

# **Collaborative Learning**

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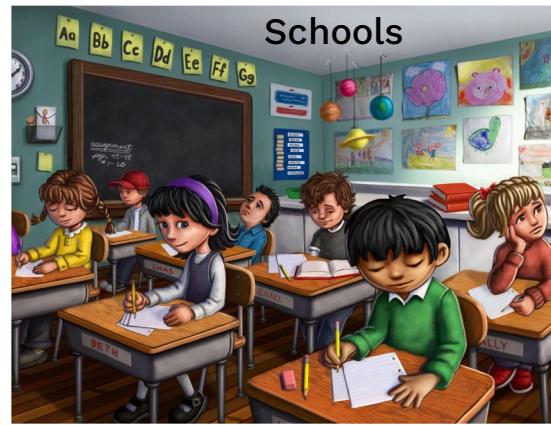
Collaborations with: Carme Roig, Juan Antonio Rodríguez, Bruno Rosell,  
Ewa Andrejczuk, Athina Georgara, Zhou Long, Alejandra López de Aberasturi,  
and others

# Motivation. Why teamwork?

- Teams help build strong bonds between its members.
- Teams enhance problem solving and allow new ideas to flourish.
- Teams improve productivity.
- Teams motivate the individuals and help them grow.



# Who needs human teams



# Our definition for education

**Collaborative Learning** is a pedagogical approach where students work together in small heterogeneous groups.

The objective of these groups is:

- to generate positive interdependence,
- to promote deeper and more meaningful learning,
- to encourage individual responsibility and
- to work on shared leadership to achieve a common goal.

# Positive interdependence

Positive interdependence exists when a member perceives that he is linked to others in such a way that **he cannot achieve success until they also achieve success** and, therefore, he must coordinate his efforts with theirs to achieve the task (Johnson and Johnson, 1989).

The members of a cooperative group have a double responsibility:

- Carry out the assigned task and
- Make sure everyone in the group does, too.

