REL Pacific Ask A REL Response

Math; Educator Effectiveness
September 2020

Question:

What might be different components, strategies, or models/theories that support how pre- and in-service teachers learn about and use the laboratory method to teach mathematics using manipulatives? Are there examples of colleges providing these learning opportunities for teachers?

Response:

Following an established REL Pacific research protocol, we conducted a web-based search for resources related to the laboratory method to support pre- and in-service teachers in teaching mathematics using manipulatives (see Methods section for search terms and resource selection criteria). We first prioritized studies in the Pacific and other Indigenous contexts for greater relevancy to our partners in the Pacific region; however, we included studies with more generalizable findings due to the limited amount of research available in these contexts. We grouped research within the following categories: components/strategies, models, or theories.

References are listed in alphabetical order within each category, not necessarily in order of relevance. Descriptions of the resources are quoted directly from the publication abstracts. We have not evaluated the quality of references and the resources provided in this response. We offer them only for your reference. Also, our search included the most commonly used research resources, but they are not comprehensive and other relevant references and resources may exist.

Research References

Component/Strategies

Hakan, S. (2016). Investigating preservice mathematics teachers' manipulative material design processes. *EURASIA Journal of Mathematics, Science & Technology Education, 12*(8), 2103–2114. https://eric.ed.gov/?id=EJ1101809

> *From the abstract:* "Students use concrete manipulatives to form an imperative affiliation between conceptual and procedural knowledge (Balka, 1993). Hence, it is necessary to design specific mathematics manipulatives that focus on different mathematical concepts. Preservice teachers need to know how to make and use manipulatives that stimulate students' thinking as it is a crucial competency, which they will need during their careers. The goal of the present study was to investigate the manipulative material design processes of preservice mathematics teachers. Data were gathered by using interviews and questionnaires to explore how the preservice teachers devise new manipulatives. It was concluded that the preservice mathematics teachers are struggling to develop new ideas for an appropriate manipulative material design. They encountered structural difficulties when they attempted to transform their ideas into concrete models. Moreover, their ideas and designs sometimes can be very different from manipulatives designed by experts."

Kamina, P. & Iyer, N. N. (2009). From concrete to abstract: Teaching for transfer of learning when using manipulatives. *NERA Conference Proceedings 2009*. https://www.semanticscholar.org/paper/From-Concrete-to-Abstract:-Teaching-for-Transfer-of-Kamina-Iyer/b6aa837b76272a7790a3b6772ba7c2d899ca7ecb

> *From the abstract:* "One of the most important uses of manipulatives in a classroom is to aid a learner to make connection from tangible concrete object to its abstraction. In this paper we discuss how teacher educators can foster deeper understanding of how manipulatives facilitate student learning of math concepts by emphasizing the connection between concrete objects and math symbolization with, preservice elementary teachers, the future implementers of knowledge. We provide an example and a model, with specific steps of how teacher educators can effectively demonstrate connections between concrete objects and abstract math concepts."

Ünlü, M. (2018). Effect of micro-teaching practices with concrete models on pre-service mathematics teachers' self-efficacy beliefs about using concrete models. *Universal Journal of Educational Research, 6*(1), 68–82. https://eric.ed.gov/?id=EJ1165419

> *From the abstract:* "The purpose of the current study was to investigate the effect of micro-teaching practices with concrete models on the pre-service teachers' self-efficacy beliefs about using concrete models and to determine the opinions of the pre-service teachers about this issue. In the current study, one of the mixed methods, the convergent design (embedded) was used. The participants in the study consisted of 41 pre-service elementary mathematics teachers who were enrolled mathematics teacher education programme at a state university in Turkey. In this research, The Instrument of Pre-service Mathematics Teachers Efficacy Beliefs about Using Concrete Models developed by Bakkaloglu and interview forms were used as data collection tools. The research revealed that the micro-teaching practices with concrete models had positive effects on the pre-service teachers' self-efficacy beliefs about using concrete models. Pre-service teachers think that these micro-teaching practices had positive effects on the skills of teaching."

