THE EFFECT OF PROFESSIONAL DEVELOPMENT ON FACULTY PERCEPTIONS AND TEACHING PRACTICES IN US-KAZAKHSTAN COLLABORATION TO INTEGRATE STEM INTO DISCRETE MATHEMATICS COURSE FOR ASPIRING MATHEMATICS TEACHERS

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Context of Study

- This study was conducted as part of the Central Asia University Partnerships Program (UniCEN) to build partnership between the Teachers College (TC) of Columbia University (USA) and two Kazakhstan universities, Suleyman Demirel University (SDU) and Kokshetau State University (KSU).
- Kazakhstan is the largest country in Central Asia. Formerly one of the Soviet republics, Kazakhstan declared its independence in 1991 shortly after the collapse of the Soviet Union. Kazakhstan has the tradition of bilingual education in Russian and Kazakh languages.
- Recently, English-based instruction has been introduced in Kazakhstan universities to prepare pre-service teachers for teaching in English.
- The project developed supplemental curriculum materials for a discrete mathematics course for preservice mathematics teachers with the purpose of connecting concepts taught in high school mathematics to mathematics taught at the university level as well as to integrate digital technology and STEM applications.
- In each university the course included a lecture and a practice seminar.
  - In KSU there was one section of the course; each faculty taught five double sessions (combined lecture and practice).
  - In SDU there were two sections of the course; one faculty taught lectures to all students; other two faculty taught different sections of the practice seminar.
- Due to the COVID-19 pandemic all classes in both universities are held online.

Purpose of the Study

Examine factors affecting Kazakhstan university faculty implementation of the English-based discrete mathematics course for pre-service mathematics teachers.

Curriculum Materials

- Main textbook used for the course by both universities: Rosen, K.H. (2011) *Discrete mathematics and its applications* (7th Ed.) McGraw-Hill
- Project-developed supplemental curriculum materials included
  - discrete mathematics textbook for teachers developed as part of the project;
  - an online GeoGebra book with compilation of explorations, simulations, and investigations adapted, modified, or development by the project team for the course.

Abstract introduction of mathematics concept → Simple examples "outside" mathematics context → Connections to school curriculum → GeoGebra investigations

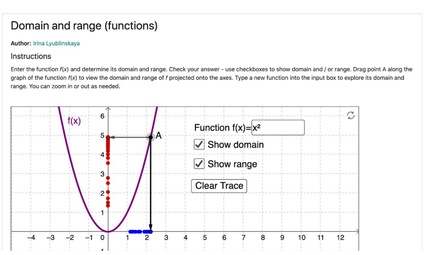
3.6.1. Function

Definition.
Let X and Y be two sets. A binary relation f from X to Y is called a functional relation or *function* (or *mapping*) *from* X *to* Y if for *every* element $x \in X$ there exists *one and only one* element $y \in Y$ such that xfy is true, or, briefly, if $\forall x \in X, \exists' y \in Y: xfy$.

A function is a special case of a binary relation with two special conditions:
1. for *every* $x \in X$ there exists $y \in Y$ such that xfy is true
2. this y is *unique*.

Examples:
1. Let M be the set of all men and W be the set of all women. Then the relation from M to W: "m is the husband of w" is not a function. Clearly, not every man is married, so the first condition in the definition of a function is not fulfilled.
2. Let C be the set of all children having at least one parent and P be the set of all parents. Then the relation from C to P: "c is the child of p" is not a function. Clearly, some children have two parents (father and mother), so the second condition in the definition of a function is not fulfilled.

4. *Constant function.* The function $f: X \to Y$ such that $\forall x \in X, f(x) = c$, where c is fixed element from Y, is called a *constant function*. $\mathrm{Im}(f) = c$. $\mathrm{Gr}(f) = X \times \{c\}$.



