Understanding the Developmental Mathematics Research Landscape: A Critical Look at Intended Audience and Outcomes

Martha Makowski
The University of Alabama

Derek Williams
Montana State University

Claire Wladis
Borough of Manhattan Community College

Katie Taylor
The University of Alabama

Although a wide variety of reports on developmental math exist, to date there has not been a large-scale examination of existing work from a math education point of view. Towards this goal, we analyzed 426 reports and peer-reviewed journal articles relating to developmental math published between 2000 and 2020. In report, we quantify the publishers and intended audience, examine the types of outcomes reported on and, where possible, examine the type of developmental math model discussed. We find that over the last decade, less than 20% of reports on developmental math have been aimed at math education audiences. While math education publications more frequently examine math knowledge and student experiences, the overall number of reports, compared to those examining pass rates, is relatively small.

Keywords: developmental math; literature analysis; outcomes

Developmental courses, which are taken by college students who have been identified as not yet ready for "college level" courses, enroll a large portion of undergraduate math students (Blair et al., 2018) and pose a conundrum to math education researchers. On one hand, developmental courses generally cover content traditionally labeled as "high school level." On the other hand, these courses take place in postsecondary environments with different norms, structures, and levels of access than high schools. Low success rates, particularly for students from marginalized populations (Chen, 2016), provide additional complexity to conversations about these classes.

Arguably, as experts in both education and math content, the math education research community is well positioned to contribute meaningfully to conversations about the value and equity of student outcomes and experiences in developmental math, and there is much to understand. The low success rates, combined, perhaps, with increased attention thanks to then President Obama's "American Graduation Initiative" in 2009, have resulted in a variety of developmental math initiatives. Some of these initiatives provide a mechanism for students to progress through the required content more quickly, including Bridge, Acceleration, Modularization, Corequisite and Emporium models (c.f., Parker, 2012, Twigg, 2003). Other initiatives change or restructure the required curriculum by removing algebra content and focusing more on quantitative reasoning or statistics, with the aim of better aligning the content with students' ultimate goals, such as the Carnegie Pathways (e.g., Hoang et al., 2017) model. Lastly, some initiatives remove requirements for developmental instruction entirely, such as legislation in California (A. B. 705, 2018) and Florida (S. B. 1720, 2013). However, we have noticed that math education journals rarely publish in this area.

As scholars concerned with developmental education, we were curious as to whether our impressions are reflective of the field. We have thus set out to critically analyze published literature on developmental math. Although many reviews related to developmental math exist, they tend to examine the efficacy of developmental math education (e.g., Davis & Palmer, 2010; Melguizo et al., 2011) or describe developmental initiatives (e.g., Jaggers & Blickenstaff, 2018).

In her comprehensive review, Mesa (2017) provides a