# Benefits of Ontologies for Collaborative Problem Solving Assessment 

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# Collaborative Problem Solving (CPS) 

- CPS is a skill critical for success in the $21^{\text {st }}$ century workforce
- Increased attention in the assessment community in the assessment of CPS



## CPS and Assessment

- Focus for assessment:
- Conceptualizing the construct
- Designing environments that provide opportunities to display CPS skills
- Determining methods for making inferences about individuals' CPS skills
- No easy solutions given the complexity of CPS


## In-Task Assessment Framework

I-TAF provides additional support for instantiating the student model, task model, and evidence model of evidence-centered design

## I-TAF in ECD

How do task affordances impact measurement?


How can observables be identified in the data?

How can the construct be operationalized in terms of behavior?

## I-TAF Procedures

1. Generate an Ontology
$\checkmark$ Delineate concepts and relationships
2. Expand to a Behavioral Ontology
$\checkmark$ Identify potential strategies
3. Expand to a Cognitively Enhanced Ontology
$\checkmark$ Link to tactics allowed by the task
4. Extract Features
$\checkmark$ Identify relevant sections of log data
5. Create Chains-of-Evidence
$\checkmark$ Link features to ontological concepts

## Example Application

Teaching Teamwork: Level D
Circuit 1 (User: Lion, Group: Animals)
$\bigcirc$ Online
We got ill Vew All Circuils


## Step 1: Generate an Ontology



## Step 2: Expand to a Behavioral Ontology



## Step 3: Expand to a Cognitively Enhanced Ontology



## CPS Ontology



## Uses for Ontologies

## Develop Rubrics

## CPS Rubric - Cognitive Dimension

| Dimension | Skill | Sub-Skill 1 | Sub-Skill2 | Definition | Examples | Action Type |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \mathrm{C} \\ \mathrm{O} \\ \mathrm{G} \\ \mathrm{~N} \\ \mathrm{I} \\ \mathrm{~T} \\ \mathrm{I} \\ \mathrm{~V} \\ \mathrm{E} \end{gathered}$ | Planning | Develop Strategies |  | Devise a plan or strategy to reach the goal state, including the steps to be undertaken | -"Using the current we find E and we can do what we did last time" <br> -"Ok now V=I*R" <br> -"then we can find our R values using Ohm's Law" <br> -"ok we set our values to $R$ and find the current" <br> -"Let's add up our values" | chat |
|  |  | Revise Strategies |  | Change to a different plan or strategy to solve the problem | -"Let's break the circuit instead" <br> -"Let's try something else" <br> -"Let's go higher" | chat |
|  | Executing | Enact Strategies |  | Carry out the plan or strategy that has or has not been explicitly verbalized | - Engage in the behaviors consistent with the stated plan for the level (e.g., change resistor to the suggested resistance value; carry out suggested calculation in calculator); does not always have to occur after a stated plan (e.g., participant may carry out Ohm's Law strategy before informing teammates) | change resistor; take measurement; calculate |
|  |  | Suggest/Direct Actions |  | Make suggestion for action for teammate to carry out | -"Don't change anything" <br> -"Enter your E and R values Bear" <br> -"Adjust yours to 300 ohms" <br> -"Sleet try now" <br> -"Wait" <br> -"Give me a sec" | chat |
|  |  | Report Actions |  | Communicate own actions being taken to carry out the plan | -"I set mine to 120 " <br> -"I'm going to set mine higher" <br> -"I used 100 ohms like you said" <br> -"Let me go a little lower and then readjust" | chat |
|  | Monitoring | Monitor Success |  | Monitor progress toward the goal, including checking intermediate and final results, detecting unexpected events, and taking remedial action when required | -State where you are or team is in relation to the goal state ("I'm good", "I got it", "We got it", "I'm too high", "I'm still a little low", "we're good?") <br> -Click submit (submit values) | chat, click submit |
|  |  | Monitor Group |  | Monitor whether teammates are present, following the rules of engagement, roles, completing tasks | -Prompt teammates to perform tasks ("come on Snow", "You forgot to put in the voltage", "Let's get a move on Sleet", "Now") <br> -Calling on teammates ("Lion", "Seagull", "Jessica") <br> -Check on the status of teammates ("Where is Rain?") <br> -Adapt team organization/roles <br> -"We need to figure this out" | open/close zoom; view board in zoom; chat |

## Step 4: Extract Features



## Feature Extraction Example



Statistical and Psychometric Modeling

## Modeling with I-TAF

- Use the ontology to generate a Student Model
- Compute aggregate features
- Count, mean, etc
- Use aggregate features as "observables" in the Stat Model


## Bayesian Networks



## Generalizability

## I-TAF Generalizability

- Use the same ontology \& behavioral ontology
- Update dark gray nodes in the cognitively enhanced ontology
- To represent different affordances in new task
- Update features
- Update chains-of-evidence
- To extract the SAME observables


## CPS Ontology for New Task

## T-Shirt Math Task



The student council at Baruch Middle School is planning to sell school $t$-shirts to the students in the ath grace class. There are axcut 300 students in the 5 sth garde class bit the student council does not expect that everyone will buy a $t$-shirt. The student council is considering three different comparies to make the $t$-shirts.

1. EZ Tees charges $\$ 8$ per shirt, and thes a cre-time setup fee of $\$ 200$
2. Ferfect Printing charges $\$ 4$ per shirt, and has a one-time setup fee of $\$ 500$

3 Shirts For Less charges a flat fee of $\$ 1,500$ for up to 350 shirts.

1. Flease talk with your partner and decide which comcany you want to recommend. Wite your recommendaton and an explanation of why you chose that company below
or Shits for Less, because the school
estrmated thet not cvery stubten: woukd buy a shirt, sc we decidec to use an estimate of 100 students buying a shirt. Bccausc of this, it would be unreascrable to use Shirts for Less. I


## Conclusions

- I-TAF provides a principled approach for assessment of complex constructs in digital environments
- Ontologies are the main component of I-TAF
- Help lay out the constructs we wish to measure in a principled way
- Can serve as an anchor representation for other components of assessment such as scoring rubrics, evidence identification, and task design.


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