Background and Rationale

- Professional development may impact faculty attitudes, beliefs, and perceptions on multiple aspects of education (Edwards et al., 2015; Tuan et al., 2017).
- Faculty practices in the classroom depend on their attitudes, beliefs, and perceptions and may impact student learning and achievement in the long run (Postareff et al., 2007, 2008; Stes et al., 2010).
- Pre-service teachers' experiences in teacher preparation programs influence their teaching competencies, and faculty is an influential model for pre-service teachers. (Korthagen et al., 2005; Lunenberg et al., 2007).
- Pre-service mathematics teachers need preparation for teaching within the context of 21st-century skills (Bergstein & Frejd, 2019).
- A significant number of Kazakhstan higher education institutions transitioned to English-based instruction (Lang, 2019; OECD, 2017).
- Studies are needed to understand how to prepare higher education faculty to address the needs of preservice mathematics teachers. Specifically, in Kazakhstan, focus is on 1) integrating digital technology and STEM applications, 2) making connections between advanced and school mathematics, and 3) teaching mathematics in English.

Methods

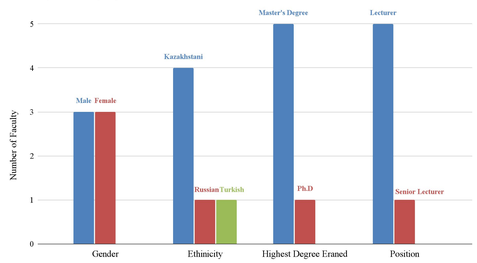
The study followed mixed-methods research methodology and was guided by the following research questions:

1. What is the effect of faculty PD on their perceptions about teaching discrete mathematics course for preservice secondary mathematics teachers?
2. What characteristics of the PD did the faculty identify as most helpful for teaching the discrete mathematics course?
3. Did university factors (public vs private) influence the effect of PD on faculty perceptions?
4. Are there differences in faculty practices between the two Kazakhstan universities?

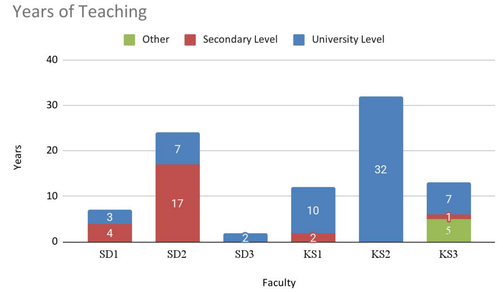
Participants

Total of six mathematics faculty (three at each university) were selected by their universities to participate in the grant-funded project. This included all faculty teaching discrete mathematics course to preservice teachers in the spring 2021.

Faculty Demographics



Years of Teaching



Instruments

1. The Faculty STEM Attitude Survey (F-STEM)
   - Modified from T-STEM survey developed and validated by Friday Institute for Educational Innovation (2012)
   - Four out of seven original sections with Likert-scaled questions: Mathematics Teaching Efficacy and Beliefs (MTEB), Mathematics Teaching Outcome Expectancy Beliefs (MTOEB), Student Technology Use (STU), Mathematics Instruction (MI)
   - The scores are composed as averages of each section
2. Faculty Demographic Survey (F-D)
3. Faculty PD evaluation survey (F-PDE)
   - Modified from Professional Development Exit Questionnaire by Friday Institute for Educational Innovation (2011)
   - Raw scores for each question were used for analysis
4. Faculty semi-structured individual interview (F-SII)
   - Modified from the Contextualize to Learn (C2L) faculty interview protocol developed by Wisconsin Center for Education Research (n.d.)
   - Each interview was was scheduled for 30 minutes
5. Faculty whole group interview (F-WGI)
   - Two parts: Project-related questions and general questions about educational traditions in Kazakhstan

