Collaborative Online International Learning (COIL)

Project Proposal 2021/2022

Tittle of the COIL project:

"Boosting mathematical reasoning across borders"

Contact person of the project:

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HRW

Collaborative Online International Learning (COIL) Project Proposal from the Faculty of Natural Sciences – Hochschule Ruhr West (HRW), University of Applied Sciences

COIL Project Title: Boosting Mathematical Reasoning across Borders

COIL Project Overview

This project is framed within the scheme "HRW goes COIL" that aims to further develop the internationalisation strategy of the HRW and which is financially supported by the German Academic Exchange Service (DAAD).

The COIL pilot project "Boosting Mathematical Reasoning across Borders" focuses on the use of the award-winning MathWeb online platform, developed by Prof. Dr. Giebermann at the HRW.

This project overview is summarized in the following table:

COIL Project Overview	
Project leader from HRW	Prof. Dr. Klaus Giebermann
Faculty/ Discipline of the proposal´s project leader at HRW	Faculty of Natural Sciences/Applied Mathematics
Contact project leader from HRW	**Affiliation:** Faculty of Natural Sciences, University of Applied Sciences Hochschule Ruhr West. Duisburger Str. 100, 45479 Mülheim an der Ruhr, Building 01 **e-mail address:** Klaus.Giebermann@hs-ruhrwest.de
Subject	Fundamentals of Mathematics
Module	One or several modules (depending on the curriculum overlap), ranging from quadratic equations to the solution of odes using Laplace-transform
Level of study of participants	Undergraduate, first year, first/second semester. Focused to students requiring fundamental mathematical knowledge
Number of participants	10-15 from each university (depends on enrolment interest)
Faculty/ Subjects of the ideal partner university	Fundamental Mathematics for Engineering or related disciplines

The above-named project is an international academic collaboration project, funded by the German Ministry of Education and Research through the German Academic Exchange Service (DAAD) within the scope of the COIL (Collaborative Online Intercultural Learning) program.

DAAD Deutscher Akademischer Austauschdienst
German Academic Exchange Service

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Aims of the COIL Project

By participating in this COIL project, students will be globally engaged since an early career stage and will expand new approaches to digital and collaborative education, learning mathematics in a more dynamic, interactive and motivating context, at the same time that they develop a wide set of competences and skills of great value for their incorporation in the job market.

COIL Project Structure and Organization

We envision that the COIL project will mostly take place through virtual exchange among students, who will work in groups along a defined period of time. The online collaboration could be supplemented by a physical exchange of students (blended project). The overall functioning scheme of the COIL project will be "tailor-made", according to the curriculum overlap, the number of participants and the needs of both participating institutions.

Within the frame of this COIL project, the use of MathWeb is conceived as a supplemental tool for lectures and other learning activities, in which the mathematical content is previously provided.

Students from both universities will team up to explain to their peers the logical path to solve a specific mathematical type of tasks and they will cooperate via MathWeb and other digital tools to solve multiple exercises.

The scope is to create positive interdependence between teams, to foster the interaction among students and to guarantee that they are not only able to solve mathematical exercises, but also to understand the logical behind the resolution paths.

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COIL Project Title:

Boosting Mathematical Reasoning across Borders

Project Leader from HRW:

Prof. Dr. Giebermann

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1. Background Information

What is COIL?

Collaborative Online International Learning (COIL) is a teaching and learning model that promotes intercultural exchange and the acquisition of competences across shared learning environments. In particular, this concept allows professors and students of the same or different disciplines to collaborate with peers from different lingual and cultural backgrounds around the world, through the use of a variety of Internet-based technological tools and pedagogic platforms (1, 2, 6).

COIL usually involves a structured cooperation between at least two faculty members who teach similar courses at a college level (1). Over the course of a COIL experience, students collaborate during a defined period of time (few weeks to an entire semester) through a common learning tool to develop a project and/or solve a given problem, while exchanging their ideas, knowledge and cultural perspectives (1).