Models

Kazemi, E., Gibbons, L., Lewis, R., Fox, A., Hintz, A., Kelley-Petersen, M., Cunard, A., Lomax, K., Lenges, A., & Balf, R. (2018). Math Labs: Teachers, teacher educators, and school leaders learning together with and from their own students. *NCSM Journal,* 23–36. https://coetedd-wpengine.netdna-ssl.com/wp-content/uploads/2017/05/JMEL-Math-Labs-2018.pdf

> *From the abstract:* "This article describes a structure for embedding professional development within a school day, which we call Math Labs. It enables teachers to come together, with the guidance of a teacher educator, to engage in collective inquiry into the teaching and learning of mathematics with time to experiment with new ideas with their own students. We explain the design principles, reflecting our commitments to equity and social justice, that motivate what occurs during a typical Math Lab. When Math Labs become an integral part of the school's culture, they allow teachers and school leaders to negotiate (1) how they position and empower students; (2) what opportunities they give students to learn rich mathematics; and (3) what shared professional values guide their inquiry into students' mathematical learning."

Morales, S., & Sainz, T. (2017). Problem solvers: MathLab's design brings professional learning into the classroom. *Learning Professional, 38*(1), 36–40. https://eric.ed.gov/?id=EJ1134833; full text available at https://creatingwhatsnext.org/journal/february-2017-vol-38-no-1/problem-solvers/

From the abstract: "Imagine teachers, administrators, and university mathematicians and staff learning together in a lab setting where students are excited about attending a week-long summer math event because they are at the forefront of the experience. Piloted in three New Mexico classrooms during summer 2014, MathLab expanded into 17 lab settings over six locations during summer 2015 and was implemented again in 2016. The enthusiasm of all participants witnessed by the New Mexico Public Education Department has resulted in funding to support future events. MathLab is an innovative learning design from New Mexico State University's Mathematically Connected Communities (MC[superscript 2]), a partnership of New Mexico educators that includes mathematicians, school leaders, researchers, and teachers. Aligned to Learning Forward's Standards for Professional Learning, MathLab began as an idea to shift from traditional one-shot professional development to ongoing professional learning situated in K-12 mathematics classrooms. This article discusses: MathLab's goals; what MathLab looks like for teachers and administrators; MathLab's framework; MathLab's results and impact; and what happens after MathLab."

Theories

Chase, K. & Abrahamson, D. (2018). Searching for buried treasure: Uncovering discovery in discovery-based learning. *Instructional Science: An International Journal of the Learning Sciences, 46*(1), 11–33. https://eric.ed.gov/?id=EJ1170533; full text available at https://edrl.berkeley.edu/publications/chase-k-abrahamson-d-2018-searching-for-buried-treasure-uncovering-discovery-in-discovery-based-learning/

From the abstract: "Forty 4th and 9th grade students participated individually in tutorial interviews centered on a problem-solving activity designed for learning basic algebra mechanics through diagrammatic modeling of an engaging narrative about a buccaneering giant burying and unearthing her treasure on a desert island. Participants were randomly assigned to experimental (Discovery) and control (No-Discovery) conditions. Mixed-method analyses revealed greater learning gains for Discovery participants. Elaborating on a heuristic activity architecture for technology-based guided-discovery learning (Chase and Abrahamson 2015), we reveal a network of interrelated inferential constraints that learners iteratively calibrate as they each refine and reflect on their evolving models. We track the emergence of these constraints by analyzing annotated transcriptions of two case-study student sessions and argue for their constituting role in conceptual development."