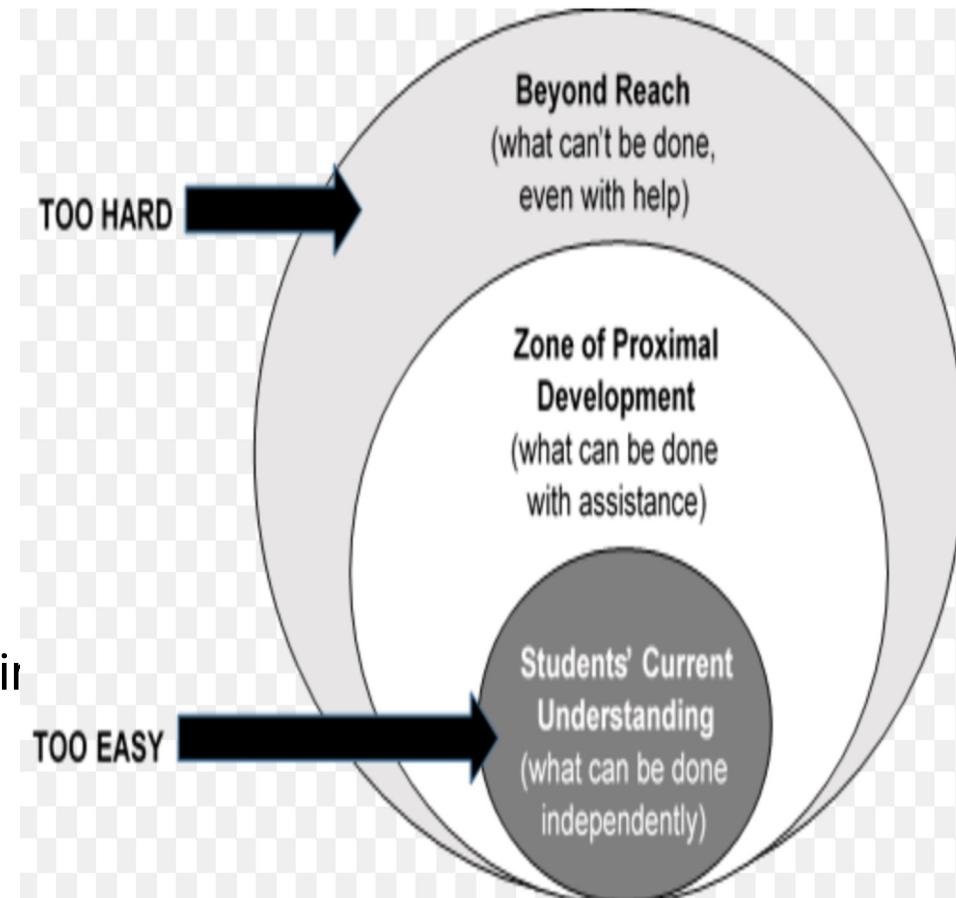
# Experiential learning

Education is not only about gaining theoretical knowledge but also getting practical experience. Learning encourages students to integrate thinking skills with tangible results. This view of education ensures students have significant experiences which are internally meaningful and contribute to their growth as learners. Powerful **questioning** and **dialogue** enable meaningful exchange during classrooms. (John Dewey).



# Social Constructivism

Cognitive development is a socially mediated process in which children acquire cultural values, beliefs, and problem-solving strategies through **collaborative** dialogues with more knowledgeable members of society. Scaffolding involves the teacher providing support structures to help students master skills just beyond their current level (Lev Vygotsky).



# Group structure. Roles lead to responsibility.

Each member of the group has a specific role that may rotate between work sessions

*leader,*  
*narrator,*  
*moderator,*  
*researcher,*  
*validator,*  
person in charge of *resources*, of  
*time*, of *communications*, of  
*presentations*, of *creativity*, of  
*technology*, of *evaluation*, etc.

# Classroom group activities

**Jigsaw**, It breaks classes into groups that each assemble a piece of an assignment and synthesize their work when finished

**Think-Pair-Share**, is done in three stages. First, students THINK about a question or prompt. Next they discuss possible answers as a group, and decide on the best answer. Finally, they SHARE their answers with the class.

**Peer tutoring**: students, when solving a task, teach and learn from each other.

**Fish tank**, Students are separated into an inner and outer circle. In the inner circle or fishbowl, students have a discussion; students in the outer circle listen to the discussion, take notes and question.

**Troubleshooting workshop**: Understand the root cause of a problem, then, in groups (1) quickly generate ideas to solve it, (2) evaluate them to ensure they are robust, (3) make a plan to test or implement the solution.

# Assessment methods

Formative evaluation

Collaboratively designed rubrics

Group's diary or *Bitácora*

Group or individual interviews

Student's self reflection (self-learning notebook)

(possibly many others)

or a combination of several techniques

## **By whom**

Peer evaluation

Self assessment

Teachers' Direct observations

Everybody involved

# How do we form teams?



EDUTEAMS

Build teams with a diversity of genres,  
personalities and intelligences for more efficient collaboration

[Log in](#) [Sign up](#)

Username or email \*

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# Human aspects to consider by AI

- Gender
- Personality
- Intelligences
- Competencies
- Preferences over tasks
- Preferences over peers
- Individual Motivation
- Critical thinking degree

|| Team Formation Alg.



# Ways of splitting people

Single Team for a Single Task

Single Teams for Many Tasks

Many Teams for a Single Task

Many Teams for Many Tasks without overlaps

Many Teams for Many Tasks with overlaps

# Use cases in education (Eduteams)

Single Teams for Many Tasks

Practicum in companies

Many Teams for Many Tasks without overlaps

Many Teams for a Single Task

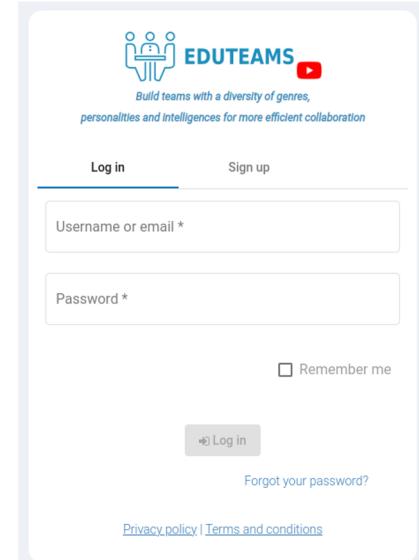
Task-based  
learning  
‘Crèdit de síntesi’

24h of FP

Practicum in companies

# Many teams for a single task

Synteam algorithm. Integrated in Eduteams.



