Using Games to Measure Children's Intuitive Knowledge of Measurement Concepts

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PBS KIDS

Research Question: To what extent can game-based measures assess children's understanding of a pan balance?

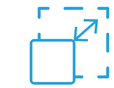
Background

Why Intuitive Knowledge?

Intuitive knowledge is associated knowledge that is hard to verbalize and often arises in dynamic, rich environments (Swaak & De Jong, 1996).

Understanding intuitive knowledge and early representations is important for developing instructional support to facilitate student learning (Gallenstein, 2005).

Why Games for Learning?

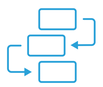


Scalable

Games support cross-platform learning (e.g., web and mobile) and can be readily adapted to both formal and informal settings (Honey & Hilton, 2011).

Multimodal Interactive

Game-based learning is not text-laden. It's friendly for learners with lower language levels and can assess both verbal and nonverbal knowledge (Wilkening & Cacchione, 2011).



Process-driven

Process data from games can contextualize problem-solving behaviors and provide richer information about the learners beyond what single-outcome measures offer (Chung & Baker, 2003).

Study

Participants

Fifty three children between the ages of 4 and 5 (M_{age} = 5.26 years).

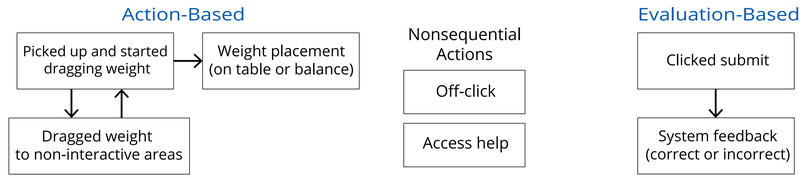
Design

Ninety nine children enrolled in the study were randomly assigned to play either ***Measure Up!*** (n = 53), an iPad app on learner's measurement concepts, or an iPad app on literacy.

Implementation

The Game ***Pan Balance***

Questions asked:
(1) What actions or game mechanics are available for children to interact with the environment?



(2) How do certain in-game behaviors relate to decisions that children may make?

Picked up and started dragging weight

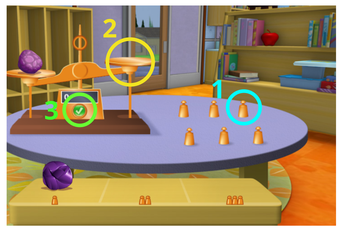
Weight placement (on table or balance)

Could relate to

1. Understanding of the state of balance
2. Weight comparison (comparing two sides of the balance)
3. Decision to add or remove weight(s)
4. Revision in response to feedback

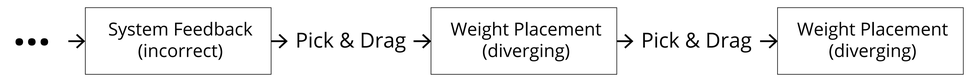
Mapping Children's Behaviors in Metz (1993) to Gameplay in Pan Balance

Higher is Heavier Misconception	
Definition by Metz (1993)	Gameplay Pattern
"Attempt to attain the goal state by displacing elements from the down-pan to the up-pan . . . Absence of concern with heavier element per se, as evidenced by . . . manipulations"	1. Picked up Weight (from table OR balance) 2. Placed Weight (on table OR balance) **# of weights diverge from # of weights needed** 3. Clicked Submit 4. System Feedback **Incorrect answer**

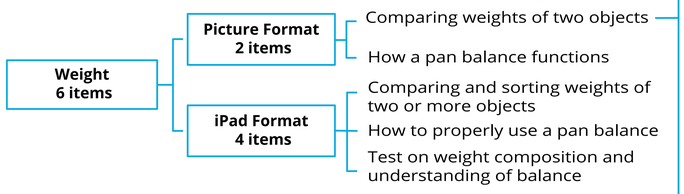


Algorithm

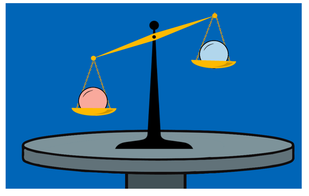
Relative to the last weight placement action,
Balanced = Weight difference between two sides equals 0
Converging = Weight difference between two sides converges to 0
Diverging = Weight difference between two sides diverges from 0



External Measure of Children's Concepts of Weight



Example Item:
"Can you tell me which ball is heavier?"



Item reliability was .75 for the overall pretest, .66 for items on weight, .80 for the overall posttest, and .78 for items on weight.

Results

Spearman's rank correlations between the frequency of "higher is heavier" misconception and external measures.

n = 53		M	SD	1	2	3	4
1	Higher is heavier	1.64	3.13				
2	Overall posttest scores	13.55	3.68	-.38**			
3	Gain in overall scores / pretest	.24	.30	-.17	.28*		
4	Weight posttest scores	3.47	1.81	-.29*	.79***	.06	
5	Gain in weight scores	1.24	1.72	-.18	.48***	.52***	.56***
n = 24		M	SD	1	2	3	4
1	Higher is heavier	3.63	3.82				
2	Overall posttest scores	12.35	3.68	-.47*			
3	Gain in overall scores / pretest	.20	.26	-.28	.40		
4	Weight posttest scores	3.06	1.80	-.40	.69***	.23	
5	Gain in weight scores	1.06	1.66	-.47*	.52*	.46*	.77***

All children (n = 53)
Children with "higher is heavier" misconception (n = 24)
*p < .05. **p < .01. ***p < .001.

Discussion

Significant correlations with external measures provide validity evidence for game-based measures.

The alignment between design, analysis, and literature findings help develop useful game-based measures for assessing cognitive constructs.

Future Directions

Formalization of current techniques (e.g., declarative representation and semantics) used to model gameplay flow and interaction.

Algorithms based on representations to detect bottlenecks and changes in strategy.

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