_post_presentation	-1.00	0.33	-3.07	0.00225924
prof_post_debating	0.48	0.26	1.87	0.06169911
prof_post_english	0.58	0.10	5.86	0.00000001

For teachers, these findings imply that soft skills play an important role for students and that greater proficiency in soft skills will enhance performance. In addition, we find that students that consider the development of soft skills more important will also achieve greater performance. This suggests that teachers should focus on developing these soft skills in students, in order to maximize students' research abilities in physics (and probably beyond). As an essential part of skill development, teachers should pay special attention to motivating students towards improving their soft skills. Given the findings from the first two stages of the report, participation in YPT-related events will be particularly helpful to achieve this goal when paired with other extracurricular activities.

X. YPT participation enhances research performance

Next, we analyse expert evaluations to understand how preparation for YPT-related events enhances students' performance (see 3.3, hypothesis S.1a). To this end, we compare how soft skill proficiency before and after YPT events shaped performance in inquiry-based learning. In our study, we observe that only pre-preparation "Presentation skills" increased performance. As discussed above, we find that 3 out of 6 post-preparation skills enhanced performance. Yet "Presentation skills" appears to be somewhat of an outlier. While it increases performance pre-preparation, it decreases performance post-preparation. Despite this outlier observation, we conclude that preparation for YPT-related events enhances performance in inquiry-based learning.

For teachers, these findings imply that participation in preparation classes for YPT-related events allows students to enhance their performance in inquiry-based learning. These results, as well as those presented above, suggest that this enhancement runs through greater proficiency in various soft skills. Teachers should therefore motive and encourage students to participate in preparatory courses for YPT events. Thereby, teachers will make an important contribution to the development of student's soft skills and eventually their performance in inquiry-based learning.

Regression results for proficiency before preparation phase in 2021

term	estimate	std.error	statistic	p.value
(Intercept)	-5.87	2.66	-2.20	0.02789855
roleRep	0.36	0.15	2.48	0.01342152
roleRev	0.73	0.15	5.00	0.00000078
age	0.79	0.15	5.37	0.00000011
prof_prae_teamwork	-0.92	0.29	-3.21	0.00139121
prof_prae_research	-0.13	0.11	-1.17	0.24442857
prof_prae_reasoning	-0.03	0.27	-0.13	0.89899302
prof_prae_presentation	0.74	0.41	1.81	0.07114430
prof_prae_debating	0.07	0.30	0.25	0.80597444
prof_prae_english	-	-	-	-

XI. Preparation for YPT participation enhances its benefits

For further analysis of the impact of preparation for YPT-related events on performance in these events, we consider how the time spent on preparation affects performance in inquiry-based learning (see 3.3, hypothesis S.1b). Our findings indicate that students achieve the greater performance in YPT tournaments the more time they spend on preparation. We assume that this effect, as the effects discussed above, runs through soft skills. Preparation gives students an opportunity to train their soft skills, which provides them with an advantage in the actual YPT competition.

Regression results for hours spent preparing

term	estimate	std.error	statistic	p.value
(Intercept)	-5.77	0.97	-5.97	3.66E-09
tournamentAYPT2021	0.51	0.15	3.50	0.00050284
roleRep	0.34	0.14	2.52	0.01183890
roleRev	0.65	0.17	3.94	0.00008833
age	0.66	0.06	11.88	7.83E-30
h_prep_AYPT	0.01	0.00	7.86	1.39E-14

It is interesting to note that students also recognized these benefits of preparation. When asked whether preparation for YPT helped to develop their soft skills, the average response across all soft skills was 2.39 (scale ranged from “1: little” to “3: a lot”). Only “English skills”, with a mean response of 1.70, appeared as an outlier. For the other categories of soft skills, we observe values above 2.0. In the case of “Scientific reasoning skills” and “Debating skills”, the self-reported contribution to soft-skill development was above 2.7.

Descriptive statistics on soft skills variables

Variable	Mean	Std. Dev.	Min.	Max.	N Teams
Development teamwork	2.319	0.746	1.0	3.0	12
Development independent research	2.319	0.533	1.5	3.0	12
Development scientific reasoning	2.750	0.405	2.0	3.0	12
Development presentation skills	2.513	0.457	2.0	3.0	12
Development debating skills	2.722	0.422	2.0	3.0	12
Development English skills	1.694	0.895	1.0	3.0	12
General development soft skills	2.386	0.379	1.8	3.0	12

For teachers, these findings imply that they should spend a substantial share of physics classes on inquiry-based learning activities. On the one hand, this will improve soft-skill development itself. On the other hand, such additional time for preparation allows students to improve on the research tasks. In addition, these extra hours will also build soft skills. There may also be a reinforcing effect between the two relations. It appears as if students recognize these benefits in terms of greater performance at YPT. Teachers should therefore build on this positive perception by students to motivate them for participation in YPT-related events. Ideally, teachers manage to link this preparation to students' other extracurricular activities. Our results from the first two stages of the report suggest that this connection between YPT and other extracurricular activities will result in a positive interaction effect.

XII. Scientific reasoning, debating, and English as pivotal skills

In line with findings from Deep et al. (2019), expert assessment show that scientific reasoning skills, debating skills, and English skills make the greatest contribution to performance in YPT (see 3.3 and regression coefficients below). This finding corroborates the importance of preparatory classes for greater performance in YPT. We observe that for "Scientific reasoning" and "Debating skill" students reported that the preparatory classes made a substantial contribution to the development of their soft skills (see mean contribution below). At the same time, students argued that they considered these skills as highly important to achieve greater performance in YPT competitions (see mean perceived importance below). In the case of "English skills", however, we observe that students consider it neither important for YPT nor do they believe the that preparatory classes add to their English skills. While this could point at self-fulfilling prophecy (i.e., students do not consider English skills important, so they do not recognize any improvement), it could also show a gap in the skills covered during preparatory classes.

For further analysis, we go back to results from stage 1 and 2 of our analysis (see 1.2 and 2.2). This shows that the contribution to "Debating skills" is particularly important, since students' self-reported proficiency was below the average for all soft skills (3.65 vs. 3.92). In addition, students reported that regular physics classes had below average usefulness to develop this soft skill (3.56 vs. 3.74). For "English skills", however, students self-reported high proficiency (4.13) and considered regular physics classes as useful for development (3.97). An explanation for these results could be that students felt that they did not gain any additional input for their English skills from the preparatory classes. This finding appears to be at odds with results from the teacher survey. Unlike students, teachers responded that while regular physics classes made only a minor contribution to English skills (4.04), the contribution of YPT-related activities was substantial (8.07, both on a scale from 1 to 10).

For teachers, these findings have major implications. First, we suggest teachers focus on developing scientific reasoning, debating, and English skills to maximize the positive effects soft skills have on student performance in inquiry-based learning. In addition, we suggest that YPT-related activities, which have particularly strong effects on developing scientific reasoning and debating skills, may play a pivotal role in preparing students to perform well on research tasks. Second, teachers should collect student feedback to analyse why students feel that preparatory classes do not add to their English skills. Such feedback may show that students' perception is merely the outcome of self-fulfilling prophecy or that preparatory classes require adaption to contribute more to students' English skills. Third, teachers should inquire why only 3 out of 6 soft skills enhanced students' performance in YPT. Appreciating the challenges in the interpretation of non-findings, teachers should ensure that students can leverage their full portfolio of soft skills during inquiry-based learning activities. This is essential for the success of soft-skill development in students. If students get the feeling that they cannot make use of all their soft skills during inquiry-based learning, this may have a negative impact on students' motivation to work on these skills and thus results in detrimental long-term effects.

Variable	Contribution to performance	Contribution to development	Perceived importance
Teamwork	-0.14	2.319	4.250
Independent research	-0.01	2.319	3.902
Scientific reasoning	0.47	2.750	4.777
Presentation skills	-1.00	2.513	4.375
Debating skills	0.48	2.722	4.736
English skills	0.58	1.694	3.319

Note: "Contribution to performance" is the coefficients from a linear model that regresses performance in YPT on proficiency in soft skills; "Contribution to development" is the average contribution of YPT preparation to soft-skill development (scale 1-3); "Perceived importance" is the average importance that students assigned to each soft skill category for success in YPT (scale 1-5).

XIII. Cross-national differences matter

As our data includes responses from students and teachers from several countries, we are interested in how cross-national differences affect our findings (see 1.3 and 2.4). We observe that responses by students as well as teachers differ by country. Home country factors (e.g., education system, curricula, teaching style) seem to affect how students and teachers consider the usefulness of the different activities to develop students' soft skills. In line with this observation, we also find that student's self-reported proficiency of soft skills varies by country.

However, the analysis shows differences in the country effects reported by students and teachers. While we find country-differences in the student-reported usefulness of YPT-related activities for all types of soft skills, for responses by teachers, we observe these differences only in the case of the "Ability to locate and use information". Along the same lines, while teachers report differences for the usefulness of other extracurricular activities, we find no differences in the student survey.

For teachers, these findings imply that preparatory classes for YPT may require more adaption than teachers initially assume. Students from different countries reported varying perceived usefulness for YPT to develop their soft skills. Teachers' responses, however, do not show substantial differences across this dimension, maybe owing to smaller a smaller number of observations.

Differences in students' responses based on country

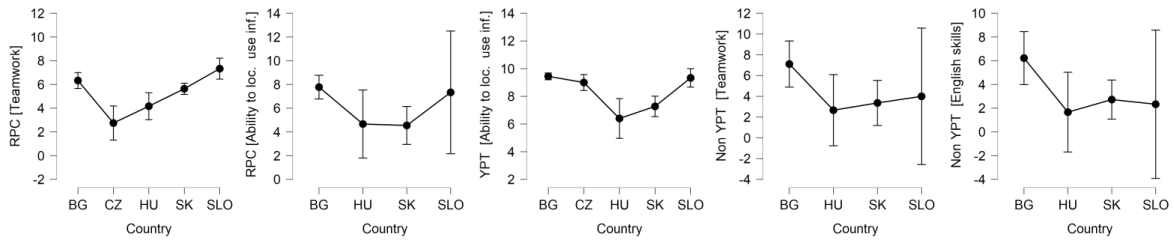
	Soft Skills - Students	df	F	p
RPC	Teamwork	4	3.637	0.007
RPC	Creativity	4	2.021	0.094
YPT	Teamwork	8	7.812	0.000
YPT	Ability to loc. and use information	7	4.602	0.000
YPT	Creativity	7	5.272	0.000
YPT	Presentation skills	8	16.316	0.000
YPT	Debating skills	8	7.476	0.000
YPT	English skills	8	6.749	0.000

Note: ANOVA (Value ~ Country), only coefficients with $p \leq 0.10$ included.

Differences in teachers' responses based on country

	Soft Skills - Teachers	df	F	p
RPC	Teamwork	4	3.188	0.028
RPC	Ability to loc. and use information	4	3.550	0.018
YPT	Ability to loc. and use information	4	2.763	0.048
Other	Team work	3	3.365	0.034
Other	English skills	3	4.235	0.015

Note: ANOVA (Value ~ Country), only coefficients with $p \leq 0.10$ included.



The relationship between inquiry-based learning in YPT and the development of soft skills

IO2 Dibali: 2019-1-SK01-KA201-060798

SUPPLEMENTARY MATERIALS

In this document, we provide supplementary materials that offer further details on the condensed guidelines presented in our report. These supplementary materials consist of three sections. The first section shows survey results on students' assessment of soft-skill development through regular physics classes, YPT-related activities, and other extracurricular activities. The second section present results from a survey of teachers' assessment of soft-skill development through these three types of activities. In section three, we present result from an expert evaluation of the relation between soft skills and performance in inquire-based learning. This analysis was conducted as part of two master theses that are included in Appendix B (separate documents).

1. Supplement: Students' Assessment of Soft-Skill Development

1.1 Data characteristics

In total, 308 students from nine countries participated in the survey. While gender was not included in some of the surveys, the female-male split overall was about one third to two thirds. In some countries the share of male participants in the survey was even 70% and beyond (Czech Republic, Hungary). In one country (Slovenia), the share of females exceeded that of male participants.

Students were classified based on the school years until they would write their final exams. Overall, for this categorization the split was even: 19% of students were in their final school year, 26% had one and 28% had two years until completion. About one fifth of the participants still had to complete three or more years until their final exams. Slovenia constitutes somewhat of an outlier with 22% of participants in their final year and 78% of participants in their second to last school year. As part of the survey, students were asked about their regular weekly physics classes. About half of participants took four hours of weekly physics classes. In the case of students from Slovakia and Slovenia, this share is even higher at 65% and 78%, respectively. 25% of participants from Bulgaria and 19% of participants from Hungary took 5 hours or more of weekly physics classes. Students also reported the time they spent on physics-related extracurricular activities. 28% of participants reported that they spent more than 20 hours per month on physics-related extracurricular activities, another 22% answered that they spent between 10 and 20 hours per month on these activities. Again, country differences seem to persist. 43% and 44% of students from Czech Republic and Slovenia, respectively, reported that they spend more than 20 hours per month on extra-curricular activities.

Gender

Country	Unknown		Female		Male		Total	
	#	%	#	%	#	%	#	%
Austria	13	100	0	0	0	0	13	4
Bulgaria	0	0	7	33	14	67	21	7
Czech Rep.	0	0	7	30	16	70	23	7
Germany	3	100	0	0	0	0	3	1
Hungary	1	1	19	26	52	72	72	23
Iran	1	100	0	0	0	0	1	0
Russia	1	100	0	0	0	0	1	0
Slovakia	0	0	63	38	102	62	165	54
Slovenia	0	0	5	56	4	44	9	3
Total	**19**	**6**	**101**	**33**	**188**	**61**	**308**	**100**

Years to final exam

Country	Unknown		0		1		2		3+		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Austria	13	100	0	0	0	0	0	0	0	0	13	4
Bulgaria	0	0	7	33	6	29	4	19	4	19	21	7
Czech Rep.	0	0	9	39	5	22	6	26	3	13	23	7
Germany	3	100	0	0	0	0	0	0	0	0	3	1
Hungary	1	1	22	31	22	31	22	31	5	7	72	23
Iran	1	100	0	0	0	0	0	0	0	0	1	0
Russia	1	100	0	0	0	0	0	0	0	0	1	0
Slovakia	0	0	20	12	40	24	53	32	52	32	165	54
Slovenia	0	0	2	22	7	78	0	0	0	0	9	3
Total	**19**	**6**	**60**	**19**	**80**	**26**	**85**	**28**	**64**	**21**	**308**	**100**

Regular physics classes per week

Country	Unknown		0		1		2		3		4		5+		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Austria	13	100	0	0	0	0	0	0	0	0	0	0	0	0	13	4
Bulgaria	0	0	2	7	1	4	7	25	0	0	11	39	7	25	28	10
Czech Rep.	0	0	2	9	1	4	0	0	9	39	11	48	0	0	23	8
Germany	3	100	0	0	0	0	0	0	0	0	0	0	0	0	3	1
Hungary	1	1	1	1	2	3	14	19	21	29	20	27	14	19	73	25
Iran	1	100	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Russia	1	100	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Slovakia	0	0	3	2	5	4	2	1	37	27	90	65	2	1	139	48
Slovenia	0	0	0	0	0	0	0	0	2	22	7	78	0	0	9	3
Total	**19**	**7**	**8**	**3**	**9**	**3**	**23**	**8**	**69**	**24**	**139**	**48**	**23**	**8**	**290**	**100**

Average hours spent on physics-related extracurricular activities per month

Country	Unknown		≤5		≤10		≤20		>20		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Austria	0	0	13	100	0	0	0	0	0	0	13	4
Bulgaria	4	19	2	10	3	14	5	24	7	33	21	7
Czech Rep.	3	13	1	4	1	4	8	35	10	43	23	7
Germany	0	0	3	100	0	0	0	0	0	0	3	1
Hungary	12	17	4	6	11	15	24	33	21	29	72	23
Iran	0	0	1	100	0	0	0	0	0	0	1	0
Russia	0	0	1	100	0	0	0	0	0	0	1	0
Slovakia	56	34	1	1	38	23	27	16	43	26	165	54
Slovenia	1	11	1	11	0	0	3	33	4	44	9	3
Total	**76**	**25**	**27**	**9**	**53**	**17**	**67**	**22**	**85**	**28**	**308**	**100**

Participants indicated their most recent participation in YPT-related activities. Only in the case of "Work on problems" events, more than half (53%) of the students participated in YPT-related activities at least once. In the other events the majority of students had never participated. When asked about their participation in other physics competitions and events, students gave similar responses as for YPT-related events. With the exception of Ad hoc competitions (42%) and Other Science Olympiads (50%), more than half of the students had never participated in any events. Yet 46% of students had participated in a Physics Olympiad at least once. Only a part of the participants evaluated their overall experience with YPT. Yet for these 73 participants, the overall evaluation was very positive (median of 4). Although the results also show some outliers, the evaluation seems equally positive across all countries.

Most recent participation in YPT-related activities

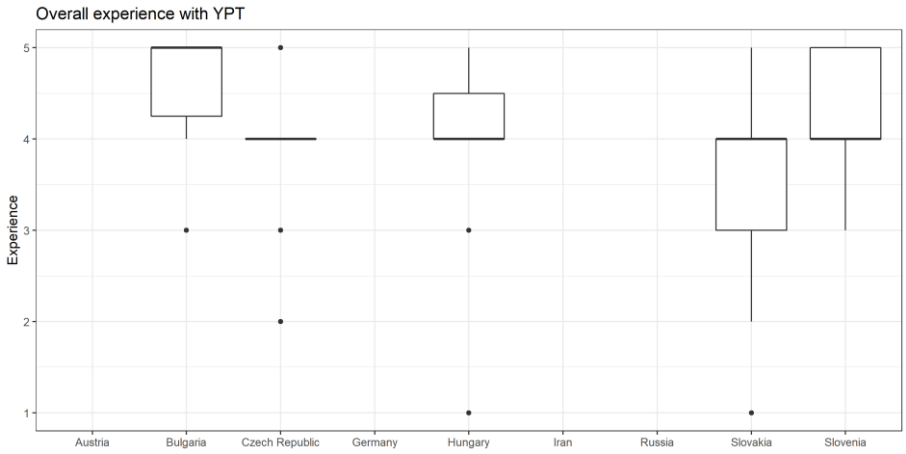
Event	This year		Last year		Earlier		Never		Total
	#	%	#	%	#	%	#	%	#
Preparatory seminar	42	19	27	12	12	5	139	63	220
Work on problems	84	35	29	12	13	5	112	47	238
Regional YPT event	47	22	21	10	16	8	125	60	209
National YPT event	50	25	9	4	15	7	129	64	203
AYPT or similar international event	9	5	5	3	13	7	161	86	188
IYPT	21	11	6	3	14	7	151	79	192

Participation in other physics competitions or preparation for them

Event	This year		Last year		Earlier		Never		Total
	#	%	#	%	#	%	#	%	#
Physics Olympiad	46	19	29	12	36	15	128	54	239
IJSO or EUSO	2	1	9	5	3	2	173	93	187
IYNT	2	1	2	1	5	3	176	95	185
Other Science Olympiad	60	26	24	10	32	14	117	50	233
Project Science Competition	18	15	9	8	8	7	83	70	118
Seminar or correspondence	42	20	16	7	28	13	129	60	215
Ad hoc competitions	73	32	38	17	29	13	87	38	227
Debate club or similar	18	9	14	7	17	8	156	76	205

Overall experience with YPT

Valid	Missing	Mean	Median	SD	Min.	Max.
73	235	3.82	4	0.96	1	5



1.2 Findings

In the survey, students were asked to evaluate their own soft skills. In addition to this evaluation, students also indicated the usefulness of regular physics classes, YPT-related activities, and other activities to develop these soft skills. Most students (about 280) completed questions on the self-evaluation of soft skills. For the assessment of usefulness of physics classes, YPT-related activities, and other activities, only responses from half the participants are available (about 140 responses).