The image shows the Eduteams login page. At the top right, there is a logo featuring three stylized human figures and the word "EDUTEAMS" in blue, with a small YouTube icon next to it. Below the logo, a tagline reads "Build teams with a diversity of genres, personalities and intelligences for more efficient collaboration". There are two buttons: "Log in" (underlined) and "Sign up". Below these are two input fields: "Username or email \*" and "Password \*". To the right of the password field is a "Remember me" checkbox. At the bottom right is a "Log in" button with a key icon, and at the very bottom right is a link "Forgot your password?". At the bottom left, there are links for "Privacy policy" and "Terms and conditions".

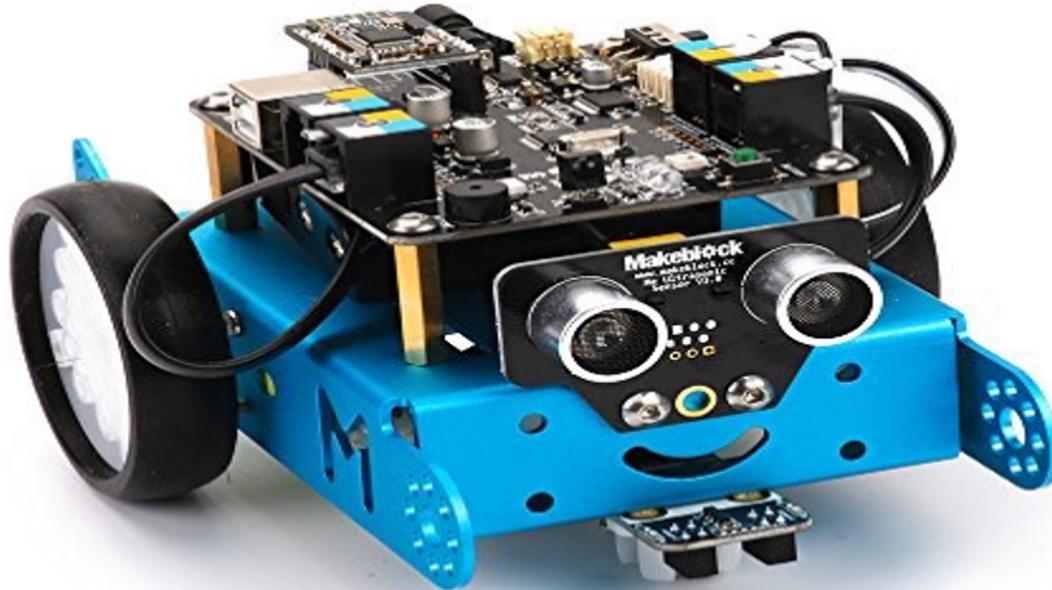
# Motivating Example

We have a classroom of 36 students and we want to divide them into teams.



# Motivating Example

We have 12 robots to program.  
We want to make robots dance.



# Motivating Example

The number of possible partitions:

$$\frac{n!}{b! \cdot (m!)^b}$$

where b is the total number of teams

$$n = 36$$

In our example:

$$m = 3$$

$$b = 12$$

$$\frac{36!}{12! \cdot (3!)^{12}} = 3.56 \cdot 10^{23}$$

There are simply too many partitions!

# Motivating Example

What do we need to perform this task?

1. A number of students per robot, i.e. teams of size  $m = 3$

	Level	Importance
2. Know how:		
- the robot mechanics work	1	0.4
- to program Arduino based robots	0.5	0.4
- to interpret the music	0.5	0.2

3. Know which student is responsible for which competence

4. We need to make sure team members work well together

How to assign students to teams so that all teams have **sufficient competences** to perform the task and **work well** together?