Sung, W. & Black, J. B. (2020). Factors to consider when designing effective learning: Infusing computational thinking in mathematics to support thinking-doing, *Journal of Research on Technology in Education,* 1–23. https://www.tandfonline.com/doi/full/10.1080/15391523.2020.1784066

From the abstract: "This study examined what factors might have a positive impact on students' learning outcomes in mathematical understanding and computational thinking skills. Specifically, whether the proposed instructional design combining computational perspectives and an embodied approach in mathematics learning improves (a) mathematics learning, (b) problem-solving skills in programing, and (c) computational thinking. The study used a quantitative quasi-experimental design with 115 second- to fourth-grade students. Findings suggested that embodied activities combined with the practice of taking computational perspectives in solving mathematics problems led to improved knowledge in mathematics, programing concepts, and computational thinking among young learners. This paper also discusses how to make the computational thinking process more concrete and relevant within the context of mathematics to promote computational thinking skills."

Vieira Oliveira, Z., & Kikuchi, L. M. (2018). The mathematics laboratory as space for teacher education. *Cadernos de Pesquisa 48*(169), 802–828. https://www.academia.edu/37681228/THE_MATHEMATICS_LABORATORY_AS_SPACE_FOR_TEACHER_EDUCATION_O_LABORAT%C3%93RIO_DE_MATEM%C3%81TICA_COMO_ESPA%C3%87O_DE_FORMA%C3%87%C3%83O_DE_PROFESSORES

> *From the abstract:* "The mathematics laboratory is an essential learning space for students of basic education as well as for early teacher education. In addition to the materials and physical space provided, it constitutes a proper space capable of promoting the reflection of future teachers. In this exploratory study, conducted with students in Teaching Methods in Mathematics Education at Universidade de São Paulo, we verified the initial conception of the students about such lectures and how the mathematics laboratory influenced them in the process of critical maturation concerning their roles as teachers. From this study, we noted that the moments of production and reflection on the tasks, in addition to practices with their peers, were crucial in preparing them for their future profession."

Additional Organizations to Consult

National Council of Teachers of Mathematics. https://www.nctm.org/

> *From the website:* "Founded in 1920, the National Council of Teachers of Mathematics (NCTM) is the world's largest mathematics education organization ... The National Council of Teachers of Mathematics advocates for high-quality mathematics teaching and learning for each and every student."

Methods

Keywords and Search Strings

The following keywords and search strings were used to search the reference databases and other sources:

- Models and pre-service teachers and manipulatives and math instruction
- "Manipulatives" and "teacher preparation"
- "Discovery method" or "laboratory method"
- "Concrete method" and "teacher preparation" and "math"
- "Learning lab"

Databases and Resources

We searched ERIC, a free online library of more than 1.6 million citations of education research sponsored by the Institute of Education Sciences, for relevant resources. Additionally, we searched the academic database Google Scholar for other resources.

Reference Search and Selection Criteria

REL Pacific searched ERIC and Google Scholar for studies that were published in peer-reviewed research journals within the last 15 years. We also conducted research harvesting of select research for additional resources. Sources included in this document were last accessed in September 2020.

REL Pacific prioritized documents that are accessible online and publicly available, and prioritized references that provide practical information based on peer-reviewed research for the education leadership who requested this Ask A REL.[1] For questions with small or nonexistent research bases, we may rely on, for example, white papers, guides, reviews in non-peer-reviewed journals, interviews with content specialists, and organization websites. Additional methodological priorities/considerations given in the review and selection of the references were:

- Study types—randomized control trials, quasi experiments, surveys, descriptive data analyses, literature reviews, etc.
- Target population, sample size, study duration, etc.
- Limitations, generalizability of the findings and conclusions, etc.

[1] This memorandum is one in a series of quick-turnaround responses to specific questions posed by education stakeholders in the Pacific Region (American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Guam, Hawai'i, the Republic of the Marshall Islands, and the Republic of Palau), which is served by the Regional Educational Laboratory (REL Pacific) at McREL International. This memorandum was prepared by REL Pacific under a contract with the U.S. Department of Education's Institute of Education Sciences (IES), Contract ED-IES-17-C-0010, administered by McREL International. Its content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.