REVIEW OF

Research on Teaching Numeracy

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The following reference document provides a brief review of academic research and relevant reports on best practices for teaching and assessing numeracy skills. The purpose of this research was to support the development of the Skills for Success Practitioner Competency Framework and was part of a series of research reviews on best practices for teaching each of the Skills for Success. This summary provides an overview of evidence-based teaching methods in the area of numeracy, key considerations when applying these practices, and a list of resources for further consideration.

METHODOLOGY

Several search queries were conducted on Google and Google Scholar using combinations of the following keywords: teaching, strategies, teacher education, instruction, learning, assessment, education, professional development, literacy, numeracy, numeracy skills, adults, and workplace.

STATE OF THE LITERATURE

Although there is extensive research on teaching mathematics, the research on best practices for teaching mathematics to adults (i.e., numeracy) is much more limited despite an increase in recent studies (Coben et al., 2003; Gal, 2020).

There is also very little research on teacher education and professional development in the area of adult numeracy (Coben et al., 2003).

CONCEPTS

The new Skills for Success Framework (SRDC, 2021) defines numeracy as follows:

DEFINITION:

"Your ability to find, understand, use, and report mathematical information presented through words, numbers, symbols, and graphics. For example, at work we use this skill to perform calculations, order and sort numbers, make estimations, and analyze and model data."

CONSTRUCTS:

- Identify the task that will require you to use numeracy
- Identify the mathematical information
- Make connections between related pieces of mathematical information
- Apply mathematical operations and tools you will need to answer the question
- Interpret and evaluate the information
- Share the mathematical information, results, and implications

However, the term 'numeracy' is disputed and there are a number of different definitions used by academics and practitioners (Coben et al., 2003). Despite differences in these definitions, they generally agree on the following key points:

- Pure mathematics is abstract and context-free, whereas numeracy includes a connection to context, purpose, or use. Numeracy weaves mathematical topics into the context of work, community, and personal life (Ginsburg, 2006);

- Numeracy is not a basic skill, but rather fundamental to mathematical understanding and activity (Coben et al., 2003);
- Not all numeracy activity is visible, which raises challenges for teachers, researchers, and learners, who may perceive their existing mathematical knowledge as 'common sense' (Coben et al., 2003).

The Organization for Economic Cooperation and Development (OECD) (2018) defines a numerate adult as one who is able to "first to use their mathematics content knowledge to recognize the mathematical nature of a situation (problem) especially those situations encountered in the real world and then to formulate it in mathematical terms," (p.8).

APPROACHES TO TEACHING NUMERACY SKILLS

At the foundational level, the research suggests that, similar to children, adult learners should be able to demonstrate all aspects of mathematical proficiency, including conceptual understanding, procedural fluency, strategic competency, and adaptive reasoning.[1] Computational fluency not only requires proficiency with arithmetic and algebraic procedures, but also a strong understanding of why and how these procedures work.

The following section provides an overview of instructional principles/practices highlighted in the literature as being important for teaching numeracy. It is important to note that these the available evidence to support these findings remains limited, given that adult numeracy is a relatively new field of study.

Learner attitudes and emotions relating to numeracy

- Numeracy instruction needs to recognize, assess, and address negative beliefs and emotions that can interfere with learning (Ginsburg et al., 2011).
- Adults who have had difficulty with math need to develop a positive attitude and sense of competence and confidence in order to succeed (Dingwall, 2000).
- Thinking and emotion are inseparable and, therefore, the use of mathematics in the 'real world' is always emotional (Coben et al., 2003).
- Research has found that addressing social, affective, and motivational factors can improve skills in numeracy for underrepresented groups, which helps to reduce their vulnerability to negative stereotypes about their abilities in mathematics (Ginsburg et al., 2011).
- A survey conducted by Singh (1993 as cited in Cohen et al., 2003) into the attitudes of adults related to mathematics found that:
  - Students cite the abstract nature and lack of real-world relevance of mathematics as reasons for their dislike of and failure in mathematics;
  - The fear of failure induced by testing and the nature of mathematics pedagogy may be one of the causes of anxiety in adults;
  - Teachers have a significant influence on whether students feel motivated to learn or become dissatisfied with mathematics;
  - Women may be more prone to develop negative attitudes toward mathematics through social environments and the content and pedagogy of mathematics.

[1] Conceptual understanding: comprehension of mathematical concepts, operations, and relations; procedural fluency: skill in carrying out procedures flexibly, accurately, efficiently, and appropriately; strategic competence: ability to formulate, represent, and solve mathematical problems; adaptive reasoning: capacity for logical thought, reflection, explanation, and justification; productive disposition: habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy (Ginsburg et al., 2011).

- To address math anxiety in adults, Tobias (2003 as cited in Cohen, D. et al., 2003) recommends:
  - Students need to take responsibility for their mathematics learning, and not be intimidated by their history and the culture of previous experiences learning mathematics;
  - Teachers must create environments where math anxiety can be discussed openly, help students recognize their mathematics strengths, and provide opportunities for success;
  - Teachers must help students develop appropriate reading skills (given that mathematics books can be challenging to read), as well as help students understand mathematical language and notation;
  - Teaching styles must be adjusted to include methods that recognize differences invoked by gender and culture;
  - Talking and writing about feelings and strategies must permeate the course.

Contextualizing mathematical instruction

Situating math instruction in the real world: Research notes that it is critical to situate mathematics problem-solving within meaningful, realistic contexts (Ginsburg et al., 2011).