# Human aspects to consider

- Gender
- Personality
- Intelligences



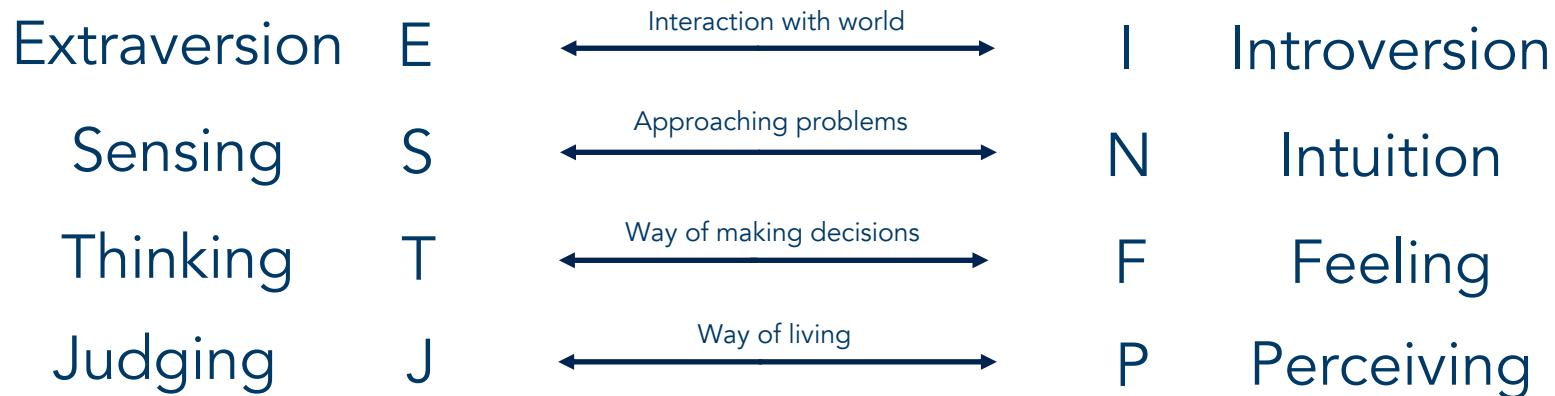
Synteam Algorithm



# Assessing personality



## The Post - Jungian Personality Theory (D. Wilde)



# Assessing personality



## MBTI Test

- 93 questions,
- Binary scale,
- Widely criticised approach.

## The Post-Jungian Test

- 20 questions,
- Grading scale,
- Novel approach interesting for research.

# Assessing personality



## The Post - Jungian Personality Theory

- 1) SN and TF personality dimensions should be as diverse as possible within a team;
- 2) A team should have a student scoring positive on EI, TF and PJ dimensions, namely an extrovert, thinking and judging person (called ETJ personality);
- 3) A team should have a student scoring negative EI dimensions, namely an introvert; and
- 4) A team should be balanced in gender.

# Team Congeniality

Team congeniality is an additive function that:

- (1) values more teams whose SN and TF dimensions are as diverse as possible;
- (2) prefers teams with at least one extrovert, thinking and judging agent;
- (3) values more teams with at least one introvert agent; and
- (4) values gender balance.