On average, students evaluated their soft skills very positively (median = 4). The lowest mean evaluations were on “Debating skills” (3.65). The highest self-evaluations were on “Ability to locate and use information” (4.18) and “English skills” (4.13). Self-evaluations for all categories of soft skills were positively correlated ($r \sim 0.3$).

In the survey, students responded that regular physics classes, YPT-related activities, as well as other activities were useful to enhance their soft skills (median ≥ 4). It seems that other activities were perceived as most useful to increase soft skills and that YPT-related activities contributed slightly more than regular physics classes (see tests below). For all three types of activities, usefulness was positively correlated across categories of soft skills. These correlations were highest for YPT-related activities (r ~ 0.5-0.6), indicating that YPT-related activities have the most holistic impact on soft skills.

Self-evaluation by student

Soft Skills	Valid	Missing	Mean	Median	SD	Min.	Max.
Teamwork	277	31	3.91	4	0.84	1	5
Ability to loc. and use information	264	44	4.18	4	0.76	1	5
Creativity	263	45	3.94	4	0.91	1	5
Presentation skills	274	34	3.73	4	1.04	1	5
Debating skills	275	33	3.65	4	1.03	1	5
English skills	276	32	4.13	4	0.90	1	5

	Soft Skills	1	2	3	4	5	6
1	Teamwork	1.00					
2	Ability to loc. and use information	0.35	1.00				
3	Creativity	0.25	0.60	1.00			
4	Presentation skills	0.20	0.29	0.25	1.00		
5	Debating skills	0.39	0.29	0.29	0.38	1.00	
6	English skills	0.25	0.21	0.23	0.17	0.33	1.00

Note: Pearson correlation coefficients.

Usefulness of regular physics classes

Soft Skills	Valid	Missing	Mean	Median	SD	Min.	Max.
Teamwork	154	154	3.79	4	1.07	1	5
Ability to loc. and use information	150	158	3.81	4	1.01	1	5
Creativity	154	154	3.58	4	1.03	1	5
Presentation skills	152	156	3.75	4	1.03	1	5
Debating skills	151	157	3.56	4	1.06	1	5
English skills	151	157	3.97	4	1.01	1	5

	Soft Skills	1	2	3	4	5	6
1	Teamwork	1.00					
2	Ability to loc. and use information	0.64	1.00				
3	Creativity	0.55	0.51	1.00			
4	Presentation skills	0.51	0.51	0.29	1.00		
5	Debating skills	0.47	0.50	0.41	0.50	1.00	
6	English skills	0.43	0.41	0.39	0.45	0.37	1.00

Note: Pearson correlation coefficients.

Usefulness of YPT activities

Soft Skills	Valid	Missing	Mean	Median	SD	Min.	Max.
Teamwork	142	166	3.82	4	1.03	1	5
Ability to loc. and use information	133	175	3.97	4	0.92	1	5
Creativity	127	181	3.93	4	0.90	1	5
Presentation skills	139	169	3.56	4	1.07	1	5
Debating skills	135	173	3.67	4	1.01	1	5
English skills	141	167	3.67	4	1.19	1	5

	Soft Skills	1	2	3	4	5	6
1	Teamwork	1.00					
2	Ability to loc. and use information	0.60	1.00				
3	Creativity	0.60	0.63	1.00			
4	Presentation skills	0.67	0.55	0.49	1.00		
5	Debating skills	0.69	0.47	0.53	0.58	1.00	
6	English skills	0.67	0.45	0.49	0.55	0.65	1.00

Note: Pearson correlation coefficients.

Usefulness of other activities

Soft Skills	Valid	Missing	Mean	Median	SD	Min.	Max.
Teamwork	149	159	4.32	4	0.79	2	5
Ability to loc. and use information	146	162	4.38	5	0.73	2	5
Creativity	144	164	4.38	4	0.68	3	5
Presentation skills	145	163	3.93	4	0.98	1	5
Debating skills	141	167	3.94	4	0.90	1	5
English skills	146	162	4.40	5	0.79	1	5

	Soft Skills	1	2	3	4	5	6
1	Teamwork	1.00					
2	Ability to loc. and use information	0.49	1.00				
3	Creativity	0.32	0.33	1.00			
4	Presentation skills	0.40	0.45	0.29	1.00		
5	Debating skills	0.38	0.40	0.28	0.44	1.00	
6	English skills	0.36	0.46	0.31	0.28	0.36	1.00

Note: Pearson correlation coefficients.

1.2.1 Differences in usefulness of RPC, YPT and other activities for Soft Skills

To verify the descriptive statistics from above, we use t-tests to test for differences between the perceived usefulness of regular physics classes, YPT-related activities, and other activities. With the exception of "Debating skills" ($p = 0.031$), we observe no statistically significant differences between the perceived usefulness of regular physics classes and YPT-related activities. We find that participants indicated greater usefulness for other activities than for regular physics classes across all categories of soft skills ($p < 0.100$). We also observe that students perceived other activities as more useful ($p < 0.001$) than YPT-related activities. Only in the case of "Presenting skills" ($p = 0.206$) and "Debating skills" ($p = 0.919$), we observed no statistically significant differences between YPT-related activities and other activities.

Usefulness of regular classes vs. YPT activities

Soft Skills	t	df	p
Teamwork	-0.845	97	0.400
Ability to loc. and use information	1.145	92	0.255
Creativity	0.223	91	0.824
Presentation skills	-1.104	95	0.272
Debating skills	**-2.188**	**99**	**0.031**
English skills	0.520	94	0.604

Note: Student's t-test. coefficients with $p \leq 0.10$ highlighted bold.

Usefulness of regular classes vs. other activities

Soft Skills	t	df	p
Teamwork	**-5.422**	**147**	**0.000**
Ability to loc. and use information	**-6.650**	**142**	**0.000**
Creativity	**-8.820**	**142**	**0.000**
Presentation skills	**-1.890**	**142**	**0.061**
Debating skills	**-4.101**	**138**	**0.000**
English skills	**-5.527**	**142**	**0.000**

Note: Student's t-test. coefficients with $p \leq 0.10$ highlighted bold.

Usefulness of YPT activities vs. other activities

Soft Skills	t	df	p
Teamwork	**-3.946**	**92**	**0.000**
Ability to loc. and use information	**-6.046**	**90**	**0.000**
Creativity	**-4.887**	**89**	**0.000**
Presentation skills	-1.273	91	0.206
Debating skills	-0.102	94	0.919
English skills	**-4.661**	**90**	**0.000**

Note: Student's t-test. coefficients with $p \leq 0.10$ highlighted bold.

1.2.2 Impact of years to final exam on usefulness of RPC, YPT and other activities

We test the hypothesis that the perceived usefulness of regular physics classes, YPT-related activities, and other activities depends on the students' level of knowledge—the number of years to their final exam. Below, we show regression results for the perceived usefulness with the responses of students in their final year as baseline.

For regular physics classes, we find greater perceived usefulness for "Ability to locate and use information" ($p = 0.084$) and "Creativity" ($p = 0.045$) for students who still had three or more years until their final exam. Students who had only two years until their final exam only indicated greater usefulness of regular physics classes for "Creativity" ($p = 0.067$). Students who were in their last year before their final exam perceived regular physics classes as more useful for "English skills" ($p = 0.086$). For the usefulness of YPT-related activities, we found somewhat surprising results. Students who still had two years until their final exam indicated lower usefulness of YPT-related activities for "Ability to located and use information" ($p = 0.057$), "Creativity" ($p = 0.039$), "Presentation skills" ($p = 0.060$). Students with three or more years until their final exam considered lower usefulness of YPT-related activities for "Ability to located and use information" ($p = 0.086$) and "Debating skills" ($p = 0.096$). Apart from these differences, we observed no significant variation in the usefulness for YPT-related activities. For the perceived usefulness of other activities, we found no significant differences dependent on number of years to final exam.

Differences in usefulness of regular classes based on years to final exam

Soft Skills - RPC	**1**	**2**	**3+**	**R^2**
Teamwork	-0.071	0.457	0.417	0.051
Std. Error	0.243	0.230	0.263	
p-value	0.772	0.049	0.115	
Ability to loc. and use information	0.053	0.371	**0.447**	0.035
Std. Error	0.236	0.225	**0.257**	
p-value	0.824	0.101	**0.084**	
Creativity	0.253	**0.414**	**0.514**	0.033
Std. Error	0.238	**0.225**	**0.254**	
p-value	0.289	**0.067**	**0.045**	
Presentation skills	0.021	0.115	-0.079	0.004
Std. Error	0.240	0.228	0.262	
p-value	0.929	0.616	0.762	
Debating skills	0.067	0.188	-0.003	0.006
Std. Error	0.251	0.237	0.269	
p-value	0.790	0.429	0.991	
English skills	**0.405**	0.060	0.237	0.025
Std. Error	**0.234**	0.222	0.258	
p-value	**0.086**	0.787	0.359	

Note: Linear regression, baseline: year of final exam, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of YPT activities based on years to final exam

Soft Skills - YPT	**1**	**2**	**3+**	**R^2**
Teamwork	0.086	-0.113	-0.239	0.017
Std. Error	0.205	0.213	0.247	
p-value	0.677	0.596	0.336	
Ability to loc. and use information	-0.024	**-0.476**	**-0.498**	0.053
Std. Error	0.234	**0.247**	**0.288**	
p-value	0.919	**0.057**	**0.086**	
Creativity	-0.164	**-0.493**	-0.146	0.038
Std. Error	0.220	**0.236**	0.275	
p-value	0.458	**0.039**	0.596	
Presentation skills	-0.029	**-0.408**	-0.108	0.036
Std. Error	0.202	**0.215**	0.257	
p-value	0.886	**0.060**	0.675	
Debating skills	0.021	-0.310	**-0.383**	0.046
Std. Error	0.183	0.192	**0.228**	
p-value	0.911	0.109	**0.096**	
English skills	-0.002	0.017	-0.271	0.015
Std. Error	0.181	0.191	0.232	
p-value	0.990	0.931	0.246	

Note: Linear regression, baseline: year of final exam, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of other activities based on years to final exam

Soft Skills - Other	**1**	**2**	**3+**	**R^2**
Teamwork	-0.081	-0.070	-0.167	0.005
Std. Error	0.184	0.176	0.203	
p-value	0.659	0.693	0.412	
Ability to loc. and use information	0.090	0.061	-0.047	0.005
Std. Error	0.175	0.165	0.190	
p-value	0.609	0.711	0.807	
Creativity	-0.163	-0.079	0.003	0.010
Std. Error	0.163	0.154	0.176	
p-value	0.318	0.606	0.985	
Presentation skills	-0.028	0.012	-0.056	0.001
Std. Error	0.234	0.221	0.253	
p-value	0.906	0.957	0.826	
Debating skills	0.037	0.135	-0.140	0.011
Std. Error	0.218	0.208	0.238	
p-value	0.866	0.517	0.558	
English skills	0.279	-0.017	-0.057	0.028
Std. Error	0.186	0.177	0.200	
p-value	0.136	0.925	0.776	

Note: Linear regression, baseline: year of final exam, coefficients with $p \leq 0.10$ highlighted bold.

1.2.3 Impact of physics classes on usefulness of RPC, YPT and other activities

We test the hypothesis that the perceived usefulness of regular physics classes, YPT-related activities, and other activities depends on the students' weekly physics classes. Below, we show regression results for the perceived usefulness with the responses of students without weekly physics classes as baseline.

As expected, we observe that students perceive their regular physics classes the more useful the greater the number of weekly physics classes. With some variation, we find that students who take more hours of weekly physics classes consider their classes as more useful to develop the "Ability to locate and use information", "Creativity", and "English skills". At the same time, we find no significantly greater effects for students with five or more hours of weekly physics classes. For the participation in YPT-related activities, we observe greater perceived usefulness to enhance "Teamwork" skill, the "Ability to locate and use information", "Debating skills", and "English skills" contingent on the number of weekly physics classes. For participation in other activities, we find lower usefulness to develop the "Ability to locate and use information", "Creativity", and "Debating skills" for students who take only one hour of weekly physics classes.

Differences in usefulness of regular classes based on regular physics classes per week

Soft Skills - RPC	**1**	**2**	**3**	**4**	**5+**	**R^2**
Teamwork	0.350	0.239	0.805	0.156	0.327	0.063
Std. Error	0.707	0.487	0.497	0.533	0.568	
p-value	0.621	0.625	0.108	0.771	0.566	
Ability to loc. and use information	0.867	**0.904**	**1.343**	**1.033**	0.836	0.071
Std. Error	0.726	**0.460**	**0.471**	**0.503**	0.536	
p-value	0.235	**0.051**	**0.005**	**0.042**	0.121	
Creativity	0.850	**1.230**	**1.274**	**1.267**	**1.055**	0.051
Std. Error	0.682	**0.470**	**0.481**	**0.514**	**0.549**	
p-value	0.215	**0.010**	**0.009**	**0.015**	**0.057**	
Presentation skills	-0.150	0.216	0.673	0.489	0.145	0.050
Std. Error	0.686	0.472	0.484	0.517	0.551	
p-value	0.827	0.648	0.166	0.346	0.792	
Debating skills	-0.450	0.314	0.544	0.522	0.164	0.034
Std. Error	0.712	0.491	0.502	0.537	0.573	
p-value	0.528	0.523	0.280	0.332	0.775	
English skills	0.950	**1.257**	**1.270**	**1.089**	**0.927**	0.057
Std. Error	0.669	**0.461**	**0.471**	**0.504**	**0.538**	
p-value	0.158	**0.007**	**0.008**	**0.032**	**0.087**	

Note: Linear regression, baseline: no weekly physics classes, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of YPT activities based on regular physics classes per week

Soft Skills - YPT	**1**	**2**	**3**	**4**	**5+**	**R^2**
Teamwork	0.500	**1.052**	**1.067**	**1.350**	0.750	0.076
Std. Error	0.654	**0.507**	**0.518**	**0.530**	0.580	
p-value	0.446	**0.040**	**0.042**	**0.012**	0.198	
Ability to loc. and use information	1.083	**1.048**	**1.126**	**1.233**	1.083	0.034
Std. Error	0.773	**0.600**	**0.614**	**0.627**	0.686	
p-value	0.164	**0.084**	**0.069**	**0.052**	0.117	
Creativity	0.167	0.500	0.381	0.767	0.667	0.032
Std. Error	0.720	0.559	0.573	0.584	0.638	
p-value	0.817	0.373	0.507	0.192	0.299	
Presentation skills	0.167	0.649	0.598	0.857	0.792	0.036
Std. Error	0.675	0.524	0.536	0.546	0.598	
p-value	0.805	0.218	0.267	0.119	0.188	
Debating skills	-0.167	0.333	0.398	0.633	**1.000**	0.079
Std. Error	0.601	0.466	0.476	0.487	**0.525**	
p-value	0.782	0.476	0.405	0.196	**0.059**	
English skills	-0.083	0.648	**0.770**	**1.000**	**0.917**	0.092
Std. Error	0.571	0.444	**0.454**	**0.462**	**0.507**	
p-value	0.884	0.147	**0.092**	**0.032**	**0.073**	

Note: Linear regression, baseline: no weekly physics classes, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of other activities based on regular physics classes per week

Soft Skills - Other	**1**	**2**	**3**	**4**	**5+**	**R^2**
Teamwork	-0.200	0.064	0.287	0.022	0.164	0.022
Std. Error	0.533	0.367	0.377	0.401	0.428	
p-value	0.708	0.862	0.448	0.956	0.703	
Ability to loc. and use information	**-1.000**	-0.114	0.038	-0.278	-0.227	0.060
Std. Error	**0.513**	0.373	0.381	0.401	0.423	
p-value	**0.053**	0.760	0.920	0.489	0.592	
Creativity	**-1.167**	-0.138	-0.038	-0.111	-0.136	0.055
Std. Error	**0.512**	0.345	0.352	0.371	0.392	
p-value	**0.024**	0.691	0.913	0.765	0.728	
Presentation skills	-0.850	0.372	0.454	0.576	-0.145	0.074
Std. Error	0.646	0.446	0.459	0.490	0.520	
p-value	0.191	0.406	0.324	0.241	0.780	
Debating skills	-0.867	-0.357	-0.171	-0.200	-0.018	0.027
Std. Error	0.663	0.420	0.434	0.462	0.490	
p-value	0.194	0.397	0.694	0.666	0.970	
English skills	-0.250	0.375	0.405	0.500	0.727	0.041
Std. Error	0.558	0.405	0.415	0.436	0.461	
p-value	0.655	0.357	0.331	0.254	0.117	

Note: Linear regression, baseline: no weekly physics classes, coefficients with $p \leq 0.10$ highlighted bold.

1.2.4 Impact of participation in YPT activities on usefulness of RPC, YPT and other activities

We test the hypothesis that the perceived usefulness of regular physics classes, YPT-related activities, and other activities depends on the students' most recent participation in YPT-related activities. Below, we show regression results for the perceived usefulness with the responses of students who never participated in YPT-related activities as baseline. Depending on the year of the survey, the year of reference—"This year"—is either 2021 or 2020. For some tests, no students responded that they had participated in YPT-related activities two or more years prior to the survey. In this case, the category is omitted in the regression tables.

For some types of soft skills, we observe that students that participated previously in YPT-related activities consider regular physics classes and other activities as less useful to develop these soft skills. We observe these effects for nearly all types of soft skills. This suggests that synergies between YPT-related activities and regular physics classes as well as other activities are limited. Apart from "English skills", we observe no differences in the perceived usefulness of YPT-related activities based on the most recent participation.

