**LITERATURE SURVEY**

1. **A tough nut to crack: Measuring collaborative problem solving**.

**AUTHORS:**  **L. Lei, J. Hao, A. von Davier, P. Kyllonen, and J-D. Zapata-Rivera.**

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levels should be distributed between the crew members with minimum

training time diﬀerences, training expenses or a maximum of the train-

ing level with a limitation of the budget.

First, a description of the cosmonaut training process is given.

Then four models are considered for the volume planning problem.

The objective of the ﬁrst model is to minimize the diﬀerences between

the total time of the preparation of all crew members, the objective of

the second one is to minimize the training expenses with a limitation of

the training level, and the objective of the third one is to maximize the

training level with a limited budget. The fourth model considers the

problem as an 𝑛-partition problem. Then two models are considered

for the calendar planning problem.

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The purpose of our project is to explore the measurement of cognitive skills in the domain of science through collaborative problem solving tasks, measure the collaborative skills, and gauge the potential feasibility of using game-like environments with avatar representation for the purposes of assessing the relevant skills. We are comparing students' performance in two conditions. In one condition, students work individually with two virtual agents in a game-like task. In the second condition, dyads of students work collaboratively with two virtual agents in the similar game-like task through a chat box. Our research is motivated by the distributed nature of cognition, extant research on computer-supported collaborative learning (CSCL) which has shown great value of collaborative activities for learning, and the framework for the Programe for International Student Assessment (PISA) framework. This chapter focuses on the development and implementation of a conceptual model to measure individuals' cognitive and social skills through collaborative activities.

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For the volume planning problem, two algorithms are presented.

The ﬁrst one is a heuristic with a complexity of (𝑛)operations. The

second one consists of a heuristic and exact parts, and it is based on

the 𝑛-partition problem approach.

2**) Human-Agent assessment: Interaction and sub-skills scoring for**

# collaborative problem solving

**AUTHORS: P. Chopade, K. Stoeffler, S. M. Khan, Y. Rosen, S. Swartz, and A. von Davier,**

# Collaborative problem solving (CPS) is one of the 21st century skills identified as a critical competency for education and workplace success. Students entering the workforce will be expected to have a level of proficiency with both cognitive and social-emotional skills. This paper presents an approach to measuring features and sub-skills associated with CPS ability and provides a methodology for CPS based performance assessment using an educational problem solving video game. Our method incorporates K-Means clustering to evaluate and analyze the feature space of the CPS evidence that was gathered from game log-data. Our results illustrate distinct participant clusters of high, medium and low-CPS skills proficiency levels that can help focus remediation efforts.

# 3. Framework for Effective Teamwork Assessment in Collaborative Learning and Problem Solving

**AUTHORS:** P. Chopade, S. M. Khan, K. Stoeffler, D. Edward, Y. Rosen, and A. von Davier

This paper presents an interactive team collaborative learning and problem-solving (ITCLP) framework for effective teamwork learning and assessment. Modeling the dynamics of a collaborative, networked system involving multimodal data presents many challenges. This framework incorporates an Artificial Intelligence (AI), a Machine Learning (ML) and computational psycho- metrics(CP) based methodology, system architecture, and algorithms to find pat- terns of learning, interactions, relationships, and effective teamwork assessment from a collaborative learning environment (CLE). Collaborative learning may take place in peer-to-peer origin large groups, to discuss concepts, or find solutions to real-time problems or working on situational judgement task (SJT). Intelligent Tutoring Systems (ITSs) have been mostly used as a supportive system for the varied needs of individual learners. The ITCLP framework enables development of ITSs for team tutoring and facilitates collaborative problem solving (CPS) by creating interactions between team members. Our team model maps team knowledge, skills, interactions, behaviors, and shared knowledge of team tasks, and performance. We will collect the team interaction log data, user eye tracking, and user portrait video/audio and will map team skills evidence based on CPS, a broad range of cross-cutting capabilities, which is part of an even broader Holistic Framework (HF) proposed by Camara and colleagues.

**4.** **Computational Psychometrics for the measurement of collaborative problem-solving skills**

**AUTHORS: S. Polyak, A. von Davier and K. Peterschmidt**

This paper describes a psychometrically-based approach to the measurement of collaborative problem solving skills, by mining and classifying behavioral data both in real-time and in post-game analyses. The data were collected from a sample of middle school children who interacted with a game-like, online simulation of collaborative problem solving tasks. In this simulation, a user is required to collaborate with a virtual agent to solve a series of tasks within a first-person maze environment. The tasks were developed following the psychometric principles of Evidence Centered Design (ECD) and are aligned with the Holistic Framework developed by ACT. The analyses presented in this paper are an application of an emerging discipline called computational psychometrics which is growing out of traditional psychometrics and incorporates techniques from educational data mining, machine learning and other computer/cognitive science fields. In the real-time analysis, our aim was to start with limited knowledge of skill mastery, and then demonstrate a form of continuous Bayesian evidence tracing that updates sub-skill level probabilities as new conversation flow event evidence is presented. This is performed using Bayes' rule and conversation item conditional probability tables. The items are polytomous and each response option has been tagged with a skill at a performance level. In our post-game analysis, our goal was to discover unique gameplay profiles by performing a cluster analysis of user's sub-skill performance scores based on their patterns of selected dialog responses.

**5.** **Multimodal analytics to study collaborative problem solving**

**in pair programming**

**AUTHORS: G. Grover, M. Bienkowsk, A. Tamrakar, B. Siddiquie, D. Salter, and A. Divakaran**

Collaborative problem solving (CPS) is seen as a key skill in K-12 education---in computer science as well as other subjects. Efforts to introduce children to computing rely on pair programming as a way of having young learners engage in CPS. Characteristics of quality collaboration are joint exploring or understanding, joint representation, and joint execution. We present a data driven approach to assessing and elucidating collaboration through modeling of multimodal student behavior and performance data.

**6.** **Deep knowledge tracing**

**AUTHORS: C. Piech, J. Bassen, J. Huang, S. Ganguli, M. Sahami, L. Guibas and J.Sohl-Dickstein**

Knowledge tracing---where a machine models the knowledge of a student as they interact with coursework---is a well established problem in computer supported education. Though effectively modeling student knowledge would have high educational impact, the task has many inherent challenges. In this paper we explore the utility of using Recurrent Neural Networks (RNNs) to model student learning. The RNN family of models have important advantages over previous methods in that they do not require the explicit encoding of human domain knowledge, and can capture more complex representations of student knowledge. Using neural networks results in substantial improvements in prediction performance on a range of knowledge tracing datasets. Moreover the learned model can be used for intelligent curriculum design and allows straightforward interpretation and discovery of structure in student tasks. These results suggest a promising new line of research for knowledge tracing and an exemplary application task for RNNs.