# Assessing Competencies

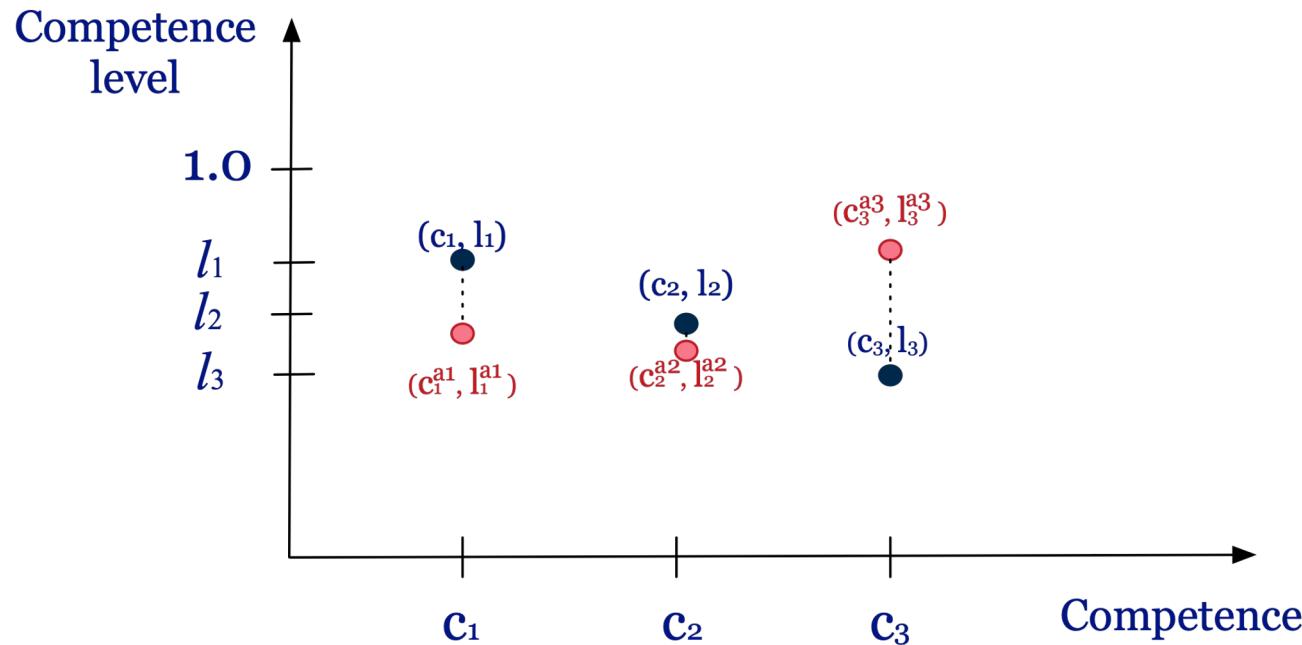


## MULTIPLE INTELLIGENCES



# Team Proficiency

Given a task assignment for a team, a proficiency value measures the degree to which the task assignment covers the task requirements.



# Team Synergy

Team synergy is a weighted combination of its proficiency and congeniality values.

$$\lambda \in [0, 1]$$

$$s(K) = \lambda \cdot u_{prof}(K) + (1 - \lambda) \cdot u_{con}(K)$$

**Team Proficiency**

**Team Congeniality**

# Solving an assignment

An optimisation problem, given a team:

- 1) We want to have each competence assigned to at least one student,
- 2) We want to have each student assigned to at least one competence,
- 3) Total cost of the assignment is minimal.

## Minimum cost flow problem

Ahuja, R., Magnanti, T., and Orlin, J. (1993). *Network flows: theory, algorithms, and applications*. Prentice hall.

# The synergistic team composition problem

The overall performance of a partition is defined as:

$$S(P_m) = \prod_{K \in P_m} s(K)$$

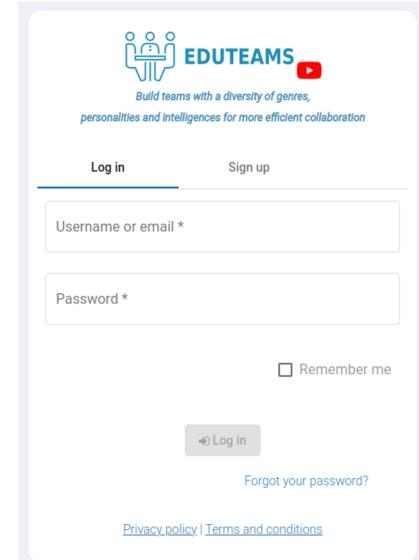
The Synergistic Team Composition Problem (STCP):

$$P_m^* = \arg \max_{P_m \in \mathcal{P}_m(A)} S(P_m)$$

Given its sheer size, the problem cannot be solved with exact methods. We use **Heuristic methods**.

# Evaluation

Synteam algorithm. Integrated in Eduteams.



The image shows the login page for the Eduteams website. The page has a light gray background with a white header bar. The Eduteams logo, featuring three stylized human figures and the text "EDUTEAMS" with a play button icon, is at the top left. Below the logo, a tagline reads "Build teams with a diversity of genres, personalities and intelligences for more efficient collaboration". There are two buttons: "Log in" (underlined) and "Sign up". Below these are two input fields: "Username or email \*" and "Password \*". A "Remember me" checkbox is followed by a "Log in" button with a key icon. At the bottom, links for "Forgot your password?" and "Privacy policy | Terms and conditions" are visible.

