

#### Using Multimodal Learning Analytics to Identify Aspects of Collaboration in Project-based Learning

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### Introduction



- Collaboration is a key part of education
- Constructivisit approaches foster 21<sup>st</sup> century skills (Banks & Barlex 2014)
- Evaluation is hard and laborious and standardized testing strategies don't work...
- But, where is the evidence for the effectiveness of these methods? (Klahr & Nigam 2004; Kirschner et al., 2006)

### **Benefits Multimodal Learning Analytics**



- Provides different tools to capture data from complex learning activities
- Low-cost sensors and inexpensive computational power for obtaining data from diverse sensors
- Our focus was on multimodal data from sensors that provided new opportunities for investigating learning activities in the real-world between small groups of learners.

# **Collaborative Problem Solving**



- We frame CPS as the process of people working together to solve a problem with equivalent roles.
- Starting from OECD (2015) Collaborative Problem Solving
  Framework we defined 3 dimensions for understanding and assessing CPS (Cukurova et al., 2016)
  - Physical Engagement
  - Synchronisation
  - Intra-individual interaction (Individual accountability)

#### **Research Aim**



- We processed and extracted multimodal interactions to answer the following question:
- Which features of MMLA are good predictors of CPS in open-ended tasks in project-based learning?
  - In particular, we performed a regression task over human evaluated
    CPS scores by means of machine learning techniques.
  - The answer to the questions provides ways to automatically identify aspects of students CPS practices and provides means for different types of interventions to support and scaffold the students and inform teaching practices.

#### **PELARS** in action 1





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#### **Types of Data Collected**



| Data Context  | Instruments            | Types of things                          | Data type                                     |
|---------------|------------------------|--|---|
| Mobile (User) | Buttons                | User incidents                           | Time Stamp, photographs                       |
|               | Mobile documentation   | self-documentation, research observation | Time stamps, rich media<br>(text, media)      |
| Workstation   | ARDUINO IDE            | components code                          | Structured text                               |
|               | Computer vision System | hands, people                            | positions, time lapse photos,<br>audio levels |



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#### **PELARS in action 2**





#### **Timelapse of an activity**

![](_page_8_Picture_1.jpeg)

![](_page_8_Picture_2.jpeg)

![](_page_8_Picture_3.jpeg)

### **PELARS System & Acquired Data**

![](_page_9_Picture_1.jpeg)

- What is the PELARS project
  - Specialised workstation with sensors and new learning objects
  - 18 Engineering students, 6 groups and 3 sequential interventions
- Face Tracking
  - Faces Looking at the Screen
  - Distance between Learners
- Hand Tracking
  - Distance between Hands
  - Hand Motion Speed
- Other Data
  - Interaction between Arduino hardware and Software, Audio Levels, and Sentiment Buttons

#### Example of how we coded

![](_page_10_Picture_1.jpeg)

- Coding of each student status as follows:
  - Active (2) whenever a student's hand is active with an object.
  - Semi-active (1) when a student is not physically active but his head is directed toward a peer (or a teacher) who is active.
  - Passive (0) passive if a student is not physically active with any object and his head is directed somewhere other than any of the peers who were active.

#### Video Grab from tool for human coding

![](_page_11_Picture_1.jpeg)

Session 1585

![](_page_11_Picture_3.jpeg)

#### **Codes for video analysis**

![](_page_12_Picture_1.jpeg)

- **Physical engagement** is measured by the percentage of code 2 over the total.
- Synchronisation is measured by the combined percentage of 222 and 111 codes. These are the two situations in which all students are active or all semi-active. The 111 code corresponds to the specific case in which a facilitator or teacher enters the scene and the students are looking (semi-active) at him/her.
- Intra-Individual / Individual accountability has been measured by the total number of situations in which at least one student is looking at another student actively working: that is all the combinations of a 2 with two 1 code, and two 2 codes with one 1 code (e.g. 211, 221).

# Coding of the student sessions with the three CPS $\oint$ pelars. scores as percentages of the total session duration

| Session | Physical Engagement | Synchronicity        |         |           | Individual Accountability |
|---------|---------------------|----------------------|---------|-----------|---------------------------|
| No      | PE Total            | SYN 111<br>(teacher) | SYN 222 | SYN Total | IA Total                  |
| 1       | 46,4%               | 30,88%               | 0,00%   | 30,88%    | 66,18%                    |
| 2       | 50,00%              | 0,00%                | 10,00%  | 10,00%    | 50,00%                    |
| 3       | 53,7%               | 1,05%                | 16,84%  | 17,89%    | 46,32%                    |
| 4       | 67,97%              | 7,1%                 | 38,3%   | 45,45%    | 47,40%                    |
| 5       | 66,0%               | 0,0%                 | 25,9%   | 25,95%    | 55,06%                    |
| 6       | 77,92%              | 0,6%                 | 48,7%   | 49,35%    | 46,75%                    |
| 7       | 51,9%               | 3,6%                 | 12,3%   | 15,94%    | 64,49%                    |
| 8       | 60,75%              | 0,0%                 | 24,8%   | 24,80%    | 34,40%                    |
| 9       | 62,7%               | 0,0%                 | 30,1%   | 30,15%    | 34,56%                    |
| 10      | 74,9%               | 3,0%                 | 43,6%   | 46,53%    | 53,5%                     |
| 11      | 46,4%               | 1,7%                 | 11,7%   | 13,33%    | 44,17%                    |
| 12      | 60,06%              | 0,0%                 | 24,5%   | 24,53%    | 53,77%                    |