- "The question of the ways in which knowledge, skills and understanding are situated and embedded in contexts and whether or not they are transferable (or translatable) is a key one for all mathematics educators" (Coben et al., 2003; p.53).
- Successfully applying new knowledge and skills reinforces both learning and the motivation for learning (Dingwall, 2000).
- Instruction should include connections to student interests, work situations, and everyday life to engage learners and promote applicability (Ginsburg et al., 2011).
- Practitioners need to develop learners' understanding by allowing them to explore mathematical ideas with concrete or visual representations and hands-on activities (Ginsburg & Gal, 2000). However, less experienced teachers might face difficulties relating the curriculum to the learner's context (Coben et al., 2003).

Building on previous knowledge and construct systems: Instruction in numeracy needs to provide knowledge and skills that learners can use to adjust and expand on the mathematical systems and models they use in their personal and work lives.

- By working with pre-existing knowledge, skills and strategies, new knowledge and skills are more easily learned, understood, and applied (Dingwall, 2000);
- Students can use their informal knowledge to construct meaning from what they learn through formal instruction, although a clear relation must exist between the two (Coben et al., 2003).

Instructional and learning practices for numeracy

Collaborative learning can have a positive influence on mathematics performance and may be of particular value for marginalized students, such as those from low-income backgrounds (Ginsburg et al., 2011).

- Collaborative or cooperative learning refers to interactive instructional strategies, which can involve formal and more casual approaches.
- For cooperative learning to succeed, it is critical that strategies and activities have a clear structure (Ginsburg et al., 2011).
- Implementing a variety of student grouping strategies can enhance learning through communication and collaboration (Coben et al., 2003).

- Collaborative learning helps prepare adults for the requirements of the workplace, as the workplace requires adults to communicate mathematics to other users and interpret the mathematics used by others. Additionally, the diverse cultural backgrounds of adult learners allow for an opportunity for learning from each other (Ginsburg et al., 2011).

Link numeracy and literacy instruction by providing opportunities for students to communicate about mathematical issues (Ginsburg & Gal, 2000; Gal et al., 2020).

- Solving a numeracy problem in a real-world context usually involves reading, interpreting, solving, and communicating in a mathematical manner (Gal et al., 2020). It is, therefore, necessary to understand and use a range of both text-embedded informal and formal linguistic approaches, as well as mathematical terms, language, symbols, and representations.

Research identifies **communication as a critical instructional and learning practice in the math classroom**.

- Communication helps learners develop problem-solving skills and integrate new information into previous knowledge. It also allows students to develop and expand on their own thinking and the ideas of others by engaging in discussion (American Institute for Research, 2014). There is also some evidence that aspects of language acquisition will develop when supplemented with conceptual tasks and activities that focus on mathematics (Coben et al., 2003).

Technology and numeracy: Although there is debate in the literature on the role and benefit of technology for math instruction, particularly around the use of calculators, the research suggests that mathematics instruction should include the technology used in the contexts for which students are preparing (Ginsburg et al., 2011).

- Although adults need to be able to compute by hand or mentally when necessary, they also need to feel comfortable using other technologies when appropriate (Ginsburg et al., 2011).
- Technology also allows practitioners to demonstrate concepts in ways that may be easier for learners to understand than hand-written or verbal explanations (American Institute for Research, 2014).
- Research suggests that a combination of classroom and digital learning seems to be most effective (American Institute for Research, 2014).

Self-Regulated Learning refers to developing a person's ability to understand and control their learning environment.

- Self-regulated learning helps to prepare adults for lifelong learning and the capacity to transfer skills, knowledge, and abilities from one context to another (American Institute for Research, 2014).
- To support self-regulated learning, numeracy instruction is most effective when connected to strong goals that have the power to motivate and inspire adults to learn and apply mathematics (Dingwall, 2000).
- Instruction also needs to be accessible, flexible, provide a range of choices, and meet the needs of students with diverse goals and unique contexts (Dingwall, 2000; Coben et al., 2003).
- The National Council for Teachers of Mathematics (American Institute for Research, 2014) promotes the following teaching methods for developing learner autonomy:
  - Be open to students using different approaches and strategies and expect them to explain their reasoning;
  - Use whole-class, group, and individual instruction and when creating small groups consider the knowledge, interests, and learning preferences of the group members;

- Use multiple instructional strategies, providing variation in content, process, and student products;
- Offer choice and flexibility in how students can engage with material, allow for different pacing, and give options in work assignments.

ASSESSMENT OF NUMERACY SKILLS

Formative assessment and constructive feedback are critical for providing descriptive, specific, timely, and measured feedback. This allows students to understand their mistakes and adjust their processes and thinking so they can reach an appropriate solution (American Institute for Research, 2014).

- Research suggests that a balance of both formative and summative assessments is important for gathering information on a student's mathematical knowledge and understanding (Ginsburg et al., 2011).
- Involving students themselves in this process can also be important for adults. Further, recognizing progress toward goals is one of the factors that increases long-term persistence for adult learners (Ginsburg et al., 2011).

CONSIDERATIONS FOR TEACHING AND ASSESSING NUMERACY SKILLS

TEACHING

Adult learns often better understand mathematical concepts when these are linked with real-world practices and contexts relevant to them and builds upon their prior experiences and knowledge. Instructors therefore need to be comfortable approaching numeracy skills in multiple ways and methods to suit the diverse goals, contexts, and needs of their learners.

Leaner's previous experiences using and learning numeracy skills has an impact on their ability to learn and retain new skills, especially if they have faced difficulties and failures in the past. Instructors need to be mindful of their leaners' fears and emotions pertaining to math, and the ways in which learner's socio-economic backgrounds can affect their feelings towards numeracy.

ASSESSING

Research recommends that instructors approach assessment in a way that is cognizant of their learners' math anxieties, and that helps leaners understand and correct their mistakes.

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