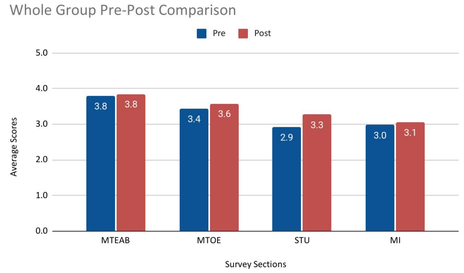
Procedure

Time period	Procedure	Data collection	Research question
Oct 2020	Using Qualtrics to collect demographics data	F-Dem	
Nov 2020	Using Qualtrics to collect faculty responses to STEM attitudes survey	F-STEM (pre)	RQ 1, 3
Nov-Dec 2020	3-day faculty PD on Saturdays	Workshop videos	
Dec 2020	Using Qualtrics to collect • faculty responses to STEM attitudes survey • faculty responses to PD evaluation survey • Individual faculty Zoom interviews	F-STEM (post) F-PDE (pre) F-SII (pre)	RQ 1, 3 RQ 1 RQ 1, 2
Jan - May 2021	• Implementation of project materials into teaching discrete mathematics course • Faculty check-in meetings with presentations and micro-teaching	3 videos and lesson plans Videos of meetings	RQ 4 RQ 4
April - May 2021	Individual faculty Zoom interviews	F-SII (post)	RQ 1, 2
May 2021	Using Qualtrics to collect faculty responses to PD evaluation	F-PDE (post)	RQ 1
Jun 2021	Faculty whole group Zoom interview	F-WGI	RQ 4

Preliminary results

Research question 1

Whole Group Pre-Post Comparison



Research question 2

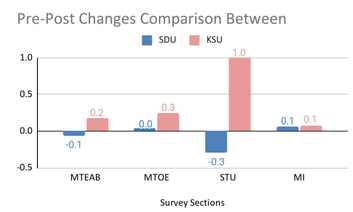
Characteristic of PD Codes

C1: Presentation about course philosophy and features, C2: Small group discussion of teaching approach, C3: Faculty developed and presented new examples outside mathematics context and connecting to school curriculum, C4: Small groups exploration of GeoGebra activities with presentations, C5: Workshop on basic GeoGebra skills, C6: Working with GeoGebra online

Code	Supporting evidence	
	After PD	**After teaching**
C1	"... I have never seen anyone in our university use STEM application in teaching discrete mathematics" (KS1)	"... instruction of abstract concepts ..., simple examples outside the mathematical context, connections with the school curriculum." (KS3)
C2	"To use real-world problems for discrete mathematics is a very good idea… it was a very abstract topic..."(SD2)	"... to master a new way [to teach], especially for discrete mathematics, because for me it's very abstract." (SD2)
C3		"[I learned] how other teachers are teaching, their experiences, teaching methods" (SD3)
C4 C6	"... use of GeoGebra [activities] for teaching discrete mathematics. I believed that this program had a limited application, but I was very wrong." (KS2)	"... using of GeoGebra … I never saw that GeoGebra can be used in the course of discrete mathematics." (KS1)
C6	"... [workshop] to create … the GeoGebra book … maybe in the future we can create [resources] like the GeoGebra book" (SD2)	

Research question 3

Pre-Post Changes Comparison Between



Research question 4

Course features	SDU (private) practices	KSU (public) practices
Organization/ structure	Separate lecture and practice taught by different faculty	Combined lecture and practice taught by the same faculty
Introduction of new material	Presentation of definitions and theorems, then presentation of examples with answers	Presentation of definitions and examples with answers, then presentation of theorems
Problem solving	Faculty pose problems to the whole class, students are called to explain their solutions.	Faculty solve problems asking students questions related to problem-solving process.
Faculty use of GeoGebra	Demonstration of examples	Demonstration of examples
Student use of GeoGebra	None	Students are called to give verbal step-by-step instructions to complete tasks with technology
Discussions	Whole class - during lecture, small group - during practice problem solving	Whole class - during problem solving only

Conclusions

The significance of this study that it is a first study that sheds some light on teaching practices and perceptions of mathematics faculty in Kazakhstan private and state universities. The preliminary findings of the study suggest that introducing faculty to different approaches to teaching discrete mathematics to preservice teachers slightly improved their perceptions about student outcome expectancy, but had a large impact on their perceptions of student technology use. The faculty indicated that exposure to GeoGebra curriculum materials for discrete mathematics was the most unexpected and helpful part of the PD. However, interviews and analysis of the course videos indicated that while faculty in both universities adapted GeoGebra for their lecture presentations, only state university faculty provided students with opportunities to learn and use technology in class. That could be due to traditional more rigid course structure.

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