This virtual learning experience fosters the development of not only intercultural competences (skills that facilitate effective interactions among people from different cultures), but also of an open communication philosophy and a full set of competences that shape students into young professionals prepared to faced the challenges of the current globalized job market (2, 6, 7).

What are the benefits of COIL courses?

Engaging in COIL projects constitutes a unique manner for enhancing internationalization at higher education institutions (1). COIL enables education to be more adaptive, involving, interesting and creative, while providing students with a first opportunity to engage with peers across different cultures, languages and geographical distance. For many students, a COIL collaboration constitutes the first opportunity to interact in a cross-cultural environment (7). Nowadays, the acquisition of intercultural competences and global thinking skills is crucial for a successful incorporation into the labour market. Such competences are easier to develop through experiential learning, rather than in a traditional classroom or lecture setting. However, physical mobility programs, such as ERASMUS, are prohibitive to students who are place-bound, or due to time and/or budget limitations, among others. Yet, participating in a COIL project is a cost-effective alternative within reach of every student and institution, since such projects involve virtual learning settings with minimal costs (1, 2, 5).

Besides the reduced costs of the COIL projects -as compared to other forms of intercultural exchange -, due to the Covid-19 pandemic universities have been forced to accelerate their digital infrastructure. Moreover, students are nowadays more familiar with digital learning platforms and communication tools than before. As a result, universities do not have to devote major resources for the implementation of COIL courses, since many of the tools used by them are already in play (3, 5)

Additional advantages of COIL courses for students is that such courses stimulate the development of a set of skills (such as cross-cultural communication, team working and leadership abilities, critical thinking, conflict resolution, media/digital competence, project and time management skills) and enable students to create an international learning community and combine different ways of thinking to find a solution to a common problem, while reflecting on cultural differences and expanding their own worldview (1, 2, 7).

Besides the multiple benefits for students, the implementation of COIL courses also has advantages for academics, as well as for the universities and/or institutions. Professors will equally benefit from acquiring international competences and ideally establishing long-term collaboration partners. Furthermore, by working together with other professors, they will obtain new methods, materials and/or tools to apply in their own courses and they will gain new perspectives on how their discipline is taught in other countries, helping them to design more effective learning environments.

In addition, by participating in COIL projects, universities benefit in several aspects. First, as already mentioned, COIL courses are a cost-effective way to ensure that students are globally engaged and increase their opportunities for job market assessment; second, these virtual experiences create added value and promote the internationalisation of the universities, and therefore their visibility; and third, engaging in successful COIL projects contributes to the sustainability of current collaborations and enables universities to acquire new partners for future collaborations.

2. COIL Project Overview

The project entitled “Boosting Mathematical Reasoning across Borders” is a COIL project framed within the scheme “HRW goes COIL” financially supported by the German Academic Exchange Service (DAAD, “Deutscher Akademischer Austauschdienst”). The project “HRW goes COIL” aims to further develop in a structured and systematic manner the internationalisation strategy of the Hochschule Ruhr West. The Hochschule Ruhr West (HRW) is a young University of Applied Sciences located in the Ruhr area, which offers Bachelors and Masters programs within a broad range of engineering, informatics, economy and natural science disciplines.

This COIL pilot project is focused on the use of the award-winning MathWeb online platform, developed by Prof. Dr. Giebermann at the HRW. Specifically, this COIL project aims to create learning opportunities in the discipline of mathematics for students in their early semesters through virtually-based collaborations with global peers, as well as to create accessible ways to connect with other students, while learning the fundamental of mathematics for engineering -or similar-disciplines. Students that participate in this COIL pilot project will cooperate to solve tasks given by MathWeb in a collaborative way.

