Exploring Help-Giving Behavior and Modeling Interaction to Provide Collaboration Support in a Cross-Platform Learning Environment

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Collaboration Scenario

Interaction and learning activities distributed across physical and virtual learning environment.

- Face to face discussion
- Watch a video
- Digital Environment
With Multiple Platforms...

Practice skills and collaborate in different ways.

Transfer skills (i.e., domain knowledge, collaborative skill) from one platform to another.

One platform might inform student behavior on the other platforms.

To encourage productive interactions, students need to be supported during collaboration.
Adaptive Collaborative Learning Support (ACLS)

Learning technology assesses student collaborations in real-time, compares interactions to an ideal model, and provides support.

Key promise: improve learning outcomes via personalized support.

Existing ACLS focuses on single activity in a given context.

(Kumar et al. 2007, Gweon et al., 2006)
Our Work

Develop an understanding of students’ collaborative interactions in a middle school mathematics classroom.

Identify what influences student interaction and how students collaborate across multiple platforms.

Cross-Platform Adaptive Collaborative Learning Support

- Take into account students collaboration in different platforms.
- Support students’ transfer of skill across different platforms.
Collaborative Skills: Help Giving

Characteristic of promotive interaction (Johnson & Johnson, 2009)

Students give explanation, provide feedback and clarify their own understanding (Webb, 1994)

Critical part of collaboration - students struggle!
Collaborative Skills Differ - But Why?

Context - face to face vs digital, synchronous (i.e., chat) vs asynchronous (i.e., email, online discussion forum).

Lack of domain knowledge or help-giving skills.

Lack of motivation in the content or help-giving.
How do students collaborate in different learning platforms?

- System Design
- Example Interaction Flow
- Quantitative Analysis
- Qualitative Analysis
System Design

Three platforms:
- Interactive Digital Textbook
- Online QA site
- Teachable Agent (Lubold, N., Pon-Barry, H., & Walker, E., 2015)

Curriculum followed Modeling Pedagogy. (Jackson, 2008)

Open ended math problems on ratios and proportions, volumes and functions.
Study Plan

Following Design-Based Research, conducted 3 iterative studies.

Five day long classroom study.

Students collaborate in multiple platforms.

Use a technology we designed.

Introduced teachable agent in the 2nd cycle.

Observe student behavior and log their interaction across the platforms.
Interactive Digital Textbook - Modelbook

General Chat

i think its 2 plus 5

dolphin

got you its 2 blue and 3 red because it continues to add 2 blue and 3 red like 4 blue and 6 red

elephant

were did you get 7!!!

squirrel

if we have 2 cups + 3 cups that would = five but we need 20 cups

ant

I agree with ant because after the whole conversation we had i was thinking that if you do 2:3 20 times, you will still have the same color

alligato

disagree once again the ratio is 2:3 not like 2:10 like what? and where did you get the green from?

leopard

Good job! This is something I totally understand.

tiger

we did that same thing

ant

Comment on this picture

Type a message to your class here

dinaffe
Online QA site: Khan Academy

Isabella Betteh a year ago
What is the easiest method for solving rates
Reply | Comment

Mckayla K 123 6 months ago
that depends on what you are trying to find
Comment

See 1 more reply

elev.dariaandreevna.rezova 7 months ago
Is it good to know them?
Reply | 1 comment

Canuck150 4 months ago
yes they are very good friends
1 comment

EpicPhantom 7 months ago
Because the rate in which you are doing something changes, do you take the average?
Teachable Agent
Sample Interaction Flow

Students divided into groups of 2 or 3

- Whiteboard activity
- Comment on other photos
- Discuss in general chat

Each group uploads one photo

- Online Collaborative activity
- Khan Academy as Homework

One-one communication

- Teachable Agent

| Face to Face Interaction + synchronous collaboration | Digital Activity + synchronous collaboration | Homework + asynchronous collab. | Human-agent communication |
Perfect Purple Paint

Create a Model

Let's make a model using blocks to represent this problem and help us find a solution. Have one color block represent red paint and another color block represent blue paint.