Differences in usefulness of regular classes based on most recent participation in YPT activities

Soft Skills - RPC	**Earlier**	**This year**	**R^2**
Teamwork	**-0.954**	-0.954	0.078
Std. Error	**0.284**	0.981	
p-value	**0.001**	0.333	
Ability to loc. and use information	**-0.966**	1.117	0.081
Std. Error	**0.295**	0.982	
p-value	**0.001**	0.257	
Creativity	**-0.856**	0.298	0.060
Std. Error	**0.288**	0.993	
p-value	**0.003**	0.765	
Presentation skills	-0.406	1.209	0.024
Std. Error	0.291	1.005	
p-value	0.166	0.231	
Debating skills	**-0.620**	1.380	0.038
Std. Error	**0.320**	1.065	
p-value	**0.055**	0.197	
English skills	**-0.538**	0.000	0.023
Std. Error	**0.300**	1.033	
p-value	**0.074**	1.000	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of YPT activities based on most recent participation in YPT activities

Soft Skills - YPT	**Earlier**	**This year**	**R^2**
Teamwork	-0.239	0.437	0.014
Std. Error	0.234	0.635	
p-value	0.309	0.493	
Ability to loc. and use information	0.102	0.837	0.013
Std. Error	0.269	0.728	
p-value	0.706	0.253	
Creativity	-0.302	0.669	0.024
Std. Error	0.252	0.681	
p-value	0.233	0.328	
Presentation skills	-0.090	0.521	0.008
Std. Error	0.232	0.644	
p-value	0.699	0.420	
Debating skills	-0.172	-0.113	0.006
Std. Error	0.214	0.581	
p-value	0.422	0.846	
English skills	**-0.393**	0.401	0.039
Std. Error	**0.205**	0.553	
p-value	**0.057**	0.470	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of other activities based on most recent participation in YPT activities

Soft Skills - Other	Earlier	This year	R^2
Teamwork	**-0.609**	0.622	0.057
Std. Error	**0.222**	0.765	
p-value	**0.007**	0.418	
Ability to loc. and use information	**-0.491**	0.600	0.039
Std. Error	**0.229**	0.730	
p-value	**0.034**	0.413	
Creativity	**-0.527**	-0.427	0.044
Std. Error	**0.220**	0.673	
p-value	**0.018**	0.526	
Presentation skills	**-0.527**	1.056	0.032
Std. Error	**0.296**	0.983	
p-value	**0.077**	0.285	
Debating skills	**-0.620**	0.017	0.036
Std. Error	**0.280**	0.892	
p-value	**0.028**	0.985	
English skills	**-0.610**	0.556	0.051
Std. Error	**0.237**	0.787	
p-value	**0.011**	0.481	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

1.2.5 Impact of participation in non-YPT competitions on usefulness of RPC, YPT and other activities

We test the hypothesis that the perceived usefulness of regular physics classes, YPT-related activities, and other activities depends on the students' most recent participation in other, non-YPT activities. Below, we show regression results for the perceived usefulness with the responses of students who never participated in other activities as baseline. Depending on the year of the survey, the year of reference—"This year"—is either 2021 or 2020.

Based on our survey, we cannot identify any differences in the perceived usefulness of activities to develop soft skills based on recent participation in non-YPT activities consider.

Differences in usefulness of regular classes based on most recent participation in other activities

Soft Skills - RPC	**Earlier**	**This year**	**R^2**
Teamwork	0.007	-1.593	0.026
Std. Error	0.343	1.187	
p-value	0.983	0.184	
Ability to loc. and use information	0.223	-1.635	0.050
Std. Error	0.301	1.008	
p-value	0.462	0.110	
Creativity	0.005	-1.528	0.028
Std. Error	0.320	1.104	
p-value	0.987	0.171	
Presentation skills	-0.288	-1.788	0.048
Std. Error	0.312	1.102	
p-value	0.359	0.109	
Debating skills	0.005	-1.462	0.026
Std. Error	0.322	1.111	
p-value	0.987	0.193	
English skills	0.260	-1.673	0.039
Std. Error	0.349	1.204	
p-value	0.459	0.169	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of YPT activities based on most recent participation in other activities

Soft Skills - YPT	**Earlier**	**This year**	**R^2**
Teamwork	-0.065	-1.065	0.024
Std. Error	0.213	0.845	
p-value	0.761	0.212	
Ability to loc. and use information	0.130	-0.783	0.016
Std. Error	0.233	0.921	
p-value	0.577	0.399	
Creativity	-0.106	-0.932	0.018
Std. Error	0.230	0.905	
p-value	0.648	0.307	
Presentation skills	0.158	-0.978	0.027
Std. Error	0.229	0.893	
p-value	0.493	0.278	
Debating skills	0.138	-1.122	0.035
Std. Error	0.204	0.816	
p-value	0.500	0.173	
English skills	-0.134	-1.178	0.036
Std. Error	0.203	0.802	
p-value	0.511	0.147	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of other activities based on most recent participation in other activities

Soft Skills - Other	Earlier	This year	R^2
Teamwork	0.006	-0.327	0.002
Std. Error	0.243	0.838	
p-value	0.979	0.698	
Ability to loc. and use information	0.019	-0.365	0.004
Std. Error	0.218	0.710	
p-value	0.930	0.608	
Creativity	-0.145	-0.529	0.016
Std. Error	0.208	0.676	
p-value	0.489	0.436	
Presentation skills	0.197	0.120	0.008
Std. Error	0.282	0.916	
p-value	0.488	0.896	
Debating skills	0.167	0.083	0.006
Std. Error	0.295	0.925	
p-value	0.575	0.929	
English skills	-0.041	-0.327	0.002
Std. Error	0.279	0.929	
p-value	0.884	0.727	

Note: Linear regression, baseline: no participation, coefficients with $p \leq 0.10$ highlighted bold.

1.2.6 Impact of RPC, YPT and other activities on self-evaluation

We test the benefits of regular physics classes, participation in YPT-related activities, and participation in other activities in terms of the students' self-evaluation of soft skills. Our results provide strong support that these activities enhance the students' evaluation of their soft skills. We find positive correlation coefficients between regular physics classes, participation in YPT-related activities, and participation in other activities and self-evaluation for all types of soft skills. Using multivariate regression analysis, we find statistically significant relations between physics-related activities and the self-evaluation of soft skills ($p \leq 0.100$). We consider this as support for the usefulness of regular physics classes, YPT-related activities, and other activities to develop students' soft skills.

Soft Skills – Self-evaluation	RPC	YPT	Other
Teamwork	0.46	0.25	0.48
Ability to loc. and use information	0.70	0.42	0.57
Creativity	0.47	0.31	0.53
Presentation skills	0.54	0.30	0.74
Debating skills	0.35	0.46	0.56
English skills	0.48	0.40	0.56

Note: Pearson correlation coefficients for self-evaluation with usefulness of each activity for the respective skill.

Soft Skills – Self-evaluation	RPC	YPT	Other	Adj. R^2
Teamwork	**0.331**	**0.183**	**0.331**	0.349
Std. Error	**0.080**	**0.096**	**0.110**	
p-value	**0.000**	**0.061**	**0.003**	
Ability to loc. and use information	**0.578**	**0.265**	0.137	0.637
Std. Error	**0.081**	**0.080**	0.100	
p-value	**0.000**	**0.001**	0.176	
Creativity	**0.346**	**0.303**	**0.201**	0.446
Std. Error	**0.102**	**0.086**	**0.112**	
p-value	**0.001**	**0.001**	**0.077**	
Presentation skills	**0.279**	**0.129**	**0.686**	0.750
Std. Error	**0.063**	**0.068**	**0.079**	
p-value	**0.000**	**0.061**	**0.000**	
Debating skills	**0.190**	**0.198**	**0.356**	0.335
Std. Error	**0.071**	**0.087**	**0.100**	
p-value	**0.008**	**0.025**	**0.001**	
English skills	**0.332**	**0.207**	**0.477**	0.452
Std. Error	**0.078**	**0.104**	**0.118**	
p-value	**0.000**	**0.049**	**0.000**	

Note: Linear regression of self-evaluation for soft skills on usefulness of each activity for the respective skill, coefficients with $p \leq 0.10$ highlighted bold.

1.3 Differences in soft skills development across countries

To test the impact of country differences on our results, we use ANOVA to test for differences in self-evaluation and perceived usefulness of regular physics classes, YPT-related activities, and other activities contingent on the student's home country. We observe that students' self-evaluations for nearly all types of soft skills differ by country. We find across-country differences in the perceived usefulness of regular physics classes for only two out of six soft skills. In the case of YPT-related activities, however, we observe that the perceived usefulness for all types of soft skills depends on students' home countries. We observe no country differences for the usefulness of participation in other activities.

Differences in self-evaluation based on country

Soft Skills – self-evaluation	**df**	**F**	**p**
Teamwork	**8**	1.664	0.107
Ability to loc. and use information	**6**	**1.825**	**0.073**
Creativity	**7**	**2.828**	**0.005**
Presentation skills	**8**	**2.519**	**0.012**
Debating skills	**8**	**1.816**	**0.096**
English skills	**8**	**2.115**	**0.043**

Note: ANOVA (Value ~ Country), coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of regular physics classes based on country

Soft Skills – RPC	**df**	**F**	**p**
Teamwork	**4**	**3.637**	**0.007**
Ability to loc. and use information	4	0.502	0.734
Creativity	**4**	**2.021**	**0.094**
Presentation skills	**4**	1.944	0.106
Debating skills	4	0.587	0.672
English skills	**4**	1.892	0.115

Note: ANOVA (Value ~ Country), coefficients with $p \leq 0.10$ highlighted bold.

Differences in usefulness of YPT activities based on country

Soft Skills – YPT	**df**	**F**	**p**
Teamwork	**8**	**7.812**	**0.000**
Ability to loc. and use information	**7**	**4.602**	**0.000**
Creativity	**7**	**5.272**	**0.000**
Presentation skills	**8**	**16.316**	**0.000**
Debating skills	**8**	**7.476**	**0.000**
English skills	**8**	**6.749**	**0.000**

Note: ANOVA (Value ~ Country), coefficients with $p \leq 0.10$ highlighted bold.

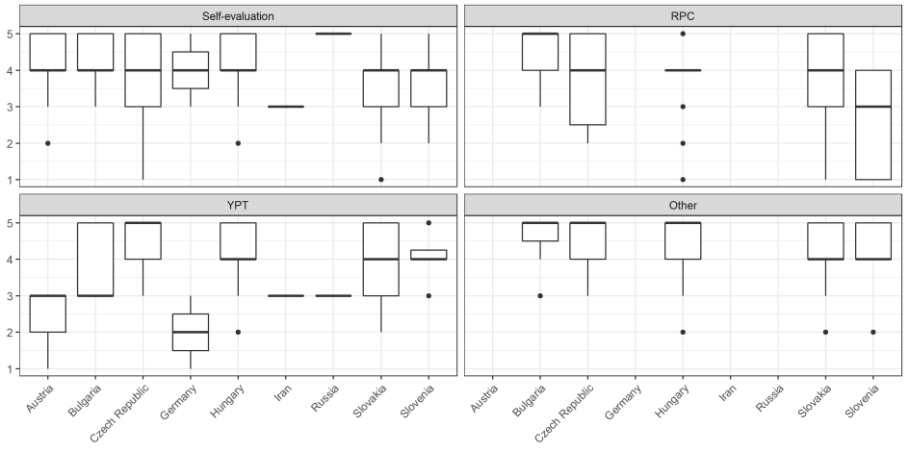
Differences in usefulness of other activities classes based on country

Soft Skills – Other	**df**	**F**	**p**
Teamwork	4	0.452	0.770
Ability to loc. and use information	4	0.620	0.649
Creativity	4	1.540	0.194
Presentation skills	4	0.804	0.524
Debating skills	4	0.658	0.623
English skills	4	0.741	0.566

Note: ANOVA (Value ~ Country), coefficients with $p \leq 0.10$ highlighted bold.

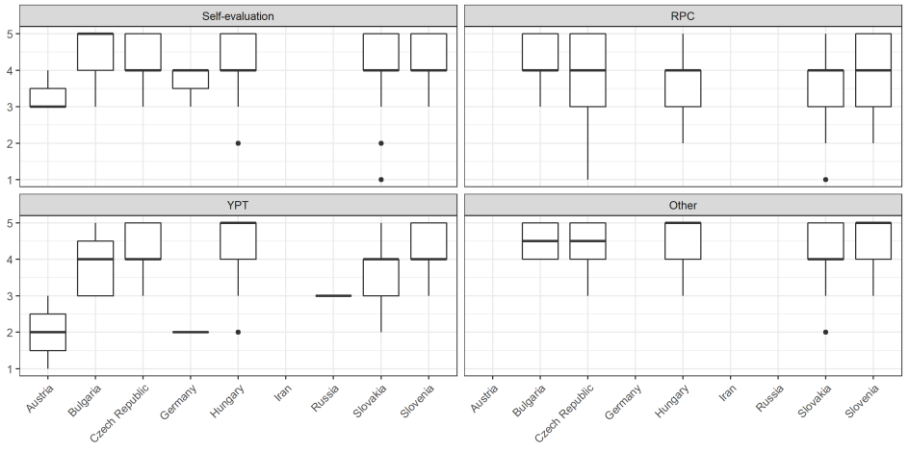
To further investigate the results from above, we provide country-level summary statistics for students' self-evaluation and the usefulness of regular physics classes, YPT-related activities, and other activities for each soft skill separately. Note: For Austria, Germany, Iran, and Russia, data on the perceived usefulness of YPT-related activities is coded on a scale from 1 to 3 instead of the 1 to 5 scale applied to all other measurements.

Teamwork



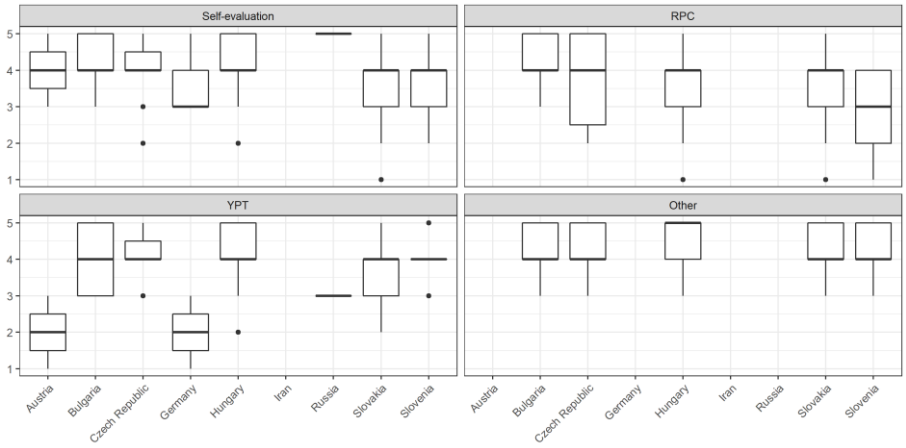
Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	13	0	4.08	4.0	0.95	2	5
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	13	0	2.38	3.0	0.77	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	4.19	4.0	0.75	3	5
	RPC	7	14	4.43	5.0	0.79	3	5
	YPT	7	14	3.86	3.0	1.07	3	5
	Other	7	14	4.57	5.0	0.79	3	5
Czech Rep.	Self-evaluation	19	4	3.68	4.0	1.25	1	5
	RPC	19	4	3.68	4.0	1.29	2	5
	YPT	15	8	4.40	5.0	0.83	3	5
	Other	20	3	4.40	5.0	0.75	3	5
Germany	Self-evaluation	3	0	4.00	4.0	1.00	3	5
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	3	0	2.00	2.0	1.00	1	3
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	46	26	4.11	4.0	0.71	2	5
	RPC	41	31	3.76	4.0	1.11	1	5
	YPT	46	26	4.11	4.0	0.85	2	5
	Other	39	33	4.36	5.0	0.81	2	5
Iran	Self-evaluation	1	0	3.00	3.0	0.00	3	3
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	1	0	5.00	5.0	0.00	5	5
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	164	1	3.85	4.0	0.80	1	5
	RPC	78	87	3.91	4.0	0.89	1	5
	YPT	48	117	3.83	4.0	0.93	2	5
	Other	75	90	4.27	4.0	0.78	2	5
Slovenia	Self-evaluation	9	0	3.44	4.0	1.01	2	5
	RPC	9	0	2.67	3.0	1.41	1	4
	YPT	8	1	4.13	4.0	0.64	3	5
	Other	8	1	4.13	4.0	0.99	2	5

Ability to locate and use information



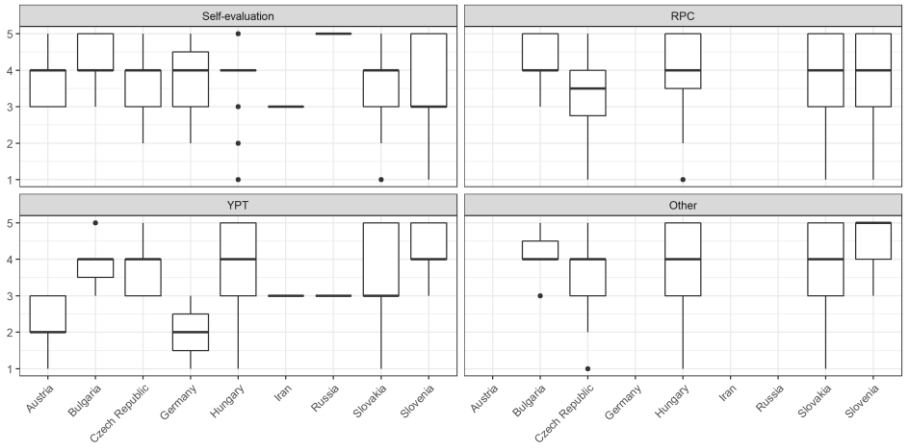
Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	3	10	3.33	3.0	0.58	3	4
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	3	10	2.00	2.0	1.00	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	4.48	5.0	0.60	3	5
	RPC	7	14	4.29	4.0	0.76	3	5
	YPT	7	14	3.86	4.0	0.90	3	5
	Other	6	15	4.50	4.5	0.55	4	5
Czech Rep.	Self-evaluation	21	2	4.10	4.0	0.77	3	5
	RPC	18	5	3.72	4.0	1.41	1	5
	YPT	15	8	4.27	4.0	0.70	3	5
	Other	18	5	4.28	4.5	0.83	3	5
Germany	Self-evaluation	3	0	3.67	4.0	0.58	3	4
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	3	0	2.00	2.0	0.00	2	2
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	45	27	4.31	4.0	0.76	2	5
	RPC	39	33	3.72	4.0	1.02	2	5
	YPT	48	24	4.31	5.0	0.83	2	5
	Other	39	33	4.49	5.0	0.64	3	5
Iran	Self-evaluation	0	1	0.00	0.0	0.00	0	0
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	0	1	0.00	0.0	0.00	0	0
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	0	1	0.00	0.0	0.00	0	0
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	162	3	4.14	4.0	0.78	1	5
	RPC	77	88	3.83	4.0	0.92	1	5
	YPT	47	118	3.79	4.0	0.78	2	5
	Other	74	91	4.31	4.0	0.78	2	5
Slovenia	Self-evaluation	9	0	4.33	4.0	0.71	3	5
	RPC	9	0	3.78	4.0	1.09	2	5
	YPT	9	0	4.11	4.0	0.78	3	5
	Other	9	0	4.56	5.0	0.73	3	5