This project overview is summarized in Table 1:

COIL Project Overview	
Level of study of participants	Undergraduate, first year, first/second semester. Focused to students requiring fundamental mathematical knowledge
Subject	Fundamentals of Mathematics Module: one/several modules (see Modules encompassed by MathWeb, Table 2), depending on the curriculum overlap
Faculty/ Discipline of the proposal´s project leader at HRW	Faculty of Natural Sciences/Applied Mathematics
Faculty/ Subjects of the ideal partner university	Fundamental Mathematics for Engineering and/or related disciplines

Table 1. "Boosting Mathematical Reasoning across Borders" COIL Project Overview

For more specific information, see below (point 4).

3. Aims of the COIL project

Students from both universities will collaborate online by using the MathWeb virtual platform to solve tasks corresponding to several mathematical modules of fundamental mathematics taught in engineering studies-or related- disciplines.

This COIL project aims to equip students with the knowledge and skills needed to solve a wide range of mathematical tasks and develop critical thinking skills. The main objective is to create learning environments to broaden and deepen the knowledge of participants, while building successful intercultural relationships through academic and personal engagement.

Moreover, by collaboratively learning, students will engage with other cultural perspectives, will be globally involved and will expand new approaches to digital learning, experiencing learning mathematics in a more dynamic and motivating context. An additional goal of this COIL project is to further expand internationalization and encourage students since their early academic stage to seek opportunities for studying and/or working abroad.

4. COIL Project Structure

Title

Boosting Mathematical Reasoning across Borders

Project Description

The underlying motivation for this project is to make students aware than mathematics is much more than just achieving the right answer. This discipline constitutes an example in which the path to the solution is as important as the solution itself. With the execution of this COIL project, we want to encourage students to apply critical thinking in order to judge the correctness of a solution procedure.

We also intend that by the collaborative and international work, students are able to come across with other ways to solve given exercises. Both, critical thinking skills and the capacity of "thinking outside the box", are vital competences for the later job market, especially for the engineering field. Thus, this COIL project aims to boost such skills by encouraging students from the very beginning of their studies to examine their and other's solution paths.

Over the course of this COIL project, students from HRW and the partner university will team up to explain to their peers the logical path to solve tasks related to several mathematical areas. This didactic activity will be followed by the student's cooperation to solve multiple exercises via the MathWeb tool. This online-based tool contains a pool of mathematical exercises covering a wide range of mathematical topics (see below, Table 2) and includes for each exercise an explanation or template solution and the corrected result.

The MathWeb virtual tool includes exercises of the following mathematical subjects:

Fundamentals/Basics		**Functions and polynomials**	
- Basic algebra, solution of equations and inequalities	- Trigonometry	- Definition of functions and their properties (continuity) - Inverse functions	- Special functions (*i.e.* polynomials, trigonometric, exponential) - Horner scheme - L'Hospital rule
Basic linear algebra		**Analytic geometry**	
- Vectors, matrices - Linear equations - Matrix algebra	- Determinant of a matrix - Eigenvalues and Eigenvectors	- Lines and planes in space - Intersections	- Distance - Angles
Calculus		**Complex analysis**	
- Definition of derivative - Extreme value tasks	- Taylor polynomials - Taylor series	- Definition of C (complex numbers) - Cartesian and polar representation of complex numbers	- Complex exponentials - Fundamental theorem of algebra
Calculus 2		**Multidimensional analysis**	
- Area under a curve - Antiderivative	- Rules to determine antiderivatives - Partial fraction decomposition	- Partial derivatives - Gradient - Hessian matrix	- Linear approximation - Extreme value tasks

<table>
<tr><th colspan="2">Multidimensional integration</th><th colspan="2">Ordinary differential equation</th></tr>
<tr><td>- Definition of multidimensional integration
- Integration w.r.t. normal domains</td><td>- Integration using parameter transformation (polar, spherical)
- Applications: Area, volume, mass, centre of gravity</td><td>- Definition of differential equation
- Initial value problems
- Separation of variables</td><td>- Linear ode of higher dimension
- Fundamental solutions/ general solution</td></tr>
<tr><th colspan="4">Integral transformation</th></tr>
<tr><td colspan="2">- Laplace: definition, forward transform, inverse transform, solution of ode with non-continuous right-hand side</td><td colspan="2">- Fourier series: definition, calculation of coefficients</td></tr>
</table>