Get in your groups, and use the blocks to show how much you could make 20 cups of purple paint. How much of each color would be needed to make 20 cups of Perfect Purple Paint?

When your group reaches a consensus, write your group members' names on the whiteboard, draw your solution, and explain your thinking in words.
Example Interaction from the Study

12sebastianrace 8 years ago
how do i name the ordered pair if the x-intercept is -2?

Reply = Comment

Dan Surerus 8 years ago
intercept at (-2,0) when x=-2 y=0. same as a Y intercept at (0,b). When
x=0 Y=b

Comment

Alligator 17 hours ago
You would say (-2,0) because there is no other number unless the
problem says something like (-2,-3)

Carter Blakely a year ago
At 0:27, how do you actually tell if -2 equals y? How is x=0 when there is 1/3
next to it?

Reply = Comment

david severin a year ago
A little after your time stamp, Sal states that we know that the y
intercept is -2 because the y intercept is where x=0. The idea of putting
an equation in slope intercept form is so that we can quickly recognize
the slope (m) and the y intercept (b). For the y intercept (where a
function crosses the y axis), x will always be zero.

Comment

Ant 2 days ago
the 0 is the x and the 1/3 is the y i think. i could be wrong

Comment
Can you help me figure out what waterproof paint I need to cover my arms and head too? I'm looking at STEP ONE OF PROBLEM TWO and I'm not sure what to do.

the answer is 1 oz because you cross multiply

Hmmm. So learning from how we did the last problem, I think it makes sense that the answer is one. But can you explain why it is one just a little more?

If you cross multiply 62/3? It be 2*3 which is 6/6 is 1

Sweet! I think I'm starting to get this. I will put the answer is one.
That was great! Can you give me a hint on STEP TWO OF PROBLEM TWO?

Sweet! The surface area of my head is nine square inches. I think I get it. But can you tell me. How did we figure this out?

the answer is 9 in because you cross multiply at 6 to? Over three 6 Sims 3 equals 18 so 18/2 is 9 the answer is 9

6/2 cross multiply that by something over at 3 so then six times three equals 18 than 18 divided by 2 equals 9

Sweet! Should we go to the next problem?
Participants

29 Middle School Students in 8th grade

Middle School from southwestern part of United States

December 20 students, March 26 Students, & April 24 Students (considering permission & drop-outs)
How do individual students’ help-giving skills vary across different learning platforms?

How does student help-giving behavior across different platforms predict learning?

How do individual differences predict student interactions across multiple platforms?
Motivational Measurement

Self-efficacy adapted from Motivational Strategy and Learning Questionnaire (Pintrich, P.R. and De Groot, E.V., 1990)

Math attitudes adapted from Attitudes Towards Mathematics Instrument (Tapia, 2004)
Data Processing and Analysis

Processed and analyzed:
- Digital interaction data from Modelbook and
- Khan Academy data from homework sheets

Coded individual student utterances and identified help-giving behaviors.

Performed statistical analysis to answer research questions.
Help-Giving Behavior Coding

Coding scheme inspired from (Webb, 2003) & Bales, R.F (1950)

Student Utterance

Level of Relevance

Level of Elaboration

Social

17% dialogues coded by 2nd coder, LOE (kappa=.805), LOR (kappa=.954) and Social (kappa=1.0)

General
“I agree because my board also was not an exact pattern.”

Specific
“I think the unit rate is not 2/3 but it is 2:3”

Offtopic

Non-elaborated
“answer is 2:3”

Elaborated
“maybe it is 5 cups to 1 because 5 cups makes 1 cup of purple”

Praise, apologetic, polite, & encouragement
Interaction Count

Mean and standard deviation of student utterance in Modelbook and Khan Academy.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utterance in Modelbook</td>
<td>10.9375</td>
<td>6.546</td>
</tr>
<tr>
<td>Utterance in Khan Academy</td>
<td>3.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Research Question

How do individual students’ help-giving skills vary across different learning platforms?

How does student help-giving behavior across different platforms predict learning?