EDUTEAMS

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# Teacher Method

BASE TEAMS:  
Stables  
Heterogeneous



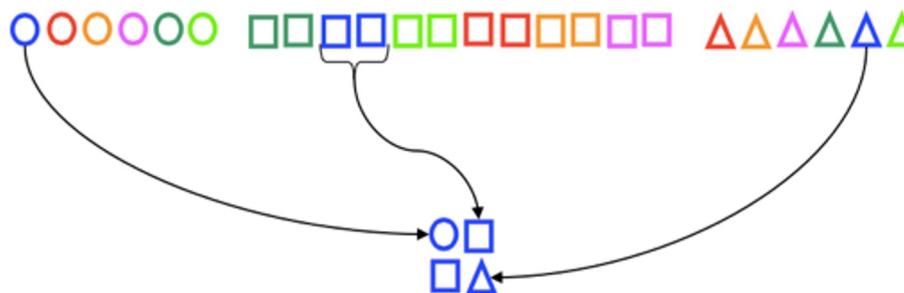
## Base of team formation:

In order to create teams, we need to divide the students in three sub-groups:

The most capable  
of giving help

The rest of students from the group

Those in need for help



# Experiment - Treball de Síntesi



Institut Torras i Bages, 1st year of Secondary Education



98 students



Each classroom was divided into teams of size three (31 teams)



- 1) We apply random sampling to split each class into two halves of similar size,
- 2) We partitioned one of the halves into teams using SynTeam. The other half was divided by the teacher method,
- 3) All teams performed the task and we collected the final marks of students,
- 4) We calculated the geometrical average of teams' results composed by teacher and composed by SynTeam

# Experiment - Scratch Programming



Institut Broggi, Institut Olorda and Institut Torras i Bages



154 students

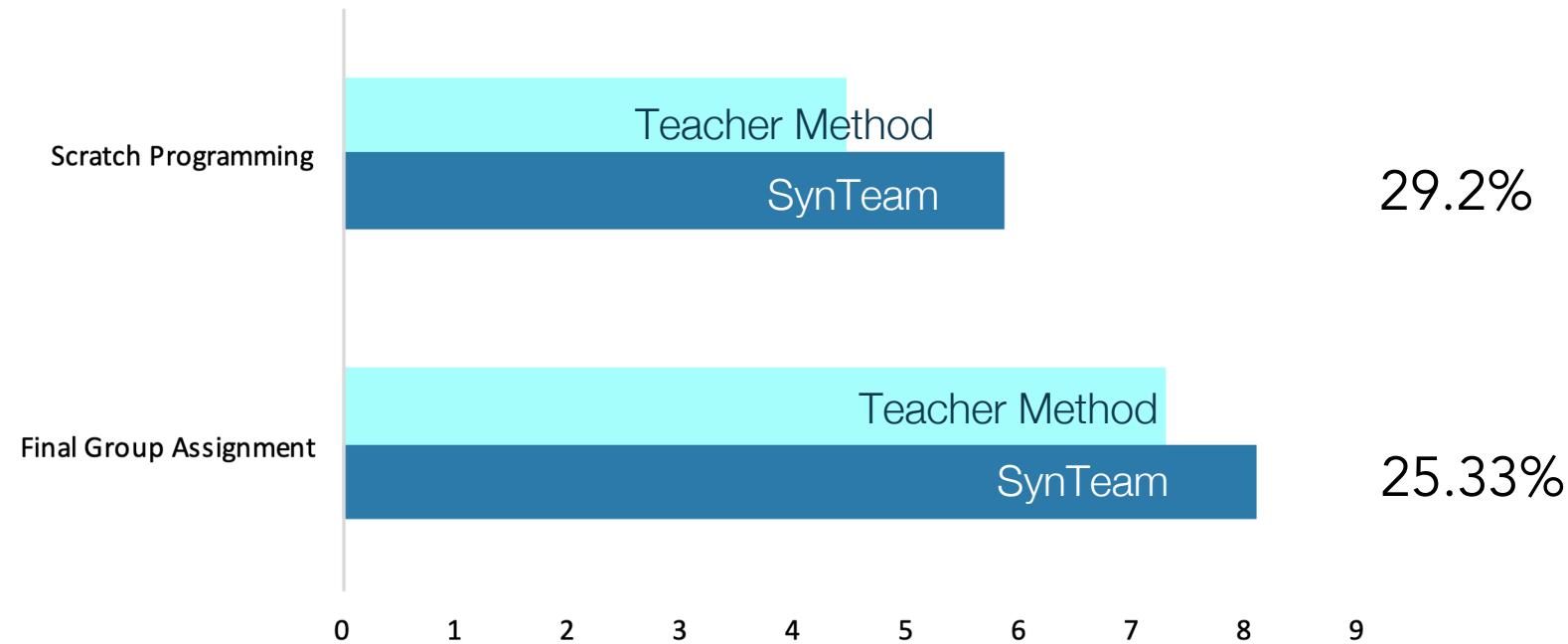


Each classroom was divided into teams of size two (75 teams)



