This project implemented authentic, hands-on, robotics-based STEM lessons to aid middle-school students develop cognitive, collaborative, and conceptual skills, and to enhance interest in STEM-based careers. Teachers implementing robotics-based lessons and activities were provided with effective professional development opportunities to deepen their technological, pedagogical, and content knowledge, and to guide a transition towards successfully implementing the three-dimensional (3D) learning of the Next Generation Science Standards (NGSS).

**RESEARCH GOALS**

- To study teachers’ various pedagogical techniques for presenting robotics-related content and observe their effects on student perceptions and attitudes
- To examine the alignment between the 3D NGSS, 5E instructional model, and robotics-based STEM lessons and factors that can improve it

**RESEARCH DESIGN**

- **Participants:**
  - Teachers who participated in three-weeklong summer workshops infused with the model of social capital
  - Afforded opportunities to participate in hands-on programming challenges and lesson tryouts
  - Engaged in examining pedagogically challenging math and science concepts and their representations using robotics
  - Developed robotics-enhanced science and math lessons, collaboratively
  - Middle school students from NYC public schools

- **Data Collection using Mixed Methods Research:**
  - Qualitative:
    - Classroom observations (field notes, recordings, interviews)
    - Response to questions (Would you like other classes in school to use robots? Why?)
  - Quantitative data collection using validated instruments (pre-/post-tests)

- **Data Analysis:**
  - Transcribed narratives
  - Anonymized data using aliases
  - Created code book: Systematic Characterization of Inquiry Instruction in Early LearNing Classroom Environments (SCIENCE)—33 codes
  - Utilized two coders for coding and used a dichotomous scale for the presence or absence of each code, cross-verified the results with two experts
  - Conducted thematic analysis and content analysis

**RESULTS and IMPACTS**

**Results:**

- **Perceptions:** Mood of students improved in all the participating classrooms, a majority (58.44%) of students surveyed responded positively
- **Standards-alignment:** Teacher resistance and challenges to NGSS-plus-5E implementation were revealed
  - Difficulty in identifying appropriate performance expectation (PE)
  - Challenging to create lessons with robotics activities that meet the 3D model
  - Rigor and time required to create 5E lessons prohibitive

**Impacts:**

- Formulated recommendations to improve adoption of robots as educational tools, with a special focus on improving alignment with standards and student perceptions
- Identified a 7-step process for NGSS-plus-5E curriculum development, co-conceptualized and created robotics-enhanced science and math lessons that are being disseminated online
- Developed and validated a three-phase model of professional development that exploits social capital to build trust and create channels for mutual recognition and acknowledgement

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