Table 2. Mathematical topics encompassed within the MathWeb online tool

MathWeb allows the students to repeat mathematical tasks (parameterized exercises) as many times as wished, as well as to monitor their progress in an automatic manner. This online platform is equipped with interactive file cards that help students to learn step by step to solve mathematical exercises of increased complexity. Thanks to the so called "traffic light system" students can gain an overview about their learning process and those concepts that need to be reinforced.

Students of the HRW and other German universities have demonstrated that the use of this program efficiently supports the learning development of students, as reflected by a decreased fail rate in the final exams (3). In addition to the improved performance of students, the participation in this COIL project does not require any expensive technology platform or redesign of the course; professors do not need to implement major changes to their lectures and the project can be adapted to the needs of both universities, as well as to their curriculum overlap. The use of MathWeb is conceived as a supplemental tool for lectures and other learning activities, in which the mathematical content is previously provided. This web-based tool enables the rehearsing and the automatic correction of a vast pool of exercises, which decreases the load of correcting and the tutoring hours for academics.

Objective

Students from both universities will engage with peers from geographically distant universities and use the MathWeb tool to strengthen and broaden their knowledge of fundamentals of mathematics, by applying their skills to solve exercises that are automatically generated and checked. The main scope is that students consolidate their knowledge on fundamentals mathematics by sharing information and learning to explain and solve mathematical tasks in a collaborative manner. Throughout this COIL project, students will develop mathematical reasoning, argumentation paths and explain exercises to peers. An additional goal of this COIL project is to provide students and lecturers with an opportunity to learn how mathematics are taught in other universities around the world and study mathematics in a more relaxed environment, while getting short-term feedback of their progress thanks to the automatization via the MathWeb tool.

Method and/or platform used

This COIL project will mostly take place by virtual exchange among the students. However, a blended or hybrid project, in which the online collaboration is supplemented by a physical exchange of the students -blended course- (*i.e.* students of the HRW visit the partner university and vice versa) is also possible. The decision regarding the scheme of the project (completely online or blended program) and the setup (synchronous or asynchronous) will be decided between both partner institutions, after aligning their courses and project outcomes

This COIL project will mainly be focused on the use of the already existing MathWeb online platform. Partner universities will have access to this tool without needing to change their current e-learning facilities or Learning Management System -LMS- (such as Moodle). Students and academic members will use additional software, and/or technological tools to improve their collaboration and facilitate the exchange among them, depending on their needs and preferences. Some examples of such tools are: G-Suite, collaborative edited documents (Google docs, Padlets, etc.), online communication technologies (videoconferencing programs such as Microsoft Teams, Skype, Cisco Webex, Zoom, etc.) and/or social media (Figure 1).