- 1) We apply random sampling to split each class into two halves of similar size,
- 2) We partitioned one of the halves into teams using SynTeam. The other half was divided by the teacher method,
- 3) All teams performed the task and we collected the final marks of teams,
- 4) We calculated the geometrical average of teams' results composed by teacher and composed by SynTeam.

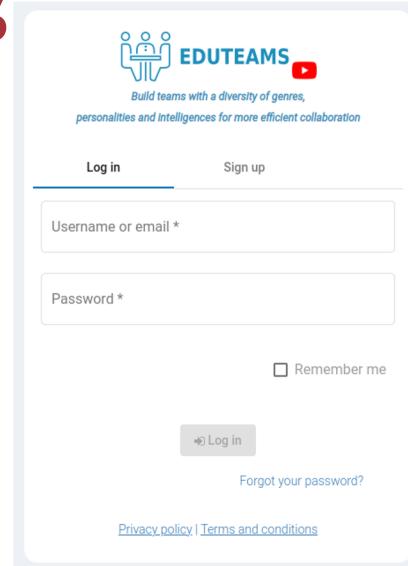
# Results Comparison



The geometrical average of marks obtained by teams composed by each method.

# Single Teams for Many Tasks

Edu2com algorithm. Integrated in Eduteams.



The image shows a screenshot of the Eduteams login page. At the top right, there is a logo with three stylized human figures and the word "EDUTEAMS" in blue, with a red play button icon next to it. Below the logo, a tagline reads: "Build teams with a diversity of genres, personalities and intelligences for more efficient collaboration". There are two buttons: "Log in" (underlined) and "Sign up". Below these are two input fields: "Username or email \*" and "Password \*". To the right of the password field is a checkbox labeled "Remember me". At the bottom left is a "Log in" button with a key icon, and at the bottom right is a link "Forgot your password?". At the very bottom, there are links for "Privacy policy" and "Terms and conditions".

# Human aspects considered

- Gender
- Personality
- Competencies
- Preferences over tasks
- Preferences over peers



Edu2Com Alg.



# Human aspects considered

**Gender.** Diversity in gender makes teams more inclusive.

**Personality.** Diverse personalities improve performance.

**Competencies (ESCO).** Matching the requirements of tasks is relevant for the outcome.

**Preferences over tasks.** Respecting them increases motivation to participate.

**Preferences over peers.** Respecting them increases social cohesion.

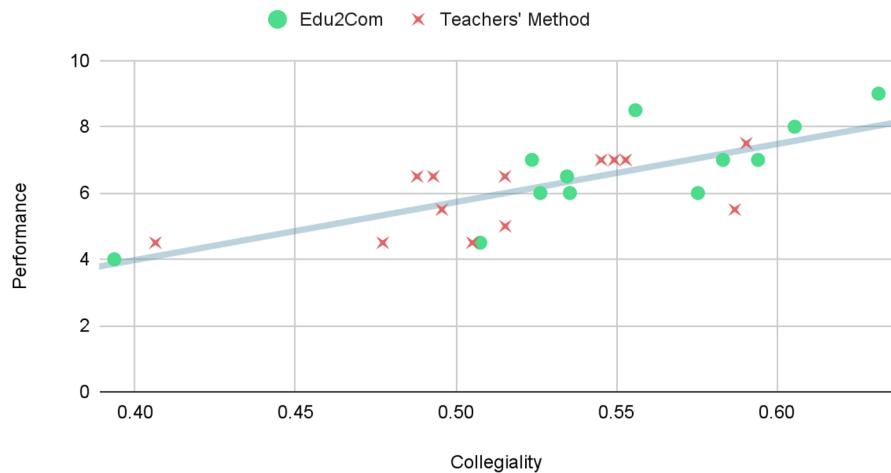
All aspects are combined in a group measure called **collegiality**.

