DEVELOPING MATHEMATICAL PROCESSES THROUGH COMMERCIAL GAMES

P. Janelle McFeetors, janelle.mcfeetors@ualberta.ca, Department of Elementary Education

QUESTION

What mathematical learning do students demonstrate through their experiences with games and with each other?

BACKGROUND

LEARNING THROUGH GAMES

Students can develop a meaningful understanding of mathematical ideas through games before they move toward abstractions (Dienes, 1971). Ernest (1986) identified three educational uses of games: gain skill-based fluency, develop conceptual understanding, and refine problem solving.

THEORY OF EXPERIENCE

Theoretically, the study is grounded in Dewey's (1938/1997) notion of educative experiences through activity and reflection. Moreover, games provide opportunities for *foundational experiences*, as those (inter)actions and reflections that prepare students for more formalized learning in subsequent mathematics classes.

MATHEMATICAL PROCESSES

Rather than content as the unifying element in curriculum, Costa and Liebmann (1997) suggest processes could be the focus of students' learning. Mathematical processes are ways in which students are active in *doing* mathematics. The provincial curriculum (Alberta Education, 2007/2015) identifies the following processes: communication, connections, mental mathematics and estimation, problem solving, reasoning, technology, and visualization. Opportunities for children to develop mathematical processes are imperative if these processes are to be used to understand specific mathematics content.

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RESEARCH DESIGN

ACTION RESEARCH

- Deweyan-inspired AR (Stark, 2014)
- 5 cycles to refine process
- In a cycle: introduction, exploration in pairs, analyzing, and convincing
- Analysis by coding moments of types of mathematical processes shown
- Interpretation by developing understanding of students' experiences

CONTEXT & PARTICIPANTS

- Two suburban elementary schools in a large Canadian city
- Lansford: lunchtime math club
- Glendale: math stations in 3 classes
- 65 students in grades 4 to 6
- 5 teachers
- Game selection by teachers to fit context and students

COMMERCIAL GAMES

- CirKis
- Equilibrio
- Farkle
- Go
- Gobblet Gobblers
- Othello/Reversi
- Quartex
- Set
- Tic Stac Toe

DATA COLLECTION

- 10-12 weekly visits per site
- Participant observation & field notes
- Photographs
- Students' working papers: pictorial and written responses
- Emergent pedagogical documentation
- Student interviews in pairs
- Individual, informal interviews with 5 teachers

RESULTS

Students' experiences point to a fourth educational intention for incorporating games in mathematics class: students can improve their capabilities in relation to mathematical processes. While I see all the mathematical processes as highly interconnected, three processes – communicating, reasoning, and visualizing – illustrated on this poster were chosen because students prominently displayed use and/or growth within them.

COMMUNICATING

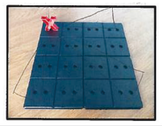
Students' mathematical communicating was inherent in negotiating and defending specific plays, and was refined as students developed language for moves and saw their peers as an authentic audience.

I like to make rhombus shapes and triangle shapes… it's difficult to capture. Renee

I think if you were playing someone experienced you'd have to shift strategies so they couldn't pick up your strategy but someone new wouldn't know necessarily what you are doing. Shifting strategies becomes important as you get good. Eve

REASONING

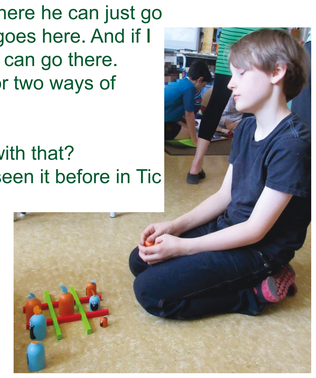
In generating and stating strategies, students started by explaining their moves. Their growth in reasoning was evidenced by providing justifications through structures like informal deductive statements and reasoning by analogy.



Because when you go in the corners you have 4 directions to go and 7 ways to win

I'm telling my strategies in the interview, but I normally like to keep them secret. … I would probably keep starting in the corners a secret. And stacking up to four a secret. Derek

E: I have Faris in the checkmate position.
I: How does the checkmate position help you?
F: Because then if I put it here he can just go here. If I put it here he goes here. And if I put it over here then he can go there.
I: So you have it set up for two ways of winning?
E: Yep
I: How did you come up with that?
E: Just from playing. I've seen it before in Tic Tac Toe.



VISUALIZING

Students' visualizing improved through first physically testing playing pieces on the game boards toward an ability to predict several moves in advance or a capability to find the best spot to place a game piece.

I'm a good looker. … SET gives your eye a good workout. Zahra

I look for two that are pairs and then I try to see if there is something that can go with that and if not I just move on to a different two. Rimira

It's all about the angles. You have to look diagonally, horizontally and vertically to see the different options. Owen

Don't just keep your piece; flip it around so that you can try to see where it can go. Sadie

DISCUSSION

Students' development within the processes was interconnected as their ability to see logical moves were verbalized to peers. Rather than the mathematical processes as reifications, students acted on the processes to improve their use through the authentic context of commercial games. Future studies could build upon this work to explore: 1) more of the mathematical processes imbedded in students' game play; 2) a broader range of commercial games, responding to the availability of new games continually being created; and 3) how parents could be invited to re-engage in their children's mathematical learning through informal game play at home.