Benefits of Ontologies for Collaborative Problem Solving Assessment

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Measuring the Power of Learning."

Collaborative Problem Solving (CPS)

- CPS is a skill critical for success in the 21st 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 How can the construct affordances impact be operationalized in terms of behavior? measurement? Evidence Model Student Model Task Model **=**(† Evidence Stat Rules Model How can observables What components of the be identified in the data? model are observable?



I-TAF Procedures

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



Example Application







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

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Develop Rubrics

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CPS Rubric – Cognitive Dimension

Dimension	Skill	Sub-Skill1	Sub-Skill2	Definition	Examples	Action Type
C O G N I T I V E	Planning	Develop Strategies			•"Using the current we find E and we can do what we did	
					last time"	
					•"Ok now V=I*R"	
					•"then we can find our R values using Ohm's Law"	
				Devise a plan or strategy to reach the goal	"ok we set our values to R and find the current"	
				state, including the steps to be undertaken	•"Let's add up our values"	chat
		Revise Strategies			 "Let's break the circuit instead" 	
				Change to a different plan or strategy to	 "Let's try something else" 	
				solve the problem	•"Let's go higher"	chat
	Executing	Enact Strategies			•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	
				Carry out the plan or strategy that has or	plan (e.g., participant may carry out Ohm's Law strategy	change resistor; take
				has not been explicitly verbalized	before informing teammates)	measurement; calculate
		Suggest/Direct Actions			•"Don't change anything"	
					 "Enter your E and R values Bear" 	
					 "Adjust yours to 300 ohms" 	
					•"Sleet try now"	
				Make suggestion for action for teammate to	•"Wait"	
				carry out	•"Give me a sec"	chat
		Report Actions			•"I set mine to 120"	
					 "I'm going to set mine higher" 	
				Communicate own actions being taken to	•"I used 100 ohms like you said"	
				carry out the plan	 "Let me go a little lower and then readjust" 	chat
	Monitoring	Monitor Success				
				Monitor progress toward the goal, including	 State where you are or team is in relation to the goal 	
				checking intermediate and final results,	state ("I'm good", "I got it", "We got it", "I'm too high",	
				detecting unexpected events, and taking	"I'm still a little low", "we're good?")	
				remedial action when required	 Click submit (submit values) 	chat, click submit
		Monitor Group				
					 Prompt teammates to perform tasks ("come on Snow", 	
					"You forgot to put in the voltage", "Let's get a move on	
					Sleet", "Now")	
					•Calling on teammates ("Lion", "Seagull", "Jessica")	
				Monitor whether teammates are present.	•Check on the status of teammates ("Where is Rain?")	
				following the rules of engagement, roles.	•Adapt team organization/roles	open/close zoom; view
				completing tasks	 "We need to figure this out" 	board in zoom; chat



Evidence Identification

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Step 4: Extract Features





Feature Extraction Example





Statistical and Psychometric Modeling

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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

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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 8th grade class. There are about 300 students in the 8th grade class, but the student council does not expect that everyone will buy a t-shirt. The student council is considering three different companies to make the t-shirts.

1. EZ Tees charges \$8 per shirt, and has a one-time setup fee of \$200.

2. Perfect 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. Please talk with your partner and decide which company you want to recommend. Write your recommendation and an explanation of why you chose that company below.

or Shirts for Less, because the school estimated that not every student would buy a shirt, so we decided to use an estimate of 100 students buying a shirt. Because of this, it would be unreasonable to use Shirts for Less,

Next





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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