The optimisation method is similar to SynTeam

# Evaluation (TUC & EADA)

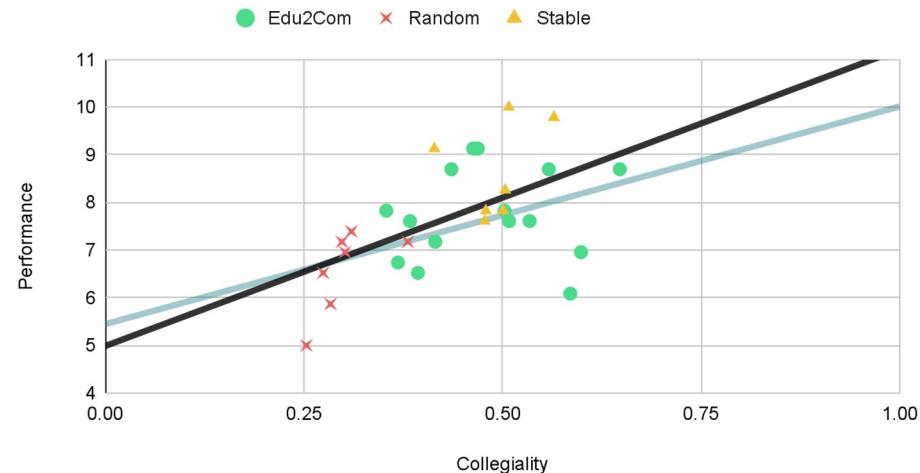
Tendency: the larger the **collegiality** the better the **performance**

Team Performance (TUC)



Stable: teams working from the beginning of the term.

Team Performance (EADA)



# Explainability

# Contrastive Explanations

Why are Beth and Mary in the same team?



If Beth and Mary were not in the same team then:

- Beth would be with Michael and Kate
- Mary would be with John, Alice and Susan
- (It is a swap between Beth and Susan)
- and **both new teams** would be **less competent!**

But then Beth and Susan don't have similar skills!

Privacy Breach

And since text editing is necessary...then Beth is worst than Susan with text editors!



And Susan told me she is the only one in her (original) team who can use a text editor and she has no other responsibilities.



# Eduteams System

Education teams

Classrooms Create a classroom Collaborate with a classroom Provide feedback

## Student Teams

There are 5 teams for the task **Coding a game**: Students will be asked to create a game in Scratch

New teams

Current teams

**Team-1**

The team members and their associated responsibilities:

**Marcus Muller** ( Intrapersonal competence, Visual-Spatial competence and Interpersonal competence )

**Patricia Reloj** ( Musical competence )

**Manel Toril** ( Bodily-kinesthetic competence, Linguistic competence and Logic-mathematics competence )



**Team-2**

The team members and their associated responsibilities:

**Rodalia Suarez** ( Intrapersonal competence, Linguistic competence, Interpersonal competence and Logic-mathematics competence )

**Alberto Maulu** ( Bodily-kinesthetic competence, Musical competence and Visual-Spatial competence )



**Team-3**

The team members and their associated responsibilities:

**Anna Maria** ( Musical competence, Intrapersonal competence and Linguistic competence )

**Eduardo Ronca** ( Bodily-kinesthetic competence, Visual-Spatial competence, Interpersonal competence and Logic-mathematics competence )



**Team-4**

The team members and their associated responsibilities:

**Maria Nova** ( Bodily-kinesthetic competence, Visual-Spatial competence and Interpersonal competence )

**Marian Potter** ( Musical competence, Intrapersonal competence, Linguistic competence and Logic-mathematics competence )



**Team-5**

The team members and their associated responsibilities:

**Lidia Aguilar** ( Musical competence, Linguistic competence, Interpersonal competence and Logic-mathematics competence )

**Borja Fernandez** ( Bodily-kinesthetic competence, Intrapersonal competence and Visual-Spatial competence )



<https://eduteams.iiia.csic.es/>

# Conclusions

- **Collaborative Learning** is a great mechanism to increase effectiveness in learning.
- Diversity is key for the success of teams
- AI can help in solving the combinatorial problem of team formation
- Eduteams is a free tool that incorporates this functionality.



# Thanks