### Machine Coding of the Student sessions

![](_page_14_Picture_1.jpeg)

#### • Preprocessing

- Data has been collected at variable data rates (around 2 Hz)
- The aggregation performed was based on counting for most of the variables, except for the distance/proximity functions for which we employed averaging, maximum and minimum.
- Zero padding was added for sessions that were too short and the individual sessions where then broken down into phases.

#### • Machine Learning

- This initial approach was based on regression task that used as inputs the features and as output the coding based scores (PE, SYN, IA) with the purpose of identifying which are the input features that can support the CPS framework.
- We opted for Linear Regression (LR), Bayesian Ridge Regression (BRR) and Support Vector Machine Regression (SVR).

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#### RESULTS

![](_page_15_Picture_1.jpeg)

- Relying less on phases was a good strategy because it avoided the need for an automatic segmentation tool.
- The NEXT slide shows the conditions for which there is a reliable regression for the given data (R2 > 0.1), this means that PE Total never provided reliable regression, and only the listed windows were successful (e.g. no regression when using the whole window).
  - IA 222 has Hand Distance (Max and Min) as regressor (with significance p < 0.05)</li>
  - SYN Total has Hand Distance (Min) as regressor (with significance p < 0.05)</li>
  - SYN 111 has Face Count and Hand Distance (Min and Max) as regressor (with significance p < 0.05)</li>
- If instead we look at the overall window duration, we obtain:
  - PE level can be regressed by Hand Max Distance (significance p < 0.005)</li>

Results of the Regression Analysis – Scores of R2 for features Hand Distance, Speed and Face Count. Only the reliable regressions are reported.

|             | Window (s) | SYN222 | IA211 |
|-------------|------------|--------|-------|
| Linear      | 1200       | 0.28   | 0.17  |
| Bayes Ridge | 1200       | 0.28   | -     |
| SVMR        | 1200       | -      | -     |
| Linear      | 1800       | 0.48   | -     |
| Bayes Ridge | 1800       | -      | -     |
| SVMR        | 1800       | -      | -     |

oelars.

![](_page_17_Picture_0.jpeg)

#### **Findings**

- We found Key Features for "collaboration" grounded in CPS approach
  - Where the students are looking (faces and gazes)
  - Distance between students
  - Motion and location of their hands
- This framing of CPS can be a starting point to investigate further what features of MMLA can be used to support collaborative learning.

#### Conclusion

![](_page_18_Picture_1.jpeg)

- The findings show similar results to other findings in MMLA (Blikstein & Worsely 2016; Ochoa et al., 2013; Grover et al., 2016) that begin to show that some **physical** aspects of collaboration are important and can be **good features**.
- Additionally, that the physicality of the learners and the log files of the hardware and software so good promise to identify collaboration patterns without a a deeper connection to the students' conversation or an inquiry-like system to support the learning.

### **FUTURE WORK**

![](_page_19_Picture_1.jpeg)

- Reducing the window size down to the fine-grained coding of the sessions at 30-seconds intervals.
- More complex coding for the training and additional features.
- Additional features through post video analysis for automatic coding.
- For this purpose, we employed a deep neural networks (DNN) for automating the scoring of students' session and providing assessment in the context of the CPS framework.

![](_page_20_Picture_0.jpeg)

# Thanks: daniel.spikol@mah.se

![](_page_20_Picture_2.jpeg)

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![](_page_20_Picture_11.jpeg)

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### Plugs

![](_page_21_Picture_1.jpeg)

- Context and Collaborative Problem Solving (CPS): the development of observable signifiers to inform the design of CPS learning analytics
  - POSTER SESSION 2
- IxD&A Emerging Design: Transforming the STEAM Learning Landscape with the Support of Digital Technologies - SPECIAL ISSUE
  - <u>http://www.mifav.uniroma2.it/inevent/events/idea2010/</u> <u>index.php?s=102&link=call34</u>
- CROSSMLA Workshop EC-TEL Tallinn September 13
  - <u>http://crossmmla.org/</u>