Creativity



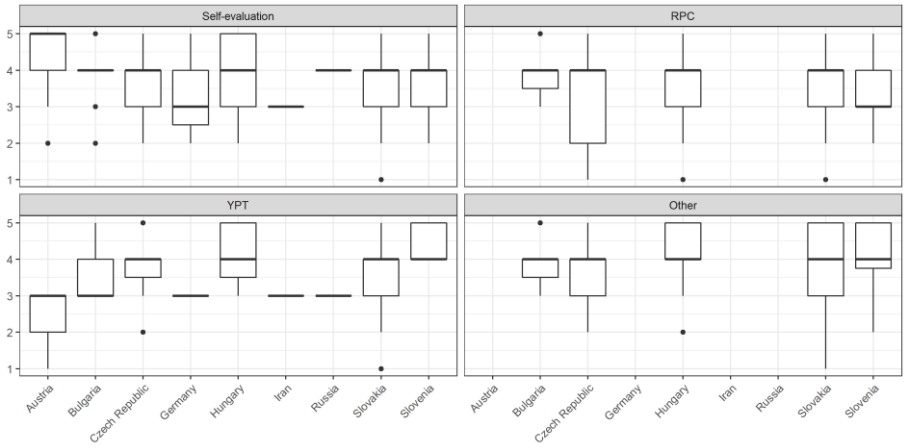
Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	3	10	4.00	4.0	1.00	3	5
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	3	10	2.00	2.0	1.00	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	4.19	4.0	0.81	3	5
	RPC	7	14	4.29	4.0	0.76	3	5
	YPT	7	14	4.00	4.0	1.00	3	5
	Other	7	14	4.29	4.0	0.76	3	5
Czech Rep.	Self-evaluation	19	4	3.95	4.0	0.91	2	5
	RPC	19	4	3.74	4.0	1.19	2	5
	YPT	15	8	4.07	4.0	0.70	3	5
	Other	16	7	4.31	4.0	0.60	3	5
Germany	Self-evaluation	3	0	3.67	3.0	1.15	3	5
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	3	0	2.00	2.0	1.00	1	3
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	45	27	4.31	4.0	0.73	2	5
	RPC	40	32	3.60	4.0	1.08	1	5
	YPT	44	28	4.25	4.0	0.75	2	5
	Other	38	34	4.61	5.0	0.59	3	5
Iran	Self-evaluation	0	1	0.00	0.0	0.00	0	0
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	0	1	0.00	0.0	0.00	0	0
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	1	0	5.00	5.0	0.00	5	5
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	162	3	3.81	4.0	0.94	1	5
	RPC	79	86	3.56	4.0	0.94	1	5
	YPT	45	120	3.80	4.0	0.81	2	5
	Other	74	91	4.30	4.0	0.72	3	5
Slovenia	Self-evaluation	9	0	3.78	4.0	0.97	2	5
	RPC	9	0	2.89	3.0	1.05	1	4
	YPT	9	0	4.11	4.0	0.60	3	5
	Other	9	0	4.22	4.0	0.67	3	5

Presentation skills



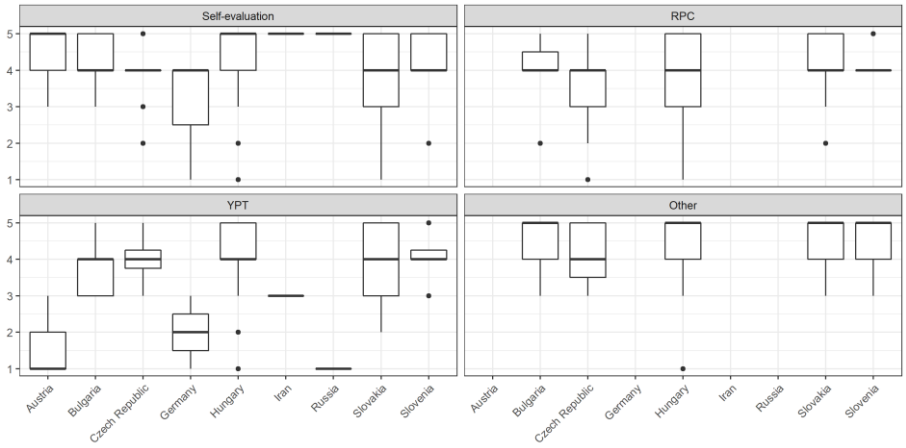
Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	13	0	3.92	4.0	0.76	3	5
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	13	0	2.38	2.0	0.65	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	4.33	4.0	0.66	3	5
	RPC	7	14	4.29	4.0	0.76	3	5
	YPT	7	14	3.86	4.0	0.69	3	5
	Other	7	14	4.14	4.0	0.69	3	5
Czech Rep.	Self-evaluation	19	4	3.84	4.0	0.83	2	5
	RPC	20	3	3.25	3.5	1.02	1	5
	YPT	15	8	3.80	4.0	0.77	3	5
	Other	20	3	3.70	4.0	1.03	1	5
Germany	Self-evaluation	3	0	3.67	4.0	1.53	2	5
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	3	0	2.00	2.0	1.00	1	3
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	45	27	3.89	4.0	0.93	1	5
	RPC	39	33	3.87	4.0	1.06	1	5
	YPT	45	27	3.78	4.0	0.97	1	5
	Other	36	36	3.94	4.0	0.95	1	5
Iran	Self-evaluation	1	0	3.00	3.0	0.00	3	3
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	1	0	5.00	5.0	0.00	5	5
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	162	3	3.59	4.0	1.10	1	5
	RPC	77	88	3.79	4.0	0.96	1	5
	YPT	45	120	3.53	3.0	1.16	1	5
	Other	75	90	3.92	4.0	1.02	1	5
Slovenia	Self-evaluation	9	0	3.44	3.0	1.42	1	5
	RPC	9	0	3.56	4.0	1.42	1	5
	YPT	9	0	4.33	4.0	0.71	3	5
	Other	7	2	4.43	5.0	0.79	3	5

Debating skills



Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	13	0	4.23	5.0	1.01	2	5
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	13	0	2.38	3.0	0.77	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	3.95	4.0	0.80	2	5
	RPC	7	14	3.86	4.0	0.69	3	5
	YPT	7	14	3.57	3.0	0.79	3	5
	Other	7	14	3.86	4.0	0.69	3	5
Czech Rep.	Self-evaluation	21	2	3.81	4.0	0.81	2	5
	RPC	19	4	3.32	4.0	1.20	1	5
	YPT	15	8	3.80	4.0	0.94	2	5
	Other	18	5	3.67	4.0	0.84	2	5
Germany	Self-evaluation	3	0	3.33	3.0	1.53	2	5
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	2	1	3.00	3.0	0.00	3	3
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	45	27	4.07	4.0	0.86	2	5
	RPC	39	33	3.54	4.0	1.19	1	5
	YPT	43	29	4.05	4.0	0.75	3	5
	Other	34	38	4.09	4.0	0.90	2	5
Iran	Self-evaluation	1	0	3.00	3.0	0.00	3	3
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	1	0	4.00	4.0	0.00	4	4
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	161	4	3.44	4.0	1.07	1	5
	RPC	77	88	3.64	4.0	1.01	1	5
	YPT	44	121	3.57	4.0	1.11	1	5
	Other	74	91	3.93	4.0	0.93	1	5
Slovenia	Self-evaluation	9	0	3.56	4.0	0.88	2	5
	RPC	9	0	3.33	3.0	0.87	2	5
	YPT	9	0	4.33	4.0	0.50	4	5
	Other	8	1	4.00	4.0	1.07	2	5

English skills



Country	Type	Valid	Missing	Mean	Median	SD	Min.	Max.
Austria	Self-evaluation	13	0	4.62	5.0	0.65	3	5
	RPC	0	13	0.00	0.0	0.00	0	0
	YPT	13	0	1.38	1.0	0.65	1	3
	Other	0	13	0.00	0.0	0.00	0	0
Bulgaria	Self-evaluation	21	0	4.38	4.0	0.67	3	5
	RPC	7	14	4.00	4.0	1.00	2	5
	YPT	7	14	3.71	4.0	0.76	3	5
	Other	7	14	4.43	5.0	0.79	3	5
Czech Rep.	Self-evaluation	19	4	3.95	4.0	0.78	2	5
	RPC	19	4	3.63	4.0	1.01	1	5
	YPT	16	7	4.00	4.0	0.73	3	5
	Other	19	4	4.11	4.0	0.81	3	5
Germany	Self-evaluation	3	0	3.00	4.0	1.73	1	4
	RPC	0	3	0.00	0.0	0.00	0	0
	YPT	3	0	2.00	2.0	1.00	1	3
	Other	0	3	0.00	0.0	0.00	0	0
Hungary	Self-evaluation	45	27	4.38	5.0	0.89	1	5
	RPC	39	33	3.72	4.0	1.34	1	5
	YPT	45	27	4.13	4.0	0.97	1	5
	Other	35	37	4.43	5.0	0.98	1	5
Iran	Self-evaluation	1	0	5.00	5.0	0.00	5	5
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	3.00	3.0	0.00	3	3
	Other	0	1	0.00	0.0	0.00	0	0
Russia	Self-evaluation	1	0	5.00	5.0	0.00	5	5
	RPC	0	1	0.00	0.0	0.00	0	0
	YPT	1	0	1.00	1.0	0.00	1	1
	Other	0	1	0.00	0.0	0.00	0	0
Slovakia	Self-evaluation	164	1	4.01	4.0	0.90	1	5
	RPC	77	88	4.14	4.0	0.82	2	5
	YPT	47	118	3.83	4.0	0.89	2	5
	Other	76	89	4.45	5.0	0.70	3	5
Slovenia	Self-evaluation	9	0	4.22	4.0	0.97	2	5
	RPC	9	0	4.22	4.0	0.44	4	5
	YPT	8	1	4.13	4.0	0.64	3	5
	Other	9	0	4.44	5.0	0.73	3	5

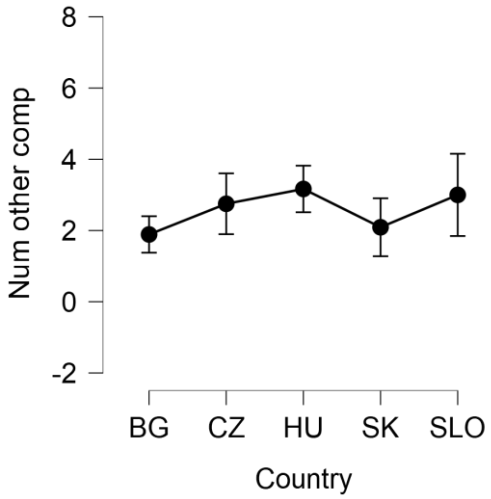
2. Supplement: Teachers' Assessment of Soft-Skill Development

2.1 Data characteristics

In this project, we have conducted a survey among 11 Slovakian, 9 Bulgarian, 6 Hungarian, 4 Czech and 3 Slovenian teachers, who are involved in preparing high school students for IYPT or any local organized YPT competitions. We have mapped they observed or assumed effect on soft (e.g. teamwork, creativity) and physical hard skills (e.g. high school physics, data analysis) in different teaching forms (RCP, YPT and Non-YPT competitions). Given the COVID situation, teachers carried out their preparatory work in 2020/2021 mainly online. This is why it is important to mention that most colleagues have been involved in preparing for YPT-type competitions for several years. Teachers had to fill in a questionnaire and answer 16x3 quantitative and 15 qualitative questions about the impact and characteristics of RCP, YPT and Non-YPT competitions.

Descriptives - Num other comp

Country	Mean	SD	N
BG	1.889	1.537	9
CZ	2.750	1.708	4
HU	3.167	1.602	6
SK	2.091	2.700	11
SLO	3.000	2.000	3



Data on teachers' answers form the questionnaire were provided in Excel format. For carrying out the empirical analysis, the software JASP[9] was used. First, descriptive analyses on skills as well as a correlation matrix using all variables. Secondly, for testing the hypotheses paired and independent t-tests (and Wilcoxon or Mann-Whitney-tests where needed) were computed. If Wilcoxon or Mann-Whitney-test was used, it is always the relevant result, t-tests are in these cases not relevant.

2.2 Results

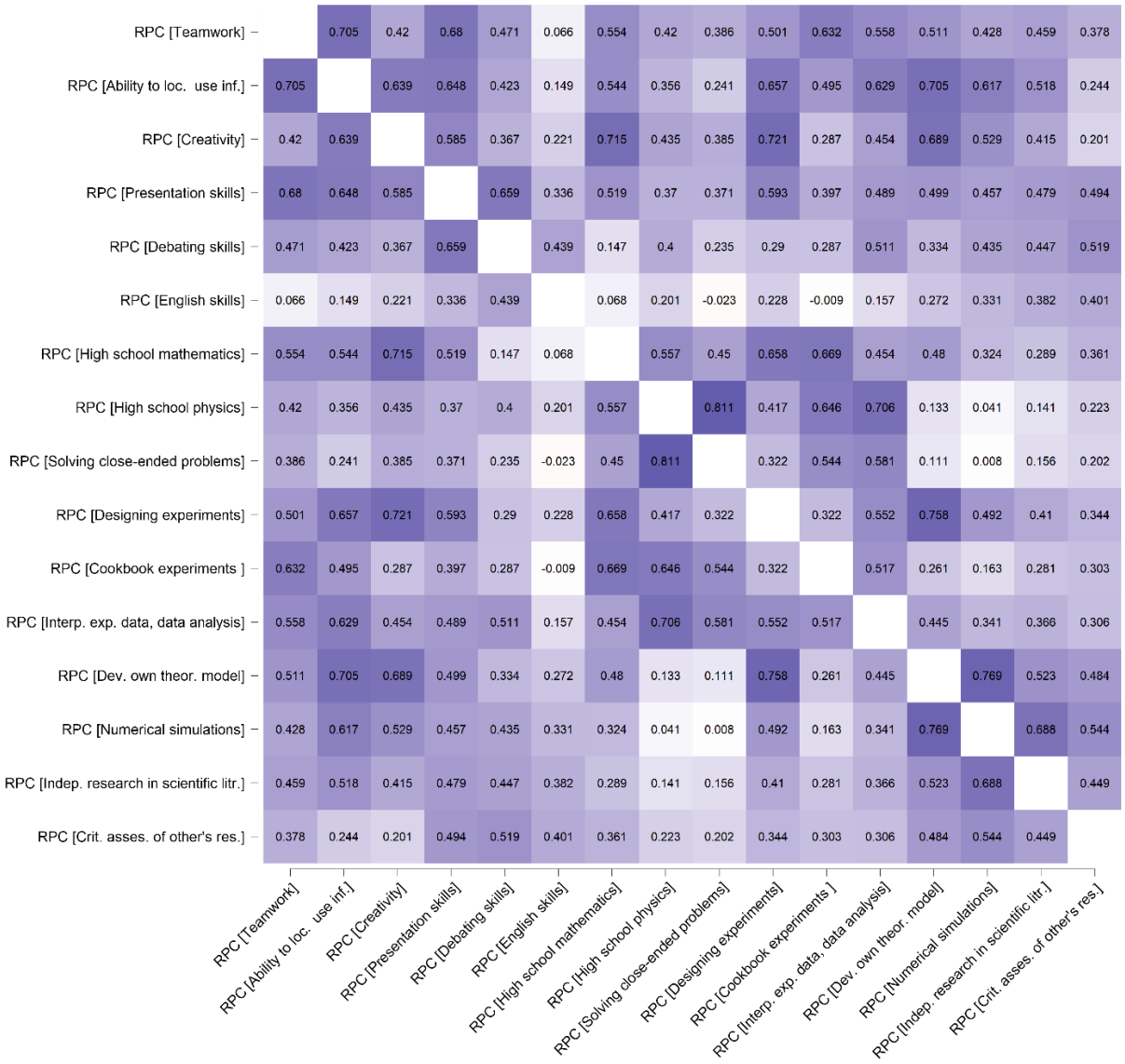
The study investigates soft skills in the context of RPC, YPT, and non-YPT. Based on the teachers' evaluation, we can determine which effect their colleagues see in different educational settings. In addition, we can explore relationships between effects that provide indirect insights into teachers' work.

[9] https://jasp-stats.org/

3.2.1 Regular physics classroom: RPC

Descriptive Statistics: Soft skills in RPC

	RPC [Teamwork]	RPC [Ability to loc. use inf.]	RPC [Creativity]	RPC [Presentation skills]	RPC [Debating skills]	RPC [English skills]
Valid	33	33	32	33	33	32
Missing	0	0	1	0	0	1
Mean	5.364	5.788	5.594	6.000	4.727	3.969
Std. Dev.	2.382	2.522	1.965	2.179	2.349	2.946
Minimum	1.000	1.000	1.000	1.000	0.000	0.000
Maximum	10.000	10.000	9.000	10.000	9.000	10.000



Of the soft skills, RPC develops most the *Presentation skills* m = 6.172, which shows a very strong correlation with *Designing experiments* r = 0,671 p < .001. *Teamwork* shows the highest degree of correlation with *Interpreting experimental data, data analysis* r = 0.764 p <.001, while *Creativity* with the *Designing experiments* shows r = 0.746 p <.001, which correlations show the conscious choice of teachers 'working methods. In physics classes, teachers feel the least development of *English language skills* m = 4.036. The development of *English skills* in regular physics classes (RPC) does not correlate with anything, it is probably not actually present in the classes, it is a possibility only – there is only one mentionable correlation with Debating skills, but it must be because of the assumptions of the questioned teachers, who are making some debates in English in their lessons. The other soft skills do not show much relationship with each other either, which may suggest that colleagues are trying to develop these soft skills independently in RPC. The strongest correlation was found between *Teamwork* and *Ability to use and locate information* r = 0.71 p <.001, and between *Debating* and *Presentation skills* r = 0.628 p <.001. The two values probably illustrate well the relationships found in teachers 'ways of organizing work, and the both skills are having interrelations. In the Hard Skills the strongest correlation to be found is between *High school physics* and *Solving close ended problems in physics* r = 0.837 p <.001. This one is highly the strongest correlation in RPC, which are also the main skills of a successful final exam. It is also clear that *Numerical simulations* m = 2.966 are not typical in RPC education, for which teachers choose other platforms.