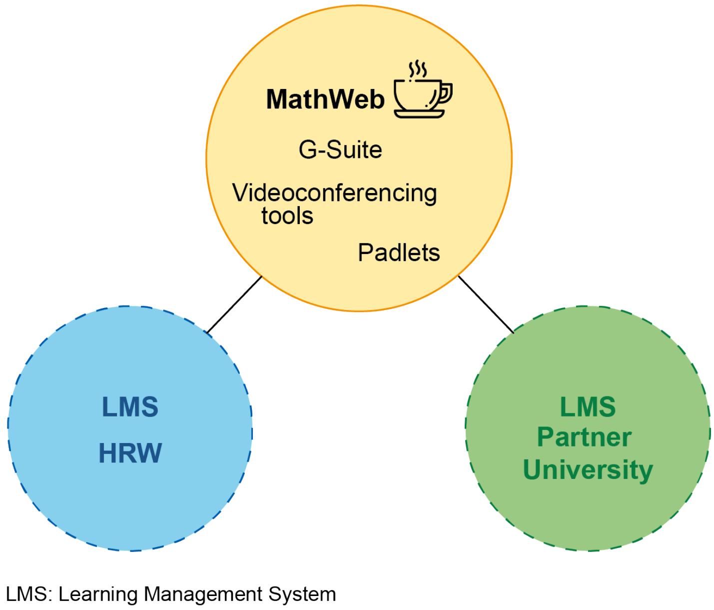

Figure 1. Digital tools for collaborative learning

Organization of the COIL project

Based on the learning overlap of the modules taught in the universities participating in this COIL project and their requirements, professors will decide whether the project will take place during an entire semester or part of it (for instance, as a project week).

At the beginning of the COIL project, guidance sessions will be given to students, in order that they learn to manipulate the MathWeb online tool. In addition, professors will provide students with a glossary in English compiling the mathematical terms, symbols and mathematical notation for each mathematical function used by this program.

We propose that students collaborate to solve mathematical problems of a specific subject, once the professors at each partner university have given their lectures corresponding to that particular topic (Figure 3). Therefore, the interplay among students and the use of MathWeb will be complementary to the usual lectures or teaching activities, which will help reinforcing the concepts taught at each institution. Students will then work in groups (depending on the number of students engaged). We would recommend group work, in which each group has two teams (namely Team A and Team B), with ideally at least 2 members in each team. These teams can be mixed (*i.e.* formed by members of both universities). However, during the pilot phase of the project, we would suggest starting with a simpler option, such as that each team is constituted by members of one single university. This team/group scheme can be easily adapted according to the numbers of participants in the project and upon agreement between professors at both institutions. A possible scheme for this team/group functioning is depicted in Figure 2.

