Effects of Discussion Strategies and Learner Interactions on Performance in Online Mathematics Courses: An Application of Learning Analytics

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Introduction
Problem Statement & Possible Solution

Problem

• High failure rates in college math courses; higher in online math courses

What we know

• In mathematics learning contexts, a few studies found that the use of online discussions helped in
  - decreasing math anxiety
  - increasing achievement outcomes
• Learners performed better in “effectively designed and structured online discussions”

Challenges in Practice & Research

• Instructors seldom design/implement structured online discussions
• Prior studies tended to focus on students’ discussion behaviors rather than instructor involvement
• Little research in mathematics learning contexts
Question: What discussion design works best in online math courses?
Research Purposes

For online introductory mathematics courses:

01 Exploring instructors’ use of discussion strategies that enhance meaningful learner interactions and performance

02 Investigating learner behaviors and interaction patterns that lead to better performance
RESEARCH QUESTIONS

RQ1: What design strategies for online discussions are associated with positive student performance?

RQ2: How do different design strategies in online discussions impact the kinds of learner interactions?

RQ3: What types of learner interactions are associated with positive student performance?

*Adopted from Biggs’s 3P (Presage-Process-Product) model of teaching and learning
Canvas Learning Management System (LMS) used at a public university located in the western U.S.

- Fully online introductory (0 and 1000 levels) math/statistics courses offered between 2011 fall and 2015 summer
- Courses that used online discussions

**METHODS**

**Research Context & Sample**

**Courses**
- # of courses: N = 72
- # of instructors: N = 11

**Students**
- # of students: N = 2,869
- Unique #: N = 2,404

**Activities (Discussion topics) (N = 703)**

**Events/Actions (Discussion messages)**
- Instructors: 1,284 messages
- Students: 20,884 messages
METHODS
Workflow & Data Analysis Methods

Knowledge Discovery in Databases (KDD) Process

Selection → Pre-processing (Data cleaning) → Transformation → Data mining → Interpretation/Evaluation

Canvas
LMS

Textual data

Clickstream data

Registration system Data

Text Mining

Instructors’ Use of Discussion Strategies

Learner Interactions

Course Performance

RQ1: Classification and Regression Tree

RQ2: Kruskal-Wallis H Test

RQ3: Hierarchical Linear Modeling

Canvas
LMS

SQL Server

LightSide

R Studio
METHODS
Measurement

Instructor’ Use of Discussion Strategies

Constructs

Discussion design
- Grouping
- Types of setting
- Types of Discussion prompts
- Monitoring
- Types of Feedback (Kleij et al., 2015)

Monitoring & Facilitation

Assessment
- Use of grades

Variables

- Whole-class
- Small group
- Threaded
- Side-comments
- Open-ended
- Other
- Instructor participation
- Instructional
- Conversational
- Operational
- Graded
- Not-graded
- Partially graded

Data sources

Log Data
Textual Data
METHODS
Data Pre-processing (Text mining)

1. Hand-coded 10% of messages
   - IRR: .908 (p = .00)

2. Imported the training into LightSIDE
   - Unigrams + Bigrams + Trigrams

3. Four built-in algorithms
   - Naïve Bayes classifier, Logistic regression, Support Vector Machines (SVM), Decision trees

4. 10-fold cross-validation
   - Confusion matrix
   - Accuracy, Kappa values

5. Hand-coded 50% of messages

6. Applied the developed model to the rest of the dataset (50% of the discussion messages)
PRELIMINARY RESULTS
Semi-automated Content Analysis

Initial Prediction Models
(hand-coding: 10% of discussion messages)

- Naïve Bayes: 0.58, 0.29
- Logistic regression: 0.63, 0.33
- SVM: 0.61, 0.37
- Decision Trees: 0.48, 0.16

Final Prediction Models
(hand-coding: 50% of discussion messages)

- Naïve Bayes: 0.66, 0.49
- Logistic regression: 0.75, 0.60
- SVM: 0.73, 0.57
- Decision Trees: 0.56, 0.30

Prediction accuracy
Cohen's kappa (κ)
PRELIMINARY RESULTS
Correlation analysis

• “Instructors’ posts” showed the strongest positive correlation with the students’ average final grades ($r = .72$, $p < .05$).

• The ratio of “open-ended prompts” ($r = .69$, $p < .05$) and the ratio of “elaborated feedback” ($r = .57$, $p < .05$) showed the significant and positive correlations with the average final grades.

• The ratio of “other prompts” ($r = -.69$, $p < .05$) and the ratio of “operational feedback” ($r = -.58$, $p < .05$) showed the significant and negative correlations with the average final grades.

*Included continuous variables only
PRELIMINARY RESULTS
RQ1: Classification and Regression Tree (CART)

N = 72 (100%)
Avg. final grade = 2.02

Open-ended prompts < 69.0%
- n = 41 (56.9%)
  Avg. final grade = 1.55
  Threaded discussions only
    - n = 25 (34.7%)
      Avg. final grade = 1.48
      Elaborated Feedback < 16.8%
    - Elaborated Feedback ≥ 16.8%

Open-ended prompts ≥ 69.0%
- n = 31 (43.1%)
  Avg. final grade = 2.64
  Side Comments, or Mixed settings
    - Grading = No or Partially
    - Grading = Yes

Node 1
n = 18 (25.0%)
Avg. final grade = 1.40

Node 2
n = 7 (9.7%)
Avg. final grade = 1.68

Node 3
n = 16 (22.2%)
Avg. final grade = 1.66

Node 4
n = 13 (18.1%)
Avg. final grade = 2.28

Node 5
n = 18 (25.0%)
Avg. final grade = 2.89
Lessons Learned & Future Work

- **Text mining (semi-automated analysis)**
  - Importance of the amount of hand-coding
  - Logistic regression outperformed other algorithms
  - Use of unigram, bigrams, trigrams altogether

- **Use of open-ended discussion prompts and grading students’ messages** will lead to better student performance in online mathematics courses.

Future Work

- Validation of the CART analysis results
- RQ2: Statistical Analyses (Kruskal-Wallis H Test)
- RQ3: Hierarchical Linear Modeling (HLM)
- Interpretation and evaluation of the results
Thank you

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