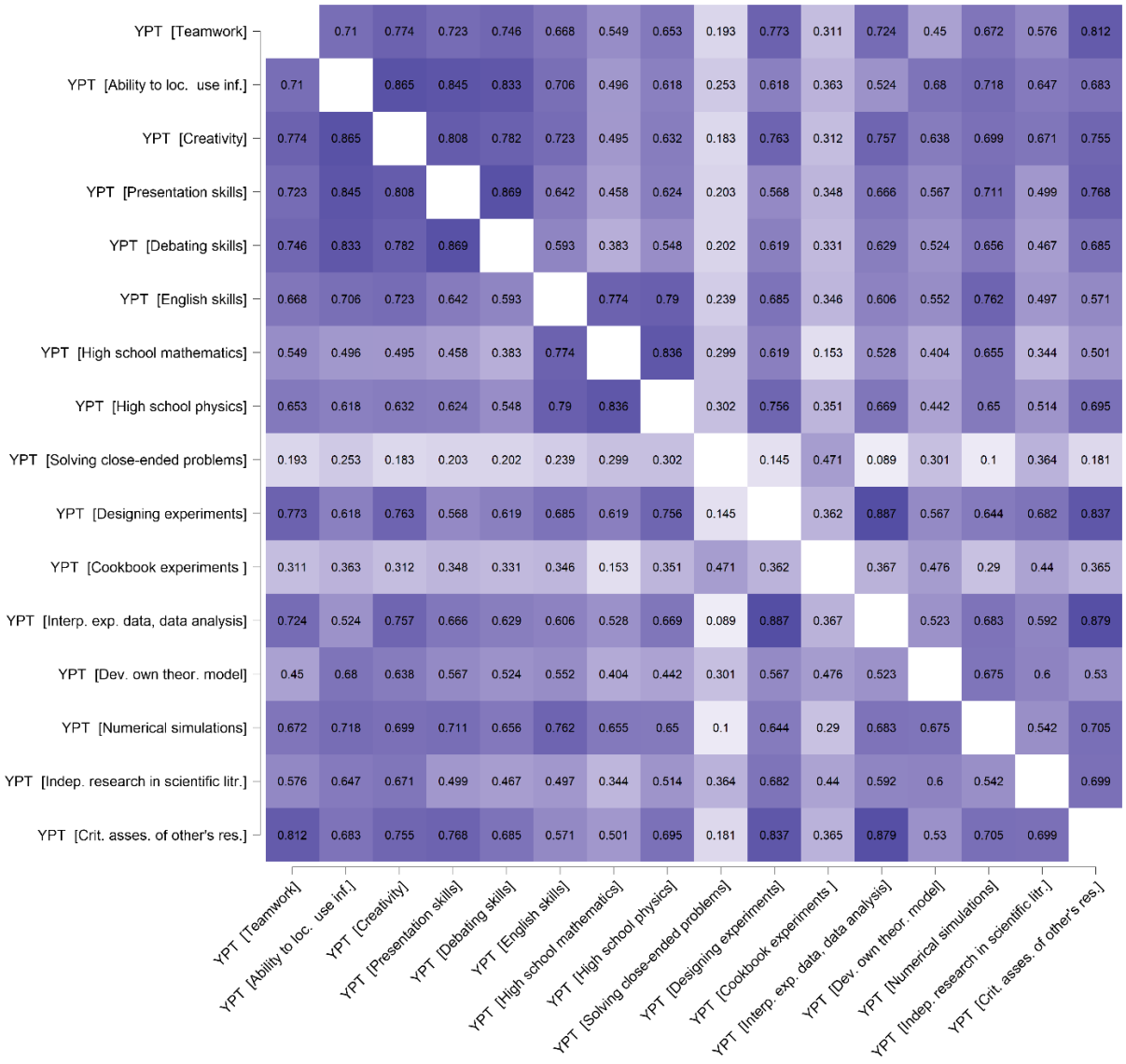
2.2.2 Young Physicists' Tournament: YPT

Descriptive Statistics: Soft skills in YPT

	YPT [Teamwork]	YPT [Ability to loc. use inf.]	YPT [Creativity]	YPT [Presentation skills]	YPT [Debating skills]	YPT [English skills]
Valid	32	32	33	33	33	33
Missing	1	1	0	0	0	0
Mean	8.281	8.156	8.576	8.394	8.182	8.061
Std. Deviation	1.922	2.259	1.696	2.179	2.157	2.263
Minimum	2.000	2.000	2.000	2.000	1.000	2.000
Maximum	10.000	10.000	10.000	10.000	10.000	10.000

In the case of YPT preparation, all soft skills show a high value in terms of judging the developmental effect compared to the RPC values. Paired t-tests show a positive significant difference for all soft skills (3.3.1). Teachers assess all soft-skills types to be strongly positively correlated.

In the case of YPT-type competitions, there is no meaningful correlation among the Soft Skills, and in the opinion of teachers, a strong connection can be discovered between almost everything. *High school physics* shows very strong correlations (r > 0.8) with *Teamwork, High school mathematics, Designing experiments, Interpreting experimental data, data analysis* and *Critical thinking of others results. Cookbook experiments* and *Solving close-ended problems* are having remarkable low marks.

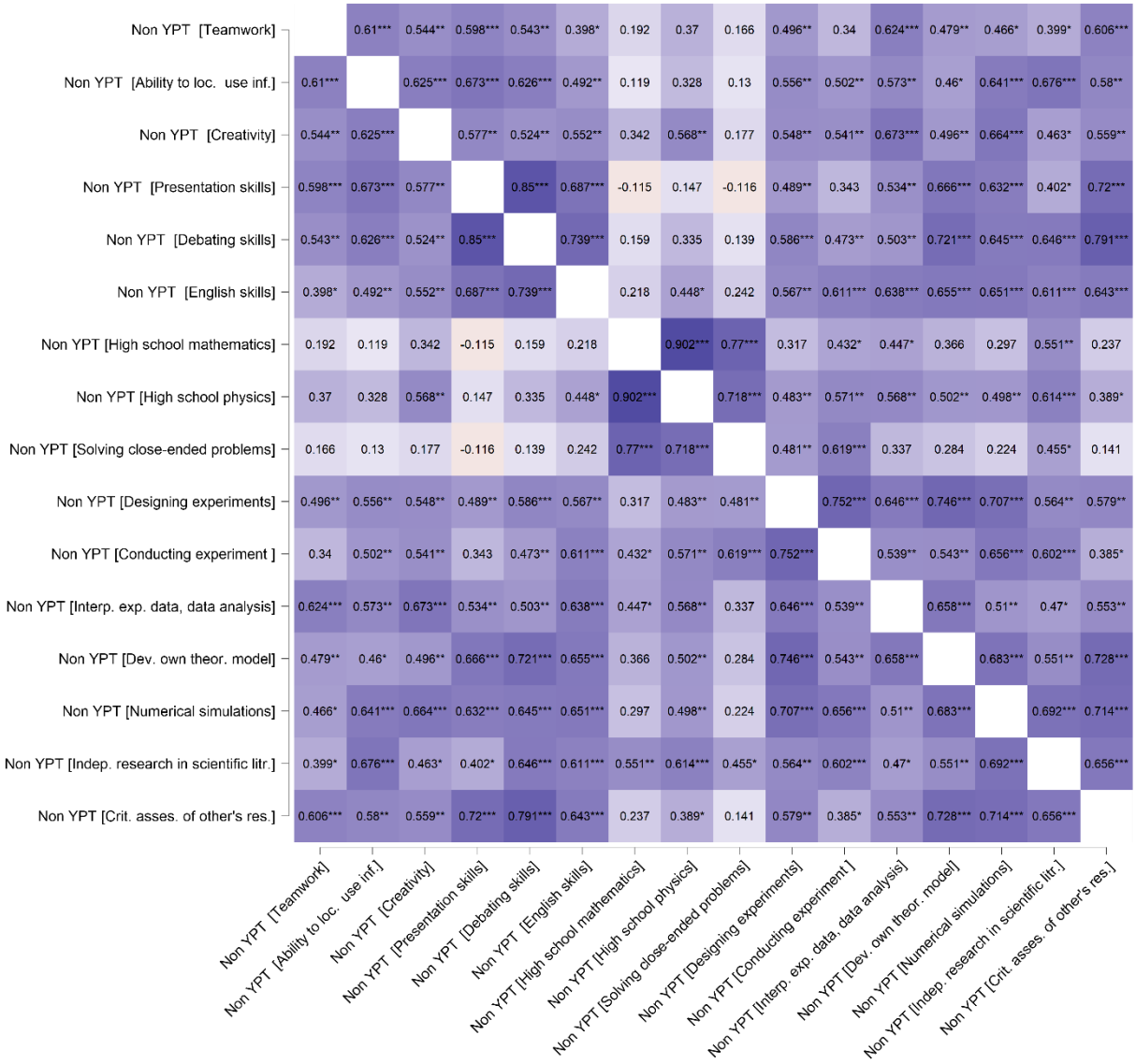


2.2.3 Non-YPT like competitions: Non-YPT

Czech teachers did not answer the questions of the questionnaire in this part, so the answers belong to the teachers of Bulgaria, Hungary, Slovakia and Slovenia.

Descriptive Statistics: Soft skills in Non-YPT

	Non YPT [Teamwork]	Non YPT [Ability to loc. use inf.]	Non YPT [Creativity]	Non YPT [Presentation skills]	Non YPT [Debating skills]	Non YPT [English skills]
Valid	29	28	29	29	29	29
Missing	0	1	0	0	0	0
Mean	4.448	6.607	6.207	3.931	3.759	3.552
Std. Deviation	3.460	2.726	2.513	3.432	3.214	3.214
Minimum	0.000	1.000	1.000	0.000	0.000	0.000
Maximum	10.000	10.000	9.000	10.000	10.000	10.000



Traditional competitions are judged by teachers to help students *Ability to locate and use information* and develop *Creativity*, but the other soft skills are also less than the impact of RPC development. Due to the diversity of Non-YPT competitions, there is only a few strong correlations between their effects on soft skills as judged by teachers: *Presentation* and *Discussion skills* r = 0.85 p <.001, and between *Discussion* and *English language skills* r = 0.739 p <.001.

In the case of YPT-type competitions, it can be said that the impact on the development of different soft skills forms a complete system. This is a good reflection of the practice, as successful racing requires all of the soft skills listed, and it is not possible to single out a few of them in terms of importance.

2.3 Comparison of soft skills

The comparison between the values given for the assessment of the soft skills listed in section 1.4 and the relationships and differences between them can be found in the following paragraphs. Also some of the results (mostly with significant difference) are shown.

2.3.1 Paired t-test on soft skills (RPC vs. YPT)

One of the most striking questions in our research is whether we see these significant differences between RPC and YPT in their impact on soft skills. To do this, we perform paired t-tests – or Wilcoxon-test, if needed.

Test of Normality (Shapiro-Wilk): Soft Skill in RCP vs. YPT

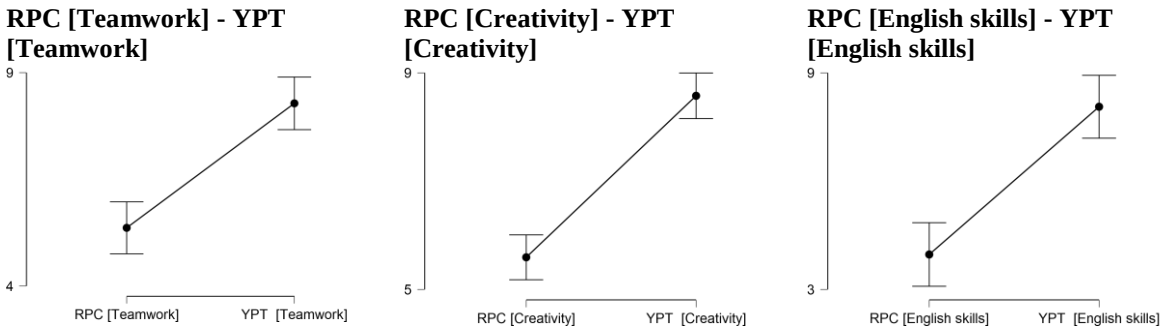
		W	p
RPC [Teamwork]	- YPT [Teamwork]	0.949	0.135
RPC [Creativity]	- YPT [Creativity]	0.925	0.028
RPC [Debating skills]	- YPT [Debating skills]	0.951	0.143
RPC [Ability to loc. use inf.]	- YPT [Ability to loc. use inf.]	0.918	0.018
RPC [Presentation skills]	- YPT [Presentation skills]	0.960	0.263
RPC [English skills]	- YPT [English skills]	0.940	0.075

Note. Significant results suggest a deviation from normality.

Paired Samples T-Test: Soft Skill in RCP vs. YPT

Measure 1	Measure 2	Test	Statistic	df	p
RPC [Teamwork]	- YPT [Teamwork]	Student	-6.503	31	< .001
RPC [Creativity]	- YPT [Creativity]	Student	-10.225	31	< .001
		Wilcoxon	0.000		< .001
RPC [Debating skills]	- YPT [Debating skills]	Student	-7.126	32	< .001
RPC [Ability to loc. use inf.]	- YPT [Ability to loc. use inf.]	Student	-7.742	31	< .001
		Wilcoxon	0.000		< .001
RPC [Presentation skills]	- YPT [Presentation skills]	Student	-6.040	32	< .001
RPC [English skills]	- YPT [English skills]	Student	-6.759	31	< .001

As can be seen, YPT achieved a significantly better effect than class work in all of the soft skill areas examined, which is, of course, due to the significant difference from class work organization methods.



2.3.2 Paired t-test on soft skills (YPT vs. Non-YPT, without CZ)

Also, an important question in our research is whether we see these significant differences between YPT and non-YPT in their impact on soft skills. To do this, we perform paired t-tests – and Wilcoxon-test if needed.

Test of Normality (Shapiro-Wilk): Soft Skills in YPT vs. Non-YPT

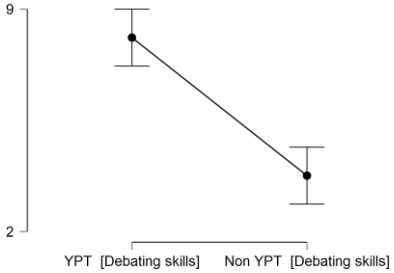
		W	p
YPT [Teamwork]	- Non YPT [Teamwork]	0.941	0.117
YPT [Creativity]	- Non YPT [Creativity]	0.940	0.097
YPT [Debating skills]	- Non YPT [Debating skills]	0.967	0.473
YPT [Ability to loc. use inf.]	- Non YPT [Ability to loc. use inf.]	0.931	0.067
YPT [Presentation skills]	- Non YPT [Presentation skills]	0.928	0.048
YPT [English skills]	- Non YPT [English skills]	0.949	0.173

Paired Samples T-Test: Soft Skills in YPT vs. Non-YPT

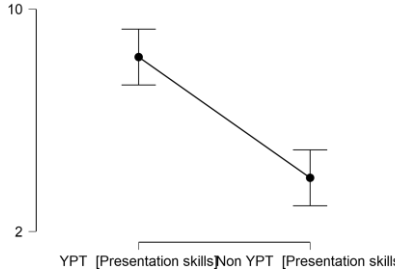
Measure 1	Measure 2	Test	Statistic	df	p
YPT [Teamwork]	- Non YPT [Teamwork]	Student	5.393	27	< .001
YPT [Creativity]	- Non YPT [Creativity]	Student	5.752	28	< .001
YPT [Debating skills]	- Non YPT [Debating skills]	Student	7.026	28	< .001
YPT [Ability to loc. use inf.]	- Non YPT [Ability to loc. use inf.]	Student	2.731	27	0.011
YPT [Presentation skills]	- Non YPT [Presentation skills]	Student	6.265	28	< .001
		Wilcoxon	293.500		< .001
YPT [English skills]	- Non YPT [English skills]	Student	8.089	28	< .001

As the results show well, non-YPT-type competitions give a significantly worse developmental effect for all soft skills than *Ability to locate. & use information*, according to teachers.

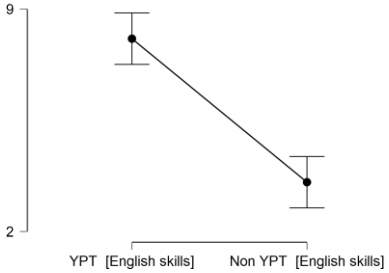
YPT [Debating skills] - Non YPT [Debating skills]



YPT [Presentation skills] - Non YPT [Presentation skills]



YPT [English skills] - Non YPT [English skills]



2.3.3 Paired t-test on soft skills (RPC vs. Non-YPT, without CZ)

It is also an important relation for the research hypothesis, and an interesting addition for the whole picture of the soft skills. Since basically RPC and traditional tournaments are in a kind of symbiosis, no major differences are expected.

Test of Normality (Shapiro-Wilk): Soft Skills in RPC vs. non-YPT

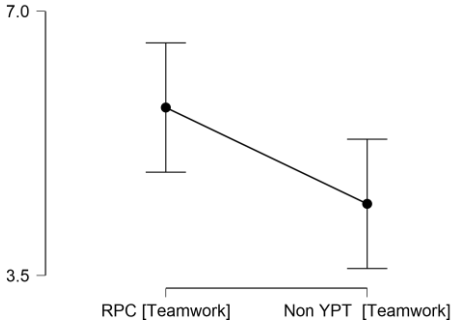
		W	p
RPC [Teamwork]	- Non YPT [Teamwork]	0.970	0.567
RPC [Creativity]	- Non YPT [Creativity]	0.942	0.113
RPC [Debating skills]	- Non YPT [Debating skills]	0.932	0.062
RPC [Ability to loc. use inf.]	- Non YPT [Ability to loc. use inf.]	0.933	0.075
RPC [Presentation skills]	- Non YPT [Presentation skills]	0.968	0.519
RPC [English skills]	- Non YPT [English skills]	0.972	0.623

Paired Samples T-Test: Soft Skills in RPC vs. non-YPT

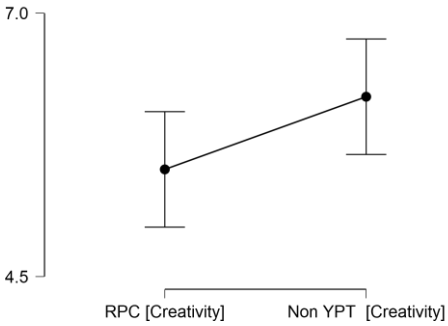
Measure 1	Measure 2	t	df	p
RPC [Teamwork]	- Non YPT [Teamwork]	2.158	28	0.040
RPC [Creativity]	- Non YPT [Creativity]	-1.823	28	0.079
RPC [Debating skills]	- Non YPT [Debating skills]	2.059	28	0.049
RPC [Ability to loc. use inf.]	- Non YPT [Ability to loc. use inf.]	-0.915	27	0.368
RPC [Presentation skills]	- Non YPT [Presentation skills]	3.447	28	0.002
RPC [English skills]	- Non YPT [English skills]	0.584	27	0.564

What can be seen, with great certainty, only three significant differences can be observed. *Teamwork* is significantly worse for Non-YPT than for RPC t = 2.158 p = .04. In addition, *Debating skills* are less developed in Non-YPT tournaments even compared to RPC t = 2.059 p = .049., and *Presentation skill*, is also significantly worse in Non-YPT as in RPC t = 3.447 p=.002.

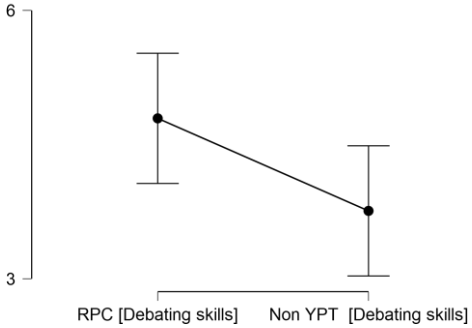
RPC [Teamwork] - Non YPT [Teamwork]



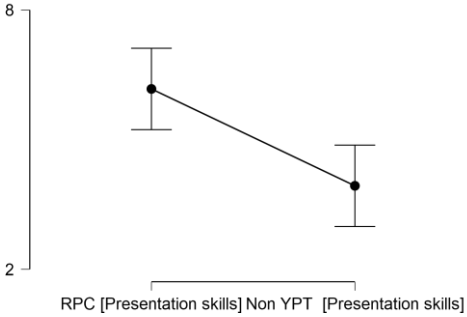
RPC [Creativity] - Non YPT [Creativity]



RPC [Debating skills] - Non YPT [Debating skills]



RPC [Pres. skills] - Non YPT [Presentation skills]



To sum up, according the answers of the teachers YPT has in every questioned Soft skill a significantly higher positive influence than RPC or Non-YPT competitions.