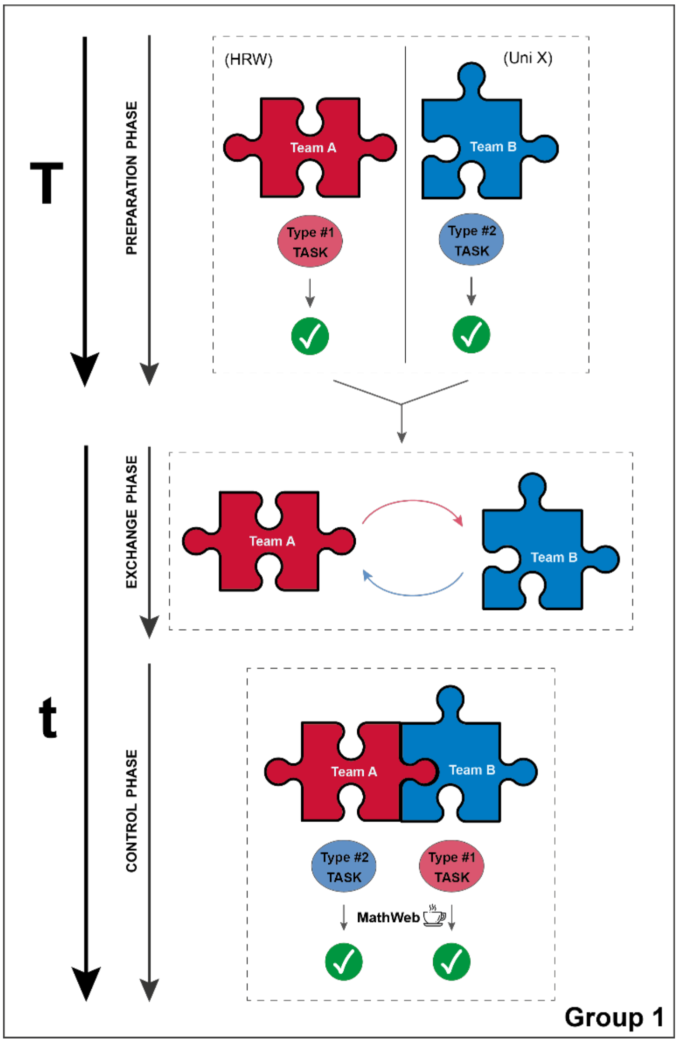

Figure 2. Example scheme of team functioning of the COIL project. "**T**" indicates a longer period of time to perform the activities; "**t**" indicates a relatively shorter period of time to complete the task.

In general, students will collaborate in three phases (see also Figure 3):

1. Preparation phase: students of Team A will be assigned a type of mathematical exercises, the resolution of which they will have to explain to the members of Team B. For this purpose, students will prepare short presentations or make use of interactive boards, or any other tool to clarify how to solve that kind of mathematical task.
2. Exchange phase: students of Team A will explain to Team B the path to solve that specific sort of mathematical tasks (without specific solution). The idea behind is that students are able to work together to understand a concept and find didactic ways to explain it to their peers. Students of Team B should also reflect in the argumentation of Team A, find possible flaws and/or reflect other ways to solve such mathematical tasks. Roles of Team A and Team B will be exchanged.
3. Evaluation and control phase: the main goal is that students work together to solve mathematical tasks given automatically via the MathWeb tool. The resolution of these exercises should aim to foster the interaction among students and to guarantee that students are able to understand the logical behind the resolution paths, as well as to solve mathematical exercises. Only when interaction among members of both teams take place, they will be able to reach the learning goal established by MathWeb and only then will they be given tasks of higher complexity. MathWeb enables that both the assignment of exercises and their correction occurs automatically.

With cooperative learning, the scope is for students to work together to maximize their own and each other's learning (1). The overall organisation of this COIL project scheme aims to guarantee that students from different teams rely on each other (positive interdependence) to better understand the resolution paths of diverse mathematical exercises, encouraging team work against individual work.

