Advancements in Intelligent Support for Collaborative Learning
From Well-Thought-Out Group Formation to Effective Peer Interactions

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The field of Computer-Supported Collaborative Learning - CSCL dedicates to study about how technology can be used to support collaborative learning and its processes (Stahl et al., 2006)
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Despite of the potential benefits of Collaborative Learning, this approach is only beneficial when there is an adequate design and orchestration of its scenarios (Hernández-Leo et al., 2006, 2011; Dillenbourg, 2013)
The Problem

- These activities are too complex and time consuming
- They also require specific knowledge and skills
How to increase the chances of successful collaborative learning (CL)?
How to provide intelligent support to design and carry out collaboration?
Challenges
Knowledge to design effective collaboration is distributed across several learning theories and pedagogical practices.

They do not share the same terminology, assumptions and expectations and can be even contradictory!

Furthermore, if we consider only 15 pedagogical practices (3 dosage levels), there are 205 trillion options to be considered.

Can we organize this pedagogical knowledge and build a computational infrastructure to use it adequately?
Our Approach

Use ontological engineering to describe formally meaningful information contained in theories.

Pedagogical knowledge

Ontological structure

Run experimental studies to:
- propose group formation;
- design group activities;
- estimate benefits, etc..

Theory aware intelligent systems

Use ontologies to support the development of ontology-aware systems.

Users
Teachers and students
Formalizing CL

whole group
smaller group
part of the whole
interaction
Whole group

\( L_A \)

\( L_B \)

\( L_C \)
Formalizing CL

Individual goal

Sub-group goal

Strategy A

Strategy B

Whole group goal

Role

\( L_A \)

\( L_B \)

\( L_C \)
Formalizing CL

Knowledge Formalization

✓ Learning Strategies
✓ Learning Goals
✓ Group Goals
✓ Roles

\[ Y \leq I \Rightarrow \text{goal}(L_A \leq L_B) \]

\[ Y \leq I \Rightarrow \text{goal}(L_B \leq L_A) \]

\[ \text{I-goal}(L_A) \]

\[ \text{I-goal}(L_B) \]

\[ \text{I-goal}(L_C) \]

\[ \text{W}(L) \Rightarrow \text{goal}({L_A, L_B}) \]

\[ \text{W}(L) \Rightarrow \text{goal}({L_A, L_B, L_C}) \]
Interaction Patterns

✓ Group Goals
✓ Learning Strategies
✓ Learning Goals
✓ Roles

![Diagram showing interaction patterns with goals and roles](image)

- \( Y \leq I \text{-goal}(L_A \leq L_B) \)
- \( Y \leq I \text{-goal}(L_B \leq L_A) \)
- \( W(L) \text{-goal} \{L_A, L_B\} \)
- \( I \text{-goal}(L_A) \)
- \( I \text{-goal}(L_B) \)
- \( I \text{-goal}(L_C) \)

How? Interaction Patterns
Interaction Patterns

Interaction Patterns for Learning Theories proposed by Inaba et al. 2003

Cognitive Apprenticeship
Peer Tutoring
Anchored Instruction
LPP
Observational Learning
Cognitive Constructivism
Sociocultural Theory
Cognitive Flexibility Theory

Influential I_L Events

Instructional Event
Learning Event

Instructor
Learner

Role
Role

learning goal (L_A)
learning goal (L_B)

action_L_A
action_L_B

Ontological framework

Influential I_L event

Instructional event

Instructor
Learning event

L_A
learning goal

Benefits for the Learner

Object
Action

Benefits for the Instructor

Object
Action

Learning object
Learning action

Interactions

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Interactions
CL Ontology

(a) CL Scenario

CL process

W(A)-goal

W(L)-goal

Common goal

How to interact

Interaction Pattern

Learning Strategy

Y<=I-goal

I-role

Role Holder

Learner

You-role

Role Holder

Learner

I-goal (I)

I-goal

(b) CL Role

Necessary Condition

Knowledge/cognitive state

Desired Condition

Knowledge/cognitive state

How to collaborate

Behavioral Role

Influential I_L event

Influential I_L event

Instructional event

Instructor

Role Holder

Instructional action

Action

Benefits for the Instructor

I-goal

Learning event

Learner

Role Holder

Learning object

Object

Learning action

Action

Benefits for the Learner

I-goal

(d) Necessary Interaction Activity

Influential I_L event

Complementary Interaction Activity

Influential I_L event

(e) How to interact

Behavioral Role

Object

Action

Benefits for the Learner

I-goal

(c) Role Holder

Role Holder

Role Holder

Role Holder
CHOCOLATO: Concrete and Helpful Ontology-aware Collaborative Learning Authoring Tool

How to group students?

Student 1

Student 2

Student 3
How to group students?

Student 1

Student 2

Student 3
How to group students?
How to group students?
Theory-Driven Group Formation

Identify which theories can help learners to achieve their goals

Learning goals

Teacher's intention

Learner

Behavioral role

participant

CL scenario

Can play

Satisfies

Learning Strategy IT<=LR

Y<=I-goal

Learning Strategy LR<=IT

Y<=I-goal

I-goal

I-role

Learner

Can play

Satisfies

I-goal

I-role

Learner

Behavioral role

participant

Teacher's intention
CHOCOLATO: Concrete and Helpful Ontology-aware Collaborative Learning Authoring Tool

Group Formation

Learners

Theories

Ontologies

Meaningful results

Effective Groups

CHOCOLATO

CL
Design

Sequence of activities

Interaction Analysis

Why does the learner want to interact with other learners?