How do individual differences predict student interactions across multiple platforms?
RQ1: How does student interaction differ between Modelbook and Khan Academy?

Computed percentages of contribution out of students’ on-topic utterances.

<table>
<thead>
<tr>
<th>N=16</th>
<th>Modelbook</th>
<th>Khan Academy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Elaborated</td>
<td>10.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Specific</td>
<td>44.0</td>
<td>26.7</td>
</tr>
<tr>
<td>Social</td>
<td>21.9</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Table: $M$ and $SD$ of percentage utterances
RQ1: How does student interaction differ between Modelbook and Khan Academy?

Repeated-measures MANOVA with help-giving behaviors as dependent variables and the platform (Modelbook/Khan Academy) as independent variable.

Overall model was significant, p < .001.

Correlation between elaborated & specific help across both platforms.

<table>
<thead>
<tr>
<th></th>
<th>MB</th>
<th></th>
<th>KA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaborated</td>
<td></td>
<td></td>
<td>Elaborated</td>
<td>r(16) = 0.433, p = 0.094</td>
</tr>
<tr>
<td>Specific</td>
<td>r(16) = 0.746, p = 0.001</td>
<td></td>
<td>Specific</td>
<td>r(16) = 0.261, p = 0.328</td>
</tr>
</tbody>
</table>

Table: Correlation between elaborated & specific help

Only specific help in Modelbook was correlated with elaborated help in Khan Academy.
Research Question

How do individual students’ help-giving skills vary across different learning platforms?

How does student help-giving behavior across different platforms predict learning?

How do individual differences predict student interactions across multiple platforms?
Repeated-Measures ANOVA showed learning was not significantly different from pretest to posttest.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ($M$)</td>
<td>4.563</td>
<td>4.687</td>
</tr>
<tr>
<td>Standard Deviation ($SD$)</td>
<td>1.4127</td>
<td>1.4477</td>
</tr>
</tbody>
</table>

RQ2: How does help-giving behavior predict learning?
RQ2: How does help-giving behavior predict learning?

Stepwise multiple regression analysis

Predictors
- percent elaborated in MB and KA
- percent specific in MB and KA
- percent social in MB
- pre-test score
- ATM score
- pre self-efficacy

Dependent Variable
- post-test score

Only percent elaborated in MB ($p=0.003$) and pretest score ($p=0.010$) significant predictors.
Research Question

How do individual students’ help-giving skills vary across different learning platforms?

How does student help-giving behavior across different platforms predict learning?

How do individual differences predict student interactions across multiple platforms?
RQ3: How does motivation and prior domain knowledge predict student help-giving behavior across the two platforms?

Multivariate regression done for both the platforms.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-test score, average self-efficacy, and average attitude towards math score</td>
<td>percent elaborated, percent specific, social</td>
</tr>
</tbody>
</table>

No significant model emerged.

Students’ motivation prior to the intervention did not have an effect on their behaviors during the intervention.
Implications

Why is there more elaborated and specific help-giving in Khan Academy compared to Modelbook? (RQ1)

Khan Academy allows asynchronous communication
- Students may take more time to formulate their response leading to more specific and elaborated help.

Modelbook represented synchronous, informal communication with peers
- Leading to overall less high-quality help but more social behaviors
Implications

Knowledge-telling vs knowledge-building. (Roscoe, R.D. and Chi, M.T., 2007)

Khan Academy students engaged in knowledge-telling behaviors, where they gave help on concepts they had already mastered.

Modelbook represented knowledge-building behaviors, where they construct their knowledge as they are constructing their explanations.
Implications

Context matters, but why and how?

Students’ complete and specific help were not correlated with each other & the different platforms influenced how students will help each other (RQ1).

Individual differences did not predict how students gave help in either platform (RQ3).

So, a student help-giving model on one platform is unlikely to generalize to the same student’s help-giving behaviors on a different platform, and context needs to be part of any knowledge-tracing model of help-giving.
Qualitative Analysis
(ongoing analysis)

Limited sample size.