2.4 Country-level effects

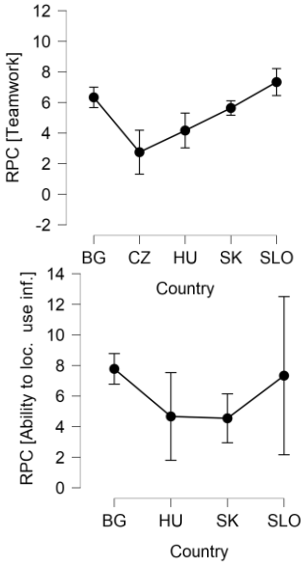
First we investigated the soft skills in RPC in the 5 countries. Here we can see the full analysis of them. The only skill *Ability to use and locate information* seems to have a country dependent value. The very similar values of the soft skills in RPC show that investigated countries have basically quite similar educational styles.

ANOVA - RPC [Teamwork]

Cases	Sum of Squares	df	Mean Square	F	p	η²
Country	56.841	4	14.210	3.188	0.028	0.313
Residuals	124.795	28	4.457			

ANOVA - RPC [Ability to loc. use inf.]

Cases	Sum of Squares	df	Mean Square	F	p	η²
Country	68.482	4	17.121	3.550	0.018	0.336
Residuals	135.033	28	4.823			



In the following we also only show skills where a significant effect of the country has been found: Ability to locate and use information in YPT, Teamwork and English skills in Non-YPT (without CZ). That depends on mostly on the different competition culture of Bulgaria (only 6 of the 19[10] mentioned competitions are only on national level) compared to the 3 other countries (41 of 54[2] mentioned competitions are only on national level, and the 11 mentioning are "Physics Olympiad" which is also a competition on mother tongue). It is important to emphasize that no significant effect of the countries in YPT has been found in any soft skill.

ANOVA - YPT [Ability to loc. use inf.]

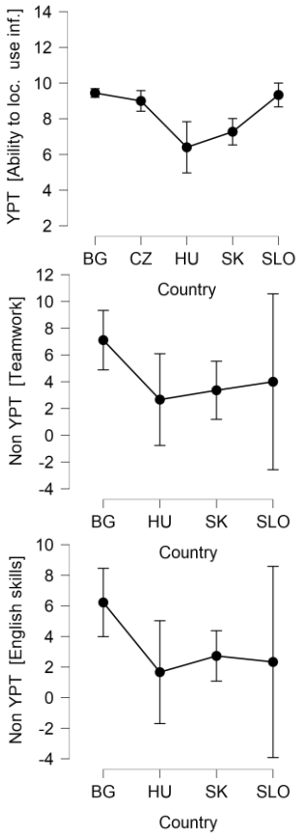
Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Country	45.948	4	11.487	2.763	0.048	0.290
Residuals	112.271	27	4.158			

ANOVA - Non YPT [Teamwork]

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Country	96.405	3	32.135	3.365	0.034	0.288
Residuals	238.768	25	9.551			

ANOVA - Non YPT [English skills]

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Country	97.435	3	32.478	4.235	0.015	0.337
Residuals	191.737	25	7.669			



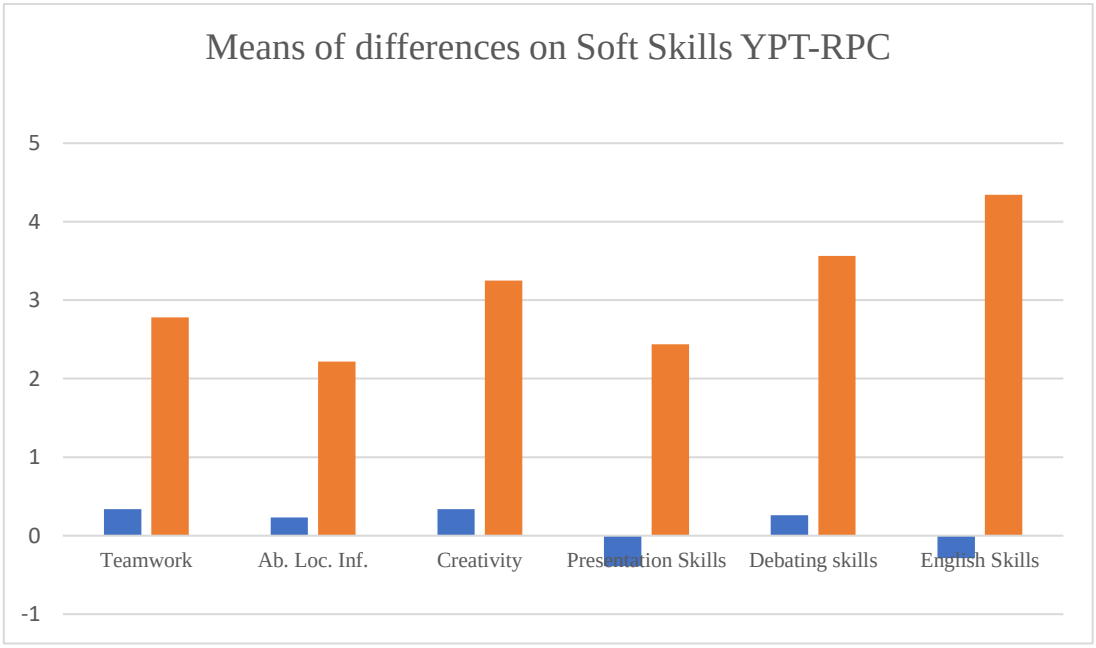
2.5 Comparison of soft-skill evaluations between students and teachers

Based on survey results on the perceived usefulness of regular physics classes and YPT-related activities by students and teachers, we compared how these two groups considered the two types of activities. For this analysis, complete answers by participants are a precondition, therefore we heavily cleaned data: only 77 students and 32 teachers answered all the questions. In addition, students' answers don't show normal distributions: thus, we applied Mann-Whitney tests.

[10] beside YPT competitons

Group Descriptives: Differences of Soft Skills between YPT and RPC

	Group	N	Mean	SD	SE
Diff. Team	Student	77	0.338	2.664	0.304
	Teacher	32	2.781	2.419	0.428
Diff. Ab.loc.	Student	77	0.234	2.470	0.282
	Teacher	32	2.219	1.621	0.287
Diff. Crea.	Student	77	0.338	2.210	0.252
	Teacher	32	3.250	1.967	0.348
Diff. Pres.	Student	77	-0.390	2.848	0.325
	Teacher	32	2.438	2.299	0.406
Diff. Deb.	Student	77	0.260	2.520	0.287
	Teacher	32	3.563	2.758	0.488
Diff. Eng.	Student	77	-0.286	1.856	0.211
	Teacher	32	4.344	3.404	0.602



Note: Blue bar shows differences in evaluation for regular physics classes and YPT-related activities by students; orange bar shows differences in evaluation for regular physics classes and YPT-related activities by students.

Independent Samples T-Test: Differences of Soft Skills between YPT and RPC

	Test	Statistic	df	p
Diff. Team	Student	-4.477	107	< .001
	Mann-Whitney	544.000		< .001
Diff. Ab.loc.	Student	-4.181	107	< .001
	Mann-Whitney	560.500		< .001
Diff. Crea.	Student	-6.463	107	< .001
	Mann-Whitney	355.500		< .001
Diff. Pres.	Student	-4.978	107	< .001
	Mann-Whitney	495.500		< .001
Diff. Deb.	Student	-6.059	107	< .001
	Mann-Whitney	413.500		< .001
Diff. Eng.	Student	-9.137	107	< .001
	Mann-Whitney	311.500		< .001

Across all types of soft skills, we observe that the differences in the perceived usefulness of regular physics classes in comparison to YPT-related activities are significantly less pronounced in the evaluation by students than in the evaluation by teachers ($p < 0.001$). Overall, however, we also find that students as well as teachers consider YPT-related activities as more useful than regular physics classes to develop the students' soft skills. Only in the case of "Presentation skills" and "English skills", students reported that they considered their regular physics classes as more useful to develop their soft skills. Teachers reported greater assumed usefulness for YPT-related activities across all types of soft skills.

3. Supplement: The Effect of Soft Skills in Inquiry-Based-Learning on Student Performance

In this deep-dive, we investigate how students' soft skills development influences learning outcomes. To this end, two master theses (Poier, 2021; Schweighart, 2021; Full theses appended) investigated how student performance in the Austrian Young Physicists' Tournament related to students' self-assessed soft skills development. A separate round of qualitative interviews with teachers guided the development of the questionnaire for this subsection of IO2.

The master theses of Poier (2021) and Schweighart (2021) dealt with the question, to what extent soft skills effect student performance in inquiry-based learning (IBL) and problem-based learning (PLB) environments. This document summarizes the theoretical background of IBL, PBL and soft skills. Afterwards, the empirical analysis based on the data from the Austrian Young Physicists Tournament (AYPT) is presented and discussed in the light of current literature.

3.1 Theoretical background

IBL is known under many different terms, such as scientific inquiry, inquiry-based teaching, authentic inquiry, modelling and argumentation, or hands-on science (Furtak et al., 2012; Rönnebeck et al., 2016). All of them have in common that the approach aims for students to "*develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments*" (National Research Council, 1996, page 105). While IBL is most often connected with STEM courses, it is not limited to those subjects. In effect, IBL is used in a variety of subjects (Mieg, 2019).

Pedaste et al. (2015) identified a framework which comprises the phases of the inquiry cycle. After an orientation phase, where students become interested in the topic, the conceptualization phase can either include questioning or hypothesis generation depending on whether specific ideas what to investigate already exist. Experiments or other methods to find answers are carried out in the investigation phase where the data is also interpreted. In the conclusion phase, the question or hypothesis from the conceptualization phase is compared to the data. All phases are accompanied by a discussion phase (Pedaste et al., 2015).

Many articles were published discussing whether IBL positively impacts student performance. A widely-known article by Kirschner et al. (2006) compared IBL to minimally guided instruction and argued that due to cognitive overload of the working memory the outcomes in IBL situations are worse than student performance in traditional teaching settings. Hmelo-Silver et al. (2007) clarified that IBL does not necessarily entail minimal guidance and that especially with the use of guidance, several studies show that guided IBL settings led to improved performance compared to direct instruction. Furtak et al. (2012), as well as Lazonder and Harmsen (2016) supported this view in their meta-studies which found that guided IBL settings were more effective than minimally or unguided versions.

In a longitudinal study among high school students from the UK, the effect of IBL on scores of the science sections of the General Certificate of Secondary Education and PISA test was only small. Students filled in a questionnaire alongside their examinations how much IBL took place in the time before the testing. The authors, however, point out that while the impact on grades was minimal, other

factors were not taken into account, such as possibly improved motivation, interest and engagement as a result of IBL (Jerrim et al., 2019).

3.1.1 Problem-based learning

The main difference of IBL and PBL lies in its origins. In its beginnings, IBL was mainly used in science education, while PBL originated from medical courses (Hmelo-Silver et al., 2007). In PBL, the approach how the problem is worked on and how the solution is found is considered the final product. While the teacher supports the students that work in small groups, they are to work on their solution in a self-directed manner, which helps them to gain "lifelong learning skills" (Hmelo-Silver, 2004, page 235). These process skills comprise for example critical thinking skills and the capability to analyse situations in depth (Oliver, 2000). IBL and PBL need to be differentiated from project-based learning (PjBL), which does not comprise an ill-defined problem and where a concrete solution needs to be produced (Bereiter & Scardamalia, 2006). Both, PBL and IBL are based on constructivism which states that the students construct or create knowledge themselves as opposed to having it transferred to them by the instructor (Chang & Mao, 1999).

Othmann et al. (2013) proposed a framework for PBL settings called "Ladder of Active Learning", where the ladders start with the introduction to the problem, input, group meeting, presentation, and exercises. While all of the ladders entail different steps, they all end with the reflection step. In a meta-analysis which investigated how effective PBL settings were compared to more traditional teaching methods, slightly more knowledge was acquired in conventional leaning environments compared to PBL environments (Dochy et al., 2003). However, Ibrahim et al. (2018) observed that students perceived PBL helpful to learn especially the basics of the science curriculum and that students reported of higher motivational levels. In addition, students' satisfaction levels in PBL classes are improved (Khoshnevisasl et al., 2014). Many authors conclude that the main advantage of PBL is the possibility to develop soft skills (Bruder & Prescott, 2013; Carvalho, 2016; Choi et al., 2014; Dochy et al., 2003; Hattie, 2009; Mohd-Yusof et al., 2013; Yeh et al., 2011). In the following section, the term soft skills will be scribed in more detail.

3.1.2 Soft skills

Many different synonyms for the term soft skills exist, such as generic competences, life skills, transferable skills, twenty-first century skills, or noncognitive skills (Cinque, 2016; Heckman & Kautz, 2012). But all of them have in common that they are defined as "personal transversal competences such as social aptitudes, language and communication capability, friendliness and ability of working in team, and other personality traits that characterize relationships between people (Cimatti, 2016, page 97). However, an exact list which competencies fall under the category soft skills does not exist (Cinque, 2016; Vogler et al., 2018).

Li et al. (1999) showed that students that are involved in learning communities at university perceived to develop critical thinking skills and communication skills due to integration of academic and social aspects. Other studies also found that collaborating at university can lead to problem-solving and decision-making skills (Smith & Bath, 2006), as well as other generic skills (Ballantine & McCourt Larres, 2007). It was observed that classes which incorporated the teaching of content knowledge and soft skills at the same time were found to be more effective than courses which focused on teaching only soft skills (Chamorro-Premuzic et al., 2010).

Many articles deal with the topic of which soft skills are developed in the course of IBL and PBL settings. In the analysis of the literature by Poier (2021), communication skills, critical thinking skills and research skills were mentioned most often in connection with IBL (see Appendix A / Table 1). In connection with PBL, the soft skills stated most often were communication skills, problem-solving skills, and teamwork skills (see Appendix A / Table 2).

To what degree soft skills have an influence on student performance was analysed by Chamorro-Premuzic et al. (2010). In this study, academic success was positively linked to how important students perceived soft skills for success, as well as how much they felt they had developed soft skills. This positive relationship was confirmed in a study among 536 (vice)principals in Nigeria who reported the same perception (Obilor, 2019). However, the same opinion could not be found among students (Majid et al., 2012). In a study by Hwang (2018), a positive correlation between teamwork skills and improved performance at an Enterprise Resource Planning simulation with university students could be found.

3.1.3 Research questions and hypotheses

Sungur and Tekkaya (2006) suggest further research to find out to what extent soft skills influence academic performance in IBL and PBL settings.

The master thesis of Poier (2021) stated as the research question was: How does proficiency in soft skills influence student performance in IBL situations? For this purpose, the following hypotheses were tested:

Hypothesis P.1: The more important students gauge soft skills to be for success, the better their academic performance.

Hypothesis P.2: The better the students self-assess their development of soft skills during the preparation period, the better their academic performance.

Hypothesis P.3: The better students self-assess their teamwork skills, the better their performance.

Hypothesis P.4: The better students self-assess their English skills, the better their performance.

Schweighart (2021) examined the following research questions in her master thesis: “How does the self-assessed development of soft skills influence student performance in PBL situations? Which soft skills are considered most important for PBL in order to be successful?” In this context, the following hypotheses were tested:

Hypothesis S.1.a: The development of soft skills in IBL situations (preparation for AYPT) is expected to be higher compared to regular physic classes.

Hypothesis S.1.b: The self-assessed development of soft skills in IBL situations (preparation for AYPT) is expected to be higher the more hours the pupils spent preparing for AYPT.

Hypothesis S.2: The higher students’ self-asses the development of soft skills (after the preparation for AYPT) the better they perform.

Hypothesis S.3.a: Students self-assess their problem-solving skills higher after the preparation period.

Hypothesis S.3.b: Students self-assess other skills (beside problem-solving) higher after the preparation period.

Hypothesis S.4: The higher students rate their problem-solving skills (after the preparation) the more they feel to develop specific content knowledge.

Hypothesis S.5.a: Students who think problem solving is important to succeed, score higher on AYPT.

Hypothesis S.5.b: Students who think other skills (beside problem solving) are important for success, score higher on the AYPT.

3.2 Methodology

The data used for the empirical testing stems from the AYPT of the years 2020 and 2021. Team leaders/teachers filled in questionnaires on their impression of students' soft skills development. The results were then used to create a survey for students which they filled out around the time of the competitions (see Appendix B for the full theses including data on the survey). Five teams completed the questionnaire in 2020, and seven teams in the year 2021. Appendix C (Table 3) includes an overview of all teams participating in 2020 and 2021 (in an anonymized way) and further information on the mean grade, the standard deviation, the minimum and maximum grade received as well as the number of stages the team participated in and the number of grades received.

In the two years, jurors awarded 1,338 grades in total. However, only grades of teams were used for statistical analysis who also filled in the questionnaire. The grades function as the dependent variables.

The questionnaires gathered data on the following soft skills: teamwork, independent research in literature and other sources, scientific reasoning skills, presentation skills, debating skills, English skills, creativity, self-directed learning, and problem-solving (the last three soft skills were added in 2021). For each soft skill, the students were asked to rate the importance for success, self-assess their proficiency before their very first AYPT and after the current preparation phase as well as the development in the soft skill during the preparation phase.

The hypotheses were tested via linear regressions using the ordinary least squares (OLS) method. The two master theses focused on the following aspects: Poier (2021) used only those variables that were part of the survey in both years leading to fewer variables, but a more observations (794) for the sample (see Appendix D / Table 4 for descriptive statistics on the variables)(Poier, 2021). And Schweighart (2021) included all variables. This is why only the respondents from 2021 could be considered for the linear regressions of the new variables. This led to between 507 and 582 observations for the sample (see Appendix E / Table 5).

3.3 Results

In this section, the results of various linear regressions to test the hypotheses are presented. Poier (2021) tested the importance of soft skills twofold: First, the aggregated independent variable General importance soft skills (which includes importance of teamwork, independent research, scientific reasoning, presentation, debating and English skills) was used. The linear regression showed an estimator of 0.6473 and a low p-value of 0.00013 (see Appendix F / Table 6). When computing the linear regressions via the importance of individual soft skills, the result is more varied: While a positive relationship between the importance of teamwork (estimator = 1.6635), independent research (estimator = 2.1286), scientific reasoning (estimator = 0.8897), and debating skills (estimator = 1.0368) and grade could be found, a negative link was observed between the importance of presentation skills (estimator = -2.6363), the importance of English skills (estimator = -0.9365) and grade (see Appendix F / Table 7). For hypothesis P.1 it can be summarized that in general, the more important students gauge soft skills for success, the better their performance. When looking at the level of individual soft skills, support for hypothesis P.1 can be found for the soft skills of teamwork, independent research, scientific reasoning and debating skills (Poier, 2021).