How does the learner change his/her state?

What activity does the group want to do?

How does the group change its state?
The model offers a solution to create theory-aware tools that help to design CL activities

Framework to design domain-dependent CL scenarios

- LO1
- LO2
- Use Model (GMIP)
- Domain independent ontologies
- Domain dependent learning objects
CHOCOLATO

Select the group goal

- No specific goal
- Creating a solution
- Knowledge Construction
- Knowledge sharing
- Spread of a skill

Select applicable theories

- All theories
- Anchored Instruction
- Peer Tutoring

Anchored Instruction

It supports a scenario where users can play 2 roles: (1) the Anchor holder role, in which the player should behave as a Presenter; (2) the Anchored instructor role, in which the player should behave as an Adviser. The desirable number of users playing the Anchor holder role is X1 and playing the Anchored instructor role is X2.

More about this theory
CHOCOLATO: Concrete and Helpful Ontology-aware Collaborative Learning Authoring Tool

Effective Groups

Group Formation

Ontologies

Theories

CL Design

Sequence of activities

Learners

Meaningful results

CHOCOLATO

Interaction Analysis
Does it really work in practice?

In vivo studies

2008

2nd principal component

st principal component

Score in the first test

Average score of all tasks

2009

Score in the first test

Average score of all tasks

2001

2006

2007
CHOCOLATO: Concrete and Helpful Ontology-aware Collaborative Learning Authoring Tool

Sequence of activities

Learners

Effective Groups

Group Formation

Ontologies

CL Design

Interaction Analysis

Why does the learner want to interact with other learners?

What activity does the group want to do?

How does the group change its state?

Meaningful results

Common goal

Primary focus (P)

Secondary focus (S)

S <= P - goal

P <= S - goal

Interaction Analysis

k./cog. state

Goal state

How does the learner change his/her state?

CHOCOLATO

Formation

Effective Groups

CHOCOLATO
Research Gap

“Affective Issues in CSCL: The Neglected Aspect of Motivation self-regulation”

Results

Understanding the Importance of Affective States in CSCL

- Studying working in Pairs
- Experiment setup (45 dyads)
  1. Positive-Positive
  2. Negative-Negative
  3. Positive-Negative

Which one correlates to better students’ performance?

- **Negative-Negative → Better Performance**

Results

Understanding the Importance of Affective States in CSCL

- Why students tend to not like to work in groups overtime?
- Experiment setup (118 undergrad students)
  1. Control group
  2. Experimental groups

  Results: collaboration may improve perceived quality, but students may avoid it because they do not want to lose a sense of personal ownership (feeling of contribution)

Understand the role of affective states in group formation (and collaborative learning processes)
Specific Objectives

1. Establish the relationship between personality trait and pedagogical theories in the context of CSCL

1) Select a set of **personality traits**
2) Apply a **filter** to avoid **duplicate** elements in **ontology**.
3) Determine the personality traits **characteristics**
Personality Trait
Characteristics

Extraversion
- Impulsive, sensible, restless
- Aggressive, easygoing, optimistic
- Active, sociable, talkative, receptive
- Lively, unconcerned, leader

Introversion
- Unsociable, reflexive, moody, reserved
- Anxious, rigid, pessimistic, quiet
- Passive, careful, peaceful, controlled
- Even-tempered, calm, reliable

4) Identify the **roles** based on collaborative **learning theories**
Collaborative Learning Theory

Anchored Instruction

Anchored Instructor

Problem Holder

5) Identify students’ **behavior** based on collaborative learning **roles**.
Collaborative Learning Theory

Anchored Instruction

Students’ behavior

- Diagnosing problems
- Advising and guiding other students
- Explain some content in his/her own words

6) Identify personality traits **characteristics** that may **negatively** influence students’ **behavior**.
May negatively influence students’ behavior

- Introverted
  - Unsociable
    - Close to interact with others students

- Extroverted
  - Impulsive
    - Difficulty in solving problems that require reflection

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<th>Behavior</th>
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Case Study

- **Place:** Escola Paidéia, Bebedouro – SP.
- **Participants:** 15 students (9 -10 years old)
- **Subject:** basic math operations
- **Material:** math games using Educacross platform
- **Characteristics:** Levels of Impusiveness (PT: Extroversion and neuroticism)

Example of CL scenario

História

a)

1. O senhor Sapo subiu na pedra para descansar.

2. Em cima da pedra, o senhor Sapo viu um monte de corujas em cima da árvore.

3. Quando o senhor sapo colocou a língua para fora algumas corujas assustaram e voaram.

4. O Senhor sapo riu das corujas que voaram.

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<th>Respostas</th>
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<td>Quantas corujas estavam <strong>em cima da árvore</strong>?</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td><strong>Quantas corujas voaram</strong> depois que o senhor Sapo colocou a língua para fora?</td>
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</tr>
<tr>
<td></td>
<td><strong>Quantas corujas ficaram na árvore</strong> depois que o senhor Sapo colocou a língua para fora?</td>
<td>20</td>
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Procedure

- Cognitive test
- Personality test

CL activities (dyads)
Results

• We observed that low impulsivity did not influence negatively the performance of students when playing the role of full participant.

• Yet, there are some indications that high impulsivity may affect students performance.

• We need more experiments and data ...

• Need to collect that in large scale ...
Future Directions

1. Establish the relationship between **personality trait** and **collaborative learning theory**

2. Establish the relationship between **emotion** and **collaborative learning theory**

3. Establish the relationship between **mood** and **collaborative learning theory**
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