Zero count interaction difficult to interpret.

Contextual information lost with individual utterance context.

In-depth analysis of the student interaction.

Identify factors associated with student interaction in different platform.
Interviews

Conducted N=16 interviews after April cycle

Semi-structured interview asking questions related to help-giving in each platform

5 questions based on Expectancy Value Theorem (*Wigfield & Eccles, 1992*)

“I ndividuals’ choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity”
Research Questions

What was the quality of students’ participation across the different platforms over time?

What are the factors associated with student interaction?

Given a similar circumstances, can we predict student participation from a model?
### Coding Scheme

(Webb 2003, Transactivity (King, A., 1998))

What was the quality of students’ participation across the different platforms over time?

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Participation</td>
<td>At a given opportunity if there is no log of student participation</td>
<td></td>
</tr>
<tr>
<td>Unhelpful Participation</td>
<td>Off-topic; repeating comments as others</td>
<td>“I agree”; “I am confused”</td>
</tr>
<tr>
<td>Helpful Participation</td>
<td>Content-free utterances that encourages discussion</td>
<td>“like you actually have to get the graph in it so you can see what's going on:”</td>
</tr>
<tr>
<td>Specific Helpful Participation</td>
<td>Non-elaborated only answer</td>
<td>“2:3”; “I think you should subtract x”</td>
</tr>
<tr>
<td>Meaningful participation</td>
<td>Elaborated transactive participation i.e., asking clarification, correcting others, answering question</td>
<td>“It's not 2/3, it's 4/3 because it is a volume ”</td>
</tr>
</tbody>
</table>

Modelbook Interaction Data from December Cycle coded by 2nd coder, kappa=0.892
Interview Coding

Extracted themes following Thematic Analysis (Boyatzis, R.E., 1998)

“.... sometimes people like they like post stuff on there that aren't really relevant ... And so if I try and give like help in math, then they might not respond or something.” – Bear, about Modelbook

“it just takes forever to get a person to get back to you. Some answers I posted five years ago.” - Zebra, about Khan Academy

“Probably because I didn't learn anything from him. He wasn't teaching me anything.” – Leopard, about Cobi

“With math, I'm second guessing. I don't want to give the person the wrong thing.” – Penguin, demonstrating Math Anxiety

* verification step ongoing
Factors from interview

Individual Factors
- Math Self-Concept
- Math Anxiety
- Task value

Opportunity Factors
- Homework vs classwork
- Instruction Hard
- Technical Issues
- Task Type (Tool vs Post)

Contextual Factors
- Help-Present
- Old Posts
- Off-topic Comments
- Agent

Social Factors
- Peers/Known
- Strangers/Agent
- (Social Interaction Anxiety)

* verification step ongoing
Factors related to whether students will participate or not

Factors related to once they give help, whether it will be meaningful or not

$\text{CF}_{\text{MB}} = f(\text{help present, off topic, no social anxiety})$

$\text{CF}_{\text{KA}} = f(\text{help present/old post, social anxiety})$

$\text{CF}_{\text{TA}} = f(\text{platform/task value, social anxiety})$

- Social Interaction Anxiety
- Contextual Factors
- Opportunity Factors
- Motivational Factors (math-anxiety, task value)

- Modelbook
- Khan Academy
- Teachable Agent

Domain Knowledge, math self-concept
Current Work

How to make predictions about student behavior within a single platform using the cross-platform interaction model

Whether and how to encourage students (1) to participate in platforms they are less comfortable with, (2) to transfer their skills from one platform to a different platform

Whether and how the same student should be given different kinds of support on different platforms
Conclusion

We investigated whether and how student interactions:
- differed across different platforms
- predicted learning
- were informed by their individual characteristics

We found that
- context influences help-giving behaviors
- individual differences does not influence help-giving behaviors

Goal: Build a cross-platform ACLS to support collaboration across multiple platforms.
Questions?

Our goal is to build cross-platform support for help-giving.

We have evidence that context influences help-giving skills.

No evidence how individual differences influence help-giving.

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