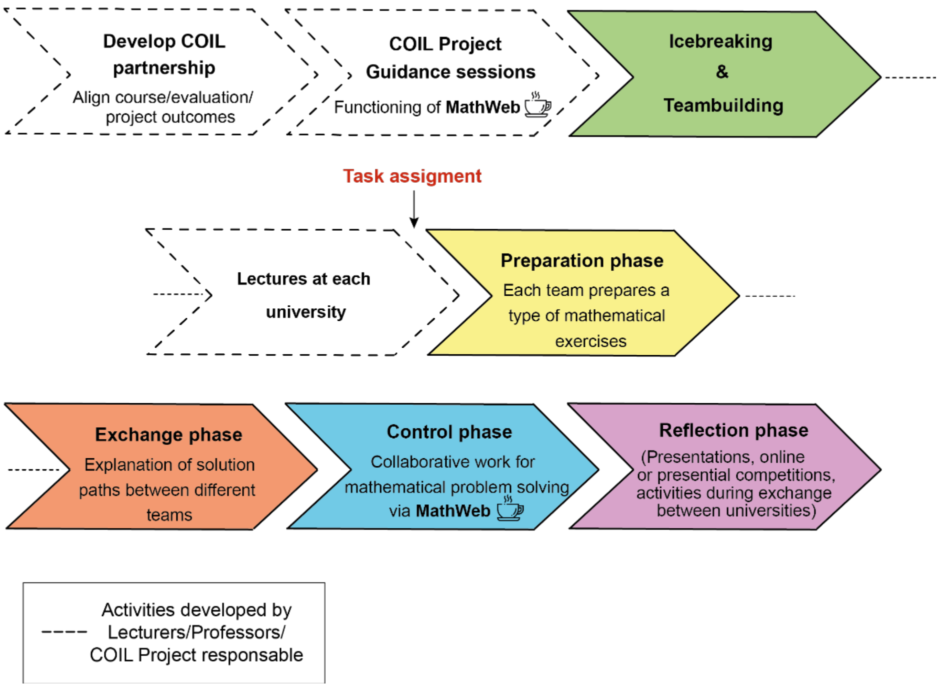

Figure 3. General structure and phases of the COIL project

Assessment of learning

Learning assessment will depend upon the modules and the scheme of the COIL project. Overall, the activities performed throughout the COIL project are conceived to be complementary to the course itself, and will therefore be evaluated according to the curriculum and the grading system of each participating university.

In general, throughout the COIL project, students will be able to self-assess the knowledge acquired and their progress, thanks to the "traffic light system" incorporated in the MathWeb tool. Students of each group will receive a relatively high number of tasks that they will need to solve together in a defined period of time. Once a percentage of correct tasks is reached, the traffic light will change colour and the next kind of exercises will be unlocked. Besides, the students will keep record of their meetings in order to create (either individually or in groups) a portfolio of evidence.

This automatic task correction could be complemented with activities that could encourage students to learn mathematics and make the learning process more dynamic and entertaining. One of such activities could be virtual competitions among students from different groups, in which they receive a random sample of mathematical tasks that they will need to solve in a limited amount of time. If a blended project is adopted, at the end of the COIL project students from both universities could take part in physical exchanges that could be combined with an on-site mathematical competition.

Evaluation method of the COIL project

Regarding evaluation, surveys and/or self-evaluation tasks will be conducted at different time points of the COIL experience for both, students and professors. Surveys before the COIL project will focus on the expectations of such learning experience, while surveys conducted after the COIL project will scope to assess whether the objectives of the project were achieved and the expectations met and if there is room for improvement.

Moreover, students will individually write a short report, reflecting critically on the interactions with other team members, the cross-cultural exchange and the effectiveness of the COIL project in acquiring the expected competences (2).

5. Learning Outcomes

The overall outcomes of the COIL project are (1, 4, 6, 7):

- Provide students with a cost-effective opportunity to interact with peers from different cultural backgrounds and increase awareness of the students to a multicultural and diverse world (*i.e.* promote interaction and working with a global lens)
- Develop intercultural competences (*i.e.* the ability to work effectively with people from different cultures, bridging cultural barriers)
- Promote foreign languages competences and confidence in speaking non-native languages

- Increase digital and media competences (*i.e.* the skills for a competent use of diverse virtual tools, as well as literature and information searching tools)
- Improve collaboration and communication skills (*i.e.* the competences such as team building and team work, effective and ordered exchange of ideas, cultural understanding, respect for diversity, conflict resolution and constructive communication)
- Enhance problem solving skills (*i.e.* the ability to solve a given task and more importantly, to combine different perspectives to find a common solution to a shared problem)
- Improve perseverance and motivational competences (*i.e.* the skills to work responsibly in a task and to motivate each other as part of a team with the same goal, including enduring unexpected problems)

In addition to the aforementioned learning outcomes, with the COIL Project "Boosting Mathematical Reasoning across borders" we pursue the following subject-specific competences (see also Figure 4):

- Provide students with an online and collaborative learning tool to solve mathematical problems
- Develop mathematical reasoning and the capacity to formulate logical mathematical argumentation chains
- Increase acquisition of and consolidate mathematical knowledge, by getting automatic and short-term feedback about the student progress, making the student more engaged with his/her own learning process, both individually and as a team
- Develop didactic skills; by working in teams and clarifying concepts to the other team, students will reinforce the concepts learned, while helping each other to understand mathematical notions
- Provide academics and students with tools for teaching/learning mathematics in a more engaging, relaxed and entertaining setting, while getting to know how mathematical concepts are explained in different cultures, sharing course material (1) and reflecting about practices in one own's country

Figure 4. General and subject-specific learning outcomes of the COIL project

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