Also the influence of soft skills development was calculated in two ways: While the general development of soft skills did not yield significant results (see Appendix G / Table 10) because of a p-value of 0.080, the development of individual soft skills led to significant results for the development of teamwork (estimator = 1.6261), scientific reasoning (estimator = 3.4105), presentation skills (estimator = -3.0370), debating skills (estimator = -1.6347), and English skills (estimator = 0.2993) (see Appendix G / Table 11). Thus, it can be summarized support for hypothesis P.2, which predicted the positive influence of the development of soft skills on academic success, could be found for teamwork, scientific reasoning, and English skills (Poier, 2021).

Support for hypothesis P.3, “The better students self-assess their teamwork skills, the better their performance”, could not be found due to insignificant results of the independent variable (p-value of 0.986) (see Appendix H / Table 14) (Poier, 2021).

Hypothesis P.4, which predicted that better English skills positively influenced academic success, was supported by the results of the linear regression: An increase of one point on the self-assessment scale of proficiency would lead to an improved score of 0.4241 (with a p-value of 0.000) (see Appendix I / Table 15) (Poier, 2021).

For hypothesis S.1.a., the regression results of the proficiency in soft skills after the preparation phase of 2020 (see Appendix J / Table 16) and the proficiency before the preparation phase of 2021 (see Appendix J / Table 17) were compared. It was summarized the better students self-assessed to be in soft skills due to the preparation for AYPT, the better their grades – except for presentation skills (prof_post_presentation: -1.00 and prof_prae_presentation: 0.74) (Schweighart, 2021).

Support for hypothesis S.1.b could be observed: For each additional hour the students invest in the preparation for AYPT, their grades increase by 0.01 points (see Appendix K / Table 18) (Schweighart, 2021).

Schweighart (2021) further analysed the influence of soft-skill development during the preparation for the AYPT on grade (see Appendix G / Tables 12 and 13). A significant positive correlation was found for the development of teamwork (estimator = 0.86), and scientific reasoning (estimator = 2.63). A significant negative links was found for the development of independent research skills (estimator = -0.69), presentation skills (estimator = -1.80), and creativity (estimator = -0.42). Thus, hypothesis S.2 was only partially be supported.

Linear regressions for individual soft skills were computed (see Appendix K / Tables 19-28) with a focus on the proficiency before and after the preparation phase to test hypothesis S.3. (Schweighart, 2021).

All students who filled in the survey felt that they acquired "a lot" content knowledge. This led to too little variance and was the reason, why hypothesis S.4. could not be tested (Schweighart, 2021).

Last, the impact of the importance of individual soft skills was tested for the hypotheses S.5.a and S.5.b. A significant positive relationship with grade was observed for the importance of teamwork (estimator = 1.46), independent research (estimator = 1.99), scientific reasoning (estimator = 0.58), debating skills (estimator = 1.08), and self-directed learning (estimator = 0.31). A significant negative relationship was found with the importance of presentation skills (estimator = -2.20), and English skills (estimator = -0.81). No significant results were observed for the importance of problem-solving and creativity (see Appendix F / Tables 8 and 9) (Schweighart, 2021).

3.4 Discussion

After having presented the results of the empirical analysis in the previous section, these will be discussed in the light of literature:

The fact that the general importance of soft skills (hypothesis P.1) as well as the importance of most individual soft skills (hypotheses P.1, S.5.a, and S.5.b) correlated positively with student performance is in accordance with studies among secondary (vice-)principals (Obilor, 2019) and among UK students (Chamorro-Premuzic et al., 2010), but contradictory to a survey among students from Singapore (Majid et al., 2012).

Computing the linear regressions to test the influence of soft skills development on grade (hypotheses P.2 and S.2) resulted in significant positive correlations for the development in teamwork, scientific reasoning, and English skills. This corresponds to the findings of Chamorro-Premuzic et al. (2010). While Palmer (2002) did not statistically analyse the influence of soft-skill development on grades, the study did show an improvement in grades and the author experienced the development of a variety of soft skills herself. The literature could not provide explanations for the significant negative influence for development of presentation and debating skills as well as creativity on academic success.

When analysing the effect of teamwork skills on student performance, no support for hypothesis P.3 was found due to a high p-value. This is opposed to a study by Hwang (2018) who found that high teamwork skills are linked to improved outcomes in an Enterprise Resource Planning simulation at university. Also Bruder and Prescott (2013) predicted a positive relationship.

The finding that better English skills can lead to improved success at AYPT (hypothesis P.4) is in line with expectations and also a study of Amaral et al. (2002).

The results from the linear regressions that tested hypotheses S.3.a and S.3.b were partially in line with a study by Choi et al. (2014), which was aimed at analysing which impact a PBL setting had on critical

thinking, problem-solving, and self-directed learning skills (compared to a traditional teaching method). The positive effect from the study could also be shown in the findings by Schweighart (2021), where most independent variables showed positive estimators except for independent research and scientific reasoning skills.

The results of Schweighart (2021) to the second research question, "Which soft skills are considered most important for PBL in order to be successful?", led to research, teamwork, and debating skills, which is in agreement with the findings of Deep et al. (2019).

3.5 Limitations

Possible limitations in the master theses of Poier (2021) and Schweighart (2021) lie in the fact that the data on soft skills is based on self-assessment. Thus, students possibly have different impression of their soft skills as opposed to reality. However, according to Chamorro-Premuzic et al. (2010) it is not possible to test soft skills in an objective and accurate way anyway. Other studies on IBL also faced this limitation by self-reported data from students and consequential "reporting and recall inaccuracies" (Jerrim et al., 2019, page 42).

In addition, it is possible that the jurors considered certain aspects regarding soft skills when deciding on a grade (e.g. professional presentation or discussion influencing the grade positively). This would lead to a situation where the data on grades and on soft skills is not as independent as it should be.

3.6 Conclusion

This summary presented the theoretical background on IBL, PBL, and soft skills. In addition, the results of Poier (2021) concluded that the perceived importance of soft skills on academic performance have a positive effect when using the aggregated variable. When analysing the effect of the importance of individual soft skills, the importance of teamwork, independent research, and debating skills had a positive impact, while the importance of presentation skills and English skills were negatively correlated. The influence of soft skills development in general on grade could not be proven due to a too high p-value. However, the analysis on the individual soft skill level showed that a positive relationship could be observed for the development of teamwork, scientific reasoning, and English skills on grade. A negative influence on grade was found for the development of presentation and debating skills. The proficiency in teamwork did not influence student performance significantly. While proficiency in English had a significant positive impact on the grade.

The results of Schweighart (2021) showed that IBL led to more soft-skill development than traditional physics classes. Further, the more hours the students invested in preparation for AYPT, the better their grades. A clear link between student performance and soft skills development could not be observed. Students who perceived their soft skills to have been improved by IBL, received better grades (except for research, scientific reasoning, and English skills). Due to too little variance, the relationship between acquisition of content knowledge and development of problem-solving skills could not be investigated. Student performance could be predicted by the perceived importance of soft skills (except for creativity, English, and presentation skills). Grade was most influenced by independent research skills.

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Appendix A: Overview of soft skills mentioned in literature

Table 1: Overview of Mentioned Soft Skills in Relation to IBL (Poier, 2021)

	Collaborative skills	Communication Skills	Creativity	Critical thinking	Data analysis	Deep learning	English skills	IT Literacy	Organization skills (incl. time mgmt.)	Presentation skills	Problem-solving	Research	Reasoning	Self-directed learning
Developing Useful and Transferable Skills: Course Design to Prepare Students for a Life of Learning (Justice et al., 2009)		**x**				**x**			**x**			**x**	**x**	**x**
Enquiry-Based Learning Can Maximise a Student's Potential (Palmer, 2002)		**x**			**x**				**x**	**x**		**x**		
Fostering students' workplace communicative competence and collaborative mindset through an inquiry-based learning design (Chen, 2021)	**x**	**x**									**x**			
Grade 4 Students' Development of Research Skills through Inquiry-Based Learning Projects (Chu et al., 2008)	**x**	**x**	**x**	**x**	**x**			**x**				**x**		**x**
Helping English learners increase achievement through inquiry-based science instruction (Amaral et al., 2002)							**x**							
Learning through inquiry: a Global Health Hackathon (Kienzler & Fontanesi, 2017)										**x**				
The impact of the use of inquiry-based learning as a teaching methodology on the development of critical thinking (Magnussen et al., 2000)				**x**										
Visible Learning: A Synthesis of over 800 Meta-Analyses Relating to Achievement (Hattie, 2009)				**x**										

Table 2: Overview of Mentioned Soft Skills in Relation to PBL (Poier, 2021)

	Analytical skills/thinking	Application of knowledge	Argumentation skills	Communication Skills	Conflict resolution	Creativity	Critical thinking	Documentation Skills	ICT skills	Information management	Interpersonal skills	Language ability	Leadership	Lifelong learning	Motivation	Multidisciplinary skills	Organization skills	Personal development	Persuasion	Presentation skills	Problem-solving	Research	Reasoning	Self-confidence	Self-directed learning	Self-discipline	(Self-)Learning	Teamwork	Time management	Work ethics
A Comparison of Problem- based learning and Traditional Education on Nursing Students' Locus of Control and Problem- Solving Skills (Günüsen et al., 2014)																					x									
Case study: use of problem- based learning to develop students' technical and professional skills (Warnock & Mohammadi-Aragh, 2016)				x																	x				x					
Conflict resolution skills of nursing students in Problem- based learning compared to conventional curricula (Seren & Ustun, 2008)					x																									
Defining Vocational Education and Training for Tertiary Level Education: Where does Problem Based Learning Fit in? – A Literature Review (Ismail, 2013)				x							x			x							x									
Developing Soft Skills by Applying Problem-Based Learning in Software Engineering Education (Yu & Adaikkalavan, 2016)				x				x			x									x	x							x		
Development and Teaching Approaches of Technical and Vocational Education Curricula (Rau et al., 2006)		x		x								x	x								x						x	x		
Effects of Problem-Based Learning and Traditional Instruction on Self- Regulated Learning (Sungur & Tekkaya, 2006)							x								x														x	
Effects of problem-based learning vs. traditional lecture on Korean nursing students' critical thinking, problem-solving, and self- directed learning (Choi et al., 2014)							x														x				x					
Exploring creativity and critical thinking in traditional and innovative problem- based learning groups (Chan, 2013)						x	x																							
First Year Agriculture Science student perception in students attribute development through Problem-based learning (Tan et al., 2016)				x									x			x		x			x	x						x	x	
From Conventional to Non- conventional Laboratory: Electrical Engineering Students' Perceptions (Bahri et al., 2013)				x																x									x	
Improving the soft skills of engineering undergraduates in Malaysia through problem-based approaches and e-learning applications (Deep et al., 2019)					x							x	x							x	x	x			x			x		

Table 2: Overview of Mentioned Soft Skills in Relation to PBL (Poier, 2021) (continued)

	Analytical skills/thinking	Application of knowledge	Argumentation skills	Communication Skills	Conflict resolution	Creativity	Critical thinking	Documentation Skills	ICT skills	Information management	Interpersonal skills	Language ability	Leadership	Lifelong learning	Motivation	Multidisciplinary skills	Organization skills	Personal development	Persuasion	Presentation skills	Problem-solving	Research	Reasoning	Self-confidence	Self-directed learning	Self-discipline	(Self-)Learning	Teamwork	Time management	Work ethics
Integrating the Development of Employability Skills into a Civil Engineering Core Subject through a Problem- based learning (Mgangira, 2003)				x						x			x				x				x							x		
PBL wrap up sessions: an approach to enhance generic skills in medical student (Razzaq & Ahsin, 2011)		x		x					x											x				x						
Problem Based Learning Implementation in the Degree of Human Nutrition and Dietetics (Lasa et al., 2013)									x																			x		
Problem-Based Learning as an Approach to increase students‘ soft skills (Pratminingsih, 2009)				x							x										x				x			x		
Problem-based learning framework for junior software developer: Empirical study for computer programming students (Panwong & Kemavuthanon, 2014)										x							x					x						x		
Problem-Based Learning in Graduate Management Education: An Integrative Model and Interdisciplinary Application (Brownell & Jameson, 2004)				x	x								x						x											
Problem-based learning in mental health nursing: The students' experience (Cooper & Carver, 2012)				x	x						x				x					x	x	x						x		
Problem-Based Learning: A Process for the Acquisition of Learning and Generic Skills (Baharom & Palaniandy, 2013)	x			x			x							x							x				x			x		
Promoting Skills for Innovation in Higher Education: A Literature Review on the Effectiveness of Problem-based Learning and of Teaching Behaviours (Hoidn & Kärkkäinen, 2014)		x		x																	x		x		x			x		
The effect of problem-based learning on enhancing students’ workforce competence (Yeh et al., 2011)													x													x	x	x		x	
The impact of PBL on transferable skills development in management education (Carvalho, 2016)		x	x		x															x		x		x				x		
The Impact of PBL Training on Legal Professions (Font & Cebrian, 2013)					x		x						x				x					x						x	x	
The impact of Problem- based learning on problem-solving skills and a sense of community in the classroom (Agbeh, 2014)							x														x									
The student perception of Problem-based learning in medical curriculum of the Faculty of medicine. University of Colombo (Seneviratne et al., 2001)				x																	x									

Appendix B: Master theses

The academic theses supporting supplement three are available from the WU Vienna University library.

Sabine Poier (2021): *The Effect of Soft Skills on Student Performance in Inquiry-Based Learning Situations.*
Supervisor: Univ.-Prof. Thomas Lindner, PhD. Examiner: Univ.-Prof. Dr. Jonas Puck

Magdalena Schweighart (2021): *The Effect of Soft Skills on Student Performance in Problem-Based Learning Situations.*
Supervisor: Univ.-Prof. Thomas Lindner, PhD. Examiner: Univ.-Prof. Dr. Jonas Puck

Appendix C: Descriptive statistics on teams

Table 3: Descriptive Statistics on Teams

Team	Year	Mean	Std. Dev.	Min.	Max.	N Stages	N Grades
Team 1	2021	8.141	0.793	6.200	9.111	12	105
Team 2	2020	7.825	0.845	6.714	9.166	8	58
Team 3	2020	7.288	0.734	6.166	8.571	8	60
Team 4	2021	7.249	0.566	6.333	7.888	12	108
Team 5	2021	7.166	0.883	5.625	8.444	9	78
Team 6	2021	6.970	0.978	5.333	8.714	12	102
Team 7	2020	6.646	1.035	5.666	8.500	6	40
Team 8	2020	6.634	0.623	5.833	7.333	6	38
Team 9	2021	6.522	0.723	5.100	7.444	9	75
Team 10	2021	6.462	0.671	5.666	7.500	9	72
Team 11	2021	6.322	0.517	5.500	7.333	9	75
Team 12	2021	6.278	0.817	4.555	7.142	9	75
Team 13	2020	5.928	0.869	4.857	7.333	6	40
Team 14	2021	5.797	1.249	3.500	7.333	9	75
Team 15	2020	5.552	0.949	4.142	7.000	6	38
Team 16	2021	5.435	1.547	2.900	7.285	9	75
Team 17	2020	5.424	1.665	3.166	8.142	6	38
Team 18	2021	5.095	1.002	3.000	6.125	9	75
Team 19	2021	5.077	0.840	3.428	6.111	9	75
Team 20	2020	4.390	0.433	4.000	5.000	6	36

Appendix D: Descriptive statistics on teams

Table 4: Descriptive Statistics on Soft Skills Variables (Poier, 2021)

Variable	Mean	Std. Dev.	Min.	Max.	N Teams
Importance teamwork	4.250	1.179	1.0	5.0	12
Importance independent research	3.902	0.524	3.0	4.6	12
Importance scientific reasoning	4.777	0.410	4.0	5.0	12
Importance presentation skills	4.375	0.611	3.0	5.0	12
Importance debating skills	4.736	0.411	4.0	5.0	12
Importance English skills	3.319	1.092	2.0	5.0	12
General importance soft skills	4.226	0.415	3.2	4.8	12
Proficiency (post-prep) teamwork	4.138	0.673	3.0	5.0	12
Proficiency (post-prep) independent research	3.486	0.862	2.0	5.0	12
Proficiency (post-prep) scientific reasoning	4.106	0.789	3.0	5.0	11
Proficiency (post-prep) presentation skills	4.000	0.738	3.0	5.0	12
Proficiency (post-prep) debating skills	4.097	0.871	2.5	5.0	12
Proficiency (post-prep) English skills	4.347	0.865	2.5	5.0	12
Development teamwork	2.319	0.746	1.0	3.0	12
Development independent research	2.319	0.533	1.5	3.0	12
Development scientific reasoning	2.750	0.405	2.0	3.0	12
Development presentation skills	2.513	0.457	2.0	3.0	12
Development debating skills	2.722	0.422	2.0	3.0	12
Development English skills	1.694	0.895	1.0	3.0	12
General development soft skills	2.386	0.379	1.8	3.0	12

Appendix E: Descriptive statistics on variables

Table 5: Descriptive Statistics on Variables (Schweighart, 2021)

Variable	Mean	Std. Dev.	Min	Max
age	16.42	1.10	15	18
importance_teamwork	4.40	0.95	1	5
importance_research	3.83	0.51	3	4.666667
importance_reasoning	4.78	0.40	4	5
importance_presentation	4.48	0.54	3	5
importance_debating	4.81	0.34	4	5
importance_english	3.40	1.09	2	5
importance_problem_solving	4.49	0.50	4	5
importance_self_learning	4.18	0.63	3	5
importance_creativity	3.87	0.99	3	5
h_prep_AYPT	95.58	67.30	30	208.3333
total_h_prep_supervised	45.05	48.90	0	130
total_h_prep_after_Febr	50.57	28.05	8.5	100
n_prep_sessions_by_teacher	11.51	11.12	0	30
ave_n_students_present_per_sessions	3.69	3.63	0	15
prof_post_teamwork	4.22	0.65	3	5
prof_post_research	3.41	0.81	2	5
prof_post_reasoning	4.12	0.72	3	5
prof_post_presentation	4.01	0.75	3	5
prof_post_debating	4.01	0.83	2.5	5
prof_post_english	4.29	0.86	2.5	5
prof_post_problem_solving	4.07	0.64	3	5
prof_post_self_learning	3.43	0.46	3	4
prof_post_creativity	3.82	0.81	3	5
prof_prae_teamwork	3.57	0.87	2	5
prof_prae_research	2.86	0.85	2	4
prof_prae_reasoning	2.70	0.89	1	4
prof_prae_presentation	3.63	0.85	2	5
prof_prae_debating	3.19	0.93	2	4
prof_prae_english	3.60	1.23	1	5
prof_prae_problem_solving	3.27	1.12	1	4
prof_prae_self_learning	2.95	0.75	2	4
prof_prae_creativity	3.63	0.77	3	5
helpful_participation_career	4.46	1.18	1	5
preparation_helped_content_knowledge	3.00	0.00	3	3
dev_teamwork	2.32	0.75	1	3
dev_research	2.35	0.53	1.5	3
dev_reasoning	2.80	0.36	2	3
dev_presentation	2.56	0.45	2	3
dev_debating	2.78	0.38	2	3
dev_english	1.73	0.89	1	3
dev_problem_solving	2.62	0.49	2	3
dev_self_learning	2.19	0.63	1	3
dev_creativity	2.06	0.74	1	3

Appendix F: Regression results for importance of soft skills

Table 6: Regression Results for General Importance of Soft Skills (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-4.5146	4.6921	-4.1114	2.2143
	(1.196)	(0.936)	(1.195)	(0.771)
	[0.000173]	[0.000001]	[0.001]	[0.004]
General importance soft skills	0.6473	0.9148	0.7892	0.9916
	(0.168)	(0.183)	(0.162)	(0.179)
	[0.00013]	[0.000001]	[0.000001]	[0.000]
Age	0.5836		0.5365	
	(0.053)		(0.051)	
	[0.000]		[0.000]	
Year 2021 (x)	0.4347	-0.0444		
	(0.145)	(0.152)		
	[0.003]	[0.770]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.128)	(0.140)	(0.128)	
	[0.045]	[0.067]	[0.046]	
Reviewer (x)	0.4181	0.4181	0.5489	
	(0.152)	(0.166)	(0.146)	
	[0.006]	[0.012]	[0.000182]	
Juror Bias	0.9672		0.9601	
	(0.149)		(0.150)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.2629	-0.3292	-0.2553	
	(0.071)	(0.078)	(0.071)	
	[0.000]	[0.000001]	[0.000372]	
Adjusted R^2	0.228	0.072	0.220	0.036

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Table 7: Regression Results for Importance of Individual Soft Skills (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-4.9897	-2.5344	-7.4135	-6.9799
	(1.510)	(1.292)	(1.532)	(1.257)
	[0.001]	[0.050]	[0.000002]	[0.000]
Importance teamwork	1.6635	1.9093	0.7841	0.9731
	(0.178)	(0.158)	(0.141)	(0.121)
	[0.000]	[0.000]	[0.000]	[0.000]
Importance independent research	2.1286	2.2570	0.9378	0.9863
	(0.219)	(0.220)	(0.161)	(0.164)
	[0.000]	[0.000]	[0.000]	[0.000]
Importance scientific reasoning	0.8897	1.1262	0.8258	1.0300
	(0.182)	(0.154)	(0.189)	(0.163)
	[0.000001]	[0.000]	[0.000014]	[0.000]
Importance presentation skills	-2.6363	-2.9906	-0.7536	-0.8618
	(0.342)	(0.326)	(0.248)	(0.233)
	[0.000]	[0.000]	[0.002]	[0.000237]
Importance debating skills	1.0368	1.0501	1.1844	1.2940
	(0.234)	(0.242)	(0.242)	(0.258)
	[0.000011]	[0.000016]	[0.000001]	[0.000001]
Importance English skills	-0.9365	-1.0651	-0.4507	-0.5614
	(0.105)	(0.092)	(0.086)	(0.075)
	[0.000]	[0.000]	[0.000]	[0.000]
Age	0.1712		0.2323	
	(0.070)		(0.072)	
	[0.014]		[0.001]	
Year 2021 (x)	1.8823	1.9511		
	(0.244)	(0.251)		
	[0.000]	[0.000]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.118)	(0.122)	(0.122)	
	[0.030]	[0.036]	[0.036]	
Reviewer (x)	0.4181	0.4181	0.5882	
	(0.140)	(0.145)	(0.144)	
	[0.003]	[0.004]	[0.000046]	
Juror Bias	1.0094		1.0095	
	(0.138)		(0.143)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.3827	-0.4518	-0.2732	
	(0.072)	(0.072)	(0.073)	
	[0.000]	[0.000]	[0.000196]	
Adjusted R^2	0.340	0.291	0.291	0.188

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Table 8: Regression Results for Importance of Individual Soft Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-8.86	1.41	-6.30	0.00000000
tournamentAYPT2021	1.61	0.25	6.39	0.00000000
roleRep	0.26	0.12	2.07	0.03915244
roleRev	0.67	0.15	4.57	0.00000555
age	0.27	0.07	3.87	0.00011965
importance_teamwork	1.46	0.18	8.00	0.00000000
importance_research	1.99	0.23	8.69	0.00000000
importance_reasoning	0.58	0.18	3.15	0.00171139
importance_presentation	-2.20	0.35	-6.31	0.00000000
importance_debating	1.08	0.25	4.40	0.00001239
importance_english	-0.81	0.11	-7.52	0.00000000

Table 9: Regression Results for Importance of Individual (New) Soft Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-3.99	1.56	-2.55	0.01092850
roleRep	0.36	0.15	2.41	0.01618754
roleRev	0.73	0.15	4.86	0.00000153
age	0.34	0.20	1.68	0.09278475
importance_problem_solving	0.84	0.45	1.88	0.06060011
importance_self_learning	0.31	0.14	2.25	0.02503817
importance_creativity	-0.10	0.09	-1.18	0.23871505

Appendix G: Regression results for development of soft skills

Table 10: Regression Results for the General Development of Soft Skills (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-1.8209	8.2783	-0.6735	5.8802
	(1.069)	(0.688)	(1.051)	(0.453)
	[0.089]	[0.000]	[0.522]	[0.000]
General development soft skills	-0.2993	0.1346	-0.1163	0.2402
	(0.171)	(0.185)	(0.168)	(0.185)
	[0.080]	[0.467]	[0.489]	[0.195]
Age	0.6291		0.5545	
	(0.054)		(0.052)	
	[0.000]		[0.000]	
Year 2021 (x)	0.6507	0.1284		
	(0.144)	(0.152)		
	[0.000007]	[0.397]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.129)	(0.142)	(0.130)	
	[0.046]	[0.071]	[0.049]	
Reviewer (x)	0.4181	0.4181	0.6188	
	(0.153)	(0.169)	(0.148)	
	[0.006]	[0.013]	[0.000032]	
Juror Bias	0.9928		0.9798	
	(0.150)		(0.152)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.2786	-0.3479	-0.2690	
	(0.072)	(0.079)	(0.072)	
	[0.000108]	[0.000012]	[0.000219]	
Adjusted R^2	0.217	0.043	0.197	0.001

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Table 11: Regression Results for the Development of Individual Soft Skills (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-9.5255	5.6875	-5.0705	3.1175
	(1.242)	(0.789)	(1.167)	(0.661)
	[0.000]	[0.000]	[0.000016]	[0.000003]
Development teamwork	1.6261	0.2036	0.8883	0.1286
	(0.175)	(0.166)	(0.157)	(0.164)
	[0.000]	[0.221]	[0.000]	[0.435]
Development independent research	-0.3376	-0.2721	-0.5505	-0.1532
	(0.192)	(0.222)	(0.199)	(0.222)
	[0.080]	[0.221]	[0.006]	[0.490]
Development scientific reasoning	3.4105	1.6816	2.9327	1.3316
	(0.321)	(0.345)	(0.329)	(0.347)
	[0.000]	[0.000001]	[0.000]	[0.000137]
Development presentation skills	-3.0370	-0.4012	-1.8665	-0.2027
	(0.357)	(0.358)	(0.342)	(0.363)
	[0.000]	[0.263]	[0.000]	[0.577]
Development debating skills	-1.6347	0.2689	-0.3484	0.3088
	(0.259)	(0.260)	(0.216)	(0.238)
	[0.000]	[0.301]	[0.108]	[0.196]
Development English skills	0.2993	-0.3835	-0.0712	-0.3849
	(0.122)	(0.130)	(0.118)	(0.131)
	[0.014]	[0.003]	[0.546]	[0.003]
Age	1.0123		0.6631	
	(0.070)		(0.058)	
	[0.000]		[0.000]	
Year 2021 (x)	1.5442	-0.1046		
	(0.186)	(0.171)		
	[0.000]	[0.542]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.118)	(0.136)	(0.123)	
	[0.029]	[0.060]	[0.037]	
Reviewer (x)	0.4181	0.4181	0.6558	
	(0.140)	(0.162)	(0.142)	
	[0.003]	[0.010]	[0.000005]	
Juror Bias	1.0015		1.0038	
	(0.137)		(0.143)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.3843	-0.4278	-0.3904	
	(0.067)	(0.077)	(0.070)	
	[0.000]	[0.000]	[0.000]	
Adjusted R^2	0.346	0.124	0.289	0.075

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Table 12: Regression Results for the Development of Individual Soft Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-11.53	1.87	-6.15	1.43601772E-09
roleRep	0.36	0.15	2.48	0.01342152
roleRev	0.73	0.15	5.00	0.00000078
age	0.99	0.07	13.67	4.94349863E-37
dev_teamwork	0.86	0.26	3.29	0.00106516
dev_research	-0.69	0.23	-2.96	0.00317238
dev_reasoning	2.63	0.68	3.88	0.00011848
dev_presentation	-1.80	0.55	-3.29	0.00106810
dev_debating	-0.49	0.31	-1.60	0.10919536

Table 13: Regression Results for the Development of Individual (New) Soft Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-4.67	1.34	-3.48	0.00053119
roleRep	0.36	0.15	2.43	0.01539813
roleRev	0.73	0.15	4.89	0.00000128
age	0.77	0.09	8.87	8.91420530E-18
dev_problem_solving	-0.45	0.23	-1.96	0.05034733
dev_self_learning	0.15	0.22	0.69	0.48779323
dev_creativity	-0.42	0.16	-2.65	0.00828371

Appendix H: Regression results for proficiency in teamwork

Table 14: Regression Results for Proficiency in Teamwork (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-2.2246	7.8149	-3.4024	5.2867
	(1.104)	(0.732)	(0.916)	(0.413)
	[0.044]	[0.000]	[0.000217]	[0.000]
Proficiency (post-prep) teamwork	0.0016	0.1537	0.1601	0.2783
	(0.092)	(0.100)	(0.088)	(0.097)
	[0.986]	[0.125]	[0.070]	[0.004]
Age	0.6103		0.5573	
	(0.054)		(0.052)	
	[0.000]		[0.000]	
Year 2021 (x)	0.5903	0.0947		
	(0.145)	(0.153)		
	[0.000052]	[0.536]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.129)	(0.142)	(0.131)	
	[0.047]	[0.071]	[0.051]	
Reviewer (x)	0.4181	0.4181	0.5861	
	(0.153)	(0.169)	(0.149)	
	[0.006]	[0.013]	[0.000090]	
Juror Bias	0.9813		0.9907	
	(0.150)		(0.153)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.2749	-0.3223		
	(0.073)	(0.081)		
	[0.000196]	[0.000073]		
Adjusted R^2	0.214	0.046	0.187	0.009

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Appendix I: Regression results for proficiency in English skills

Table 15: Regression Results for Proficiency in English Skills (Poier, 2021)

	Model 1	**Model 2**	**Model 3**	**Model 4**
(Intercept)	-2.3206	6.1942	6.6406	4.5729
	(1.024)	(0.581)	(0.549)	(0.315)
	[0.024]	[0.000]	[0.000]	[0.000]
Proficiency (post-prep) English skills	0.4241	0.6081	0.5241	0.4408
	(0.071)	(0.074)	(0.069)	(0.072)
	[0.000]	[0.000]	[0.000]	[0.000]
Age	0.5201			
	(0.054)			
	[0.000]			
Year 2021 (x)	0.8096	0.5548		
	(0.142)	(0.151)		
	[0.000]	[0.00026]		
Opposition (x)	-0.2567	-0.2567	-0.2567	
	(0.126)	(0.136)	(0.134)	
	[0.042]	[0.060]	[0.056]	
Reviewer (x)	0.4181	0.4181	0.5965	
	(0.150)	(0.162)	(0.152)	
	[0.005]	[0.010]	[0.000099]	
Juror Bias	0.9931		0.9844	
	(0.147)		(0.156)	
	[0.000]		[0.000]	
Comp_Avg_Grade	-0.3362	-0.4269	-0.3830	
	(0.071)	(0.076)	(0.075)	
	[0.000003]	[0.000]	[0.000]	
Adjusted R^2	0.247	0.118	0.146	0.044

(x) Dummy variables
The table shows the coefficients, the standard deviations in round brackets, and the p-values in square brackets.

Appendix J: Regression results for comparison between IBL and regular physics class

Table 16: Regression Results for Proficiency after Preparation Phase in 2020 (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-2.42	1.67	-1.45	0.14684470
tournamentAYPT2021	1.22	0.21	5.73	0.00000001
roleRep	0.29	0.14	2.13	0.03331587
roleRev	0.66	0.17	4.01	0.00006743
age	0.36	0.11	3.31	0.00097471
prof_post_teamwork	-0.14	0.19	-0.76	0.44499886
prof_post_research	-0.01	0.11	-0.06	0.95270594
prof_post_reasoning	0.47	0.23	2.09	0.03661578
prof_post_presentation	-1.00	0.33	-3.07	0.00225924
prof_post_debating	0.48	0.26	1.87	0.06169911
prof_post_english	0.58	0.10	5.86	0.00000001

Table 17: Regression Results for Proficiency before Preparation Phase in 2021 (Schweighart, 2020)

term	estimate	std.error	statistic	p.value
(Intercept)	-5.87	2.66	-2.20	0.02789855
roleRep	0.36	0.15	2.48	0.01342152
roleRev	0.73	0.15	5.00	0.00000078
age	0.79	0.15	5.37	0.00000011
prof_prae_teamwork	-0.92	0.29	-3.21	0.00139121
prof_prae_research	-0.13	0.11	-1.17	0.24442857
prof_prae_reasoning	-0.03	0.27	-0.13	0.89899302
prof_prae_presentation	0.74	0.41	1.81	0.07114430
prof_prae_debating	0.07	0.30	0.25	0.80597444
prof_prae_english	-	-	-	-

Appendix K: Regression results for hours spent preparing

Table 18: Regression Results for Hours Spent Preparing (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-5.77	0.97	-5.97	3.66E-09
tournamentAYPT2021	0.51	0.15	3.50	0.00050284
roleRep	0.34	0.14	2.52	0.01183890
roleRev	0.65	0.17	3.94	0.00008833
age	0.66	0.06	11.88	7.83E-30
h_prep_AYPT	0.01	0.00	7.86	1.39E-14

Appendix L: Regression Results for Individual Soft Skills

Table 19: Regression Results for Problem-Solving Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	10.98	3.04	3.61	0.00033003
roleRep	0.36	0.15	2.48	0.01336641
roleRev	0.73	0.15	5.00	0.00000077
age	-1.31	0.36	-3.63	0.00030906
importance_problem_solving	4.47	0.75	5.97	0.00000000
prof_post_problem_solving	0.15	0.11	1.34	0.18179661
prof_prae_problem_solving	-0.81	0.13	-6.05	2.57959819E-09
dev_problem_solving	-0.59	0.19	-3.03	0.00259591

Table 20: Regression Results for Teamwork (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-4.88	0.91	-5.35	0.0000001
roleRep	0.36	0.15	2.47	0.0139858
roleRev	0.73	0.15	4.97	0.0000009
age	0.83	0.06	13.25	0.0000000
importance_teamwork	-0.44	0.21	-2.13	0.0339140
prof_post_teamwork	0.21	0.20	1.03	0.3049109
prof_prae_teamwork	-0.29	0.08	-3.90	0.0001067
dev_teamwork	-0.09	0.19	-0.49	0.6244983

Table 21: Regression Results for Independent Research Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	0.45	1.48	0.30	0.76315062
roleRep	0.36	0.15	2.47	0.01396031
roleRev	0.73	0.15	4.97	0.00000090
age	0.36	0.09	4.08	0.00005105
importance_research	1.32	0.30	4.36	0.00001566
prof_post_research	-2.16	0.40	-5.34	0.00000013
prof_prae_research	-0.85	0.13	-6.31	0.00000000
dev_research	1.86	0.37	5.07	0.00000054

Table 22: Regression Results for Scientific Reasoning Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-6.90	1.74	-3.96	0.00008648
roleRep	0.43	0.15	2.79	0.00548096
roleRev	0.73	0.15	4.74	0.00000281
age	0.60	0.12	5.05	0.00000063
importance_reasoning	1.07	0.21	4.99	0.00000082
prof_post_reasoning	-0.31	0.13	-2.40	0.01676674
prof_prae_reasoning	-0.23	0.15	-1.59	0.11145954
dev_reasoning		-	-	-

Table 23: Regression Results for Presentation Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-5.27	1.23	-4.30	0.00001970
roleRep	0.36	0.15	2.41	0.01620572
roleRev	0.73	0.15	4.86	0.00000154
age	0.85	0.06	13.53	0.00000000
importance_presentation	-0.33	0.16	-2.09	0.03738902
prof_post_presentation	0.18	0.09	1.94	0.05304621
prof_prae_presentation	-0.26	0.08	-3.21	0.00139855
dev_presentation	-0.22	0.14	-1.66	0.09803643

Table 24: Regression Results for Debating Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-6.76	2.35	-2.88	0.00416394
roleRep	0.36	0.15	2.48	0.01334130
roleRev	0.73	0.15	5.00	0.00000076
age	0.91	0.07	12.74	0.00000000
importance_debating	0.33	0.59	0.57	0.56850407
prof_post_debating	0.24	0.12	2.02	0.04340459
prof_prae_debating	-0.23	0.07	-3.18	0.00152770
dev_debating	-1.27	0.23	-5.58	0.00000004

Table 25: Regression Results for English Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-6.83	0.93	-7.32	8.60960724E-13
roleRep	0.36	0.15	2.48	0.01336348
roleRev	0.73	0.15	5.00	0.00000077
age	0.70	0.05	13.09	0.00000000
importance_english	-0.63	0.12	-5.35	0.00000013
prof_post_english	0.28	0.14	2.01	0.04511322
prof_prae_english	0.45	0.15	2.93	0.00356195
dev_english	0.57	0.14	4.00	0.00007181

Table 26: Regression Results for Self-Directed Learning Skills (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-4.34	1.27	-3.43	0.00066314
roleRep	0.27	0.16	1.70	0.09061880
roleRev	0.67	0.16	4.30	0.00002100
age	0.72	0.10	6.86	0.00000000
importance_self_learning	0.25	0.12	2.14	0.03324166
prof_post_self_learning	0.25	0.22	1.16	0.24804051
prof_prae_self_learning	-0.58	0.11	-5.07	0.00000056
dev_self_learning	-0.64	0.23	-2.83	0.00478459

Table 27: Regression Results for Creativity (Schweighart, 2021)

term	estimate	std.error	statistic	p.value
(Intercept)	-5.38	1.31	-4.10	0.00004647
roleRep	0.36	0.15	2.46	0.01432018
roleRev	0.73	0.15	4.95	0.00000098
age	0.75	0.06	12.99	0.00000000
importance_creativity	-0.03	0.11	-0.29	0.77473688
prof_post_creativity	0.55	0.18	3.05	0.00235545
prof_prae_creativity	-0.35	0.12	-2.94	0.00346858
dev_creativity	-0.64	0.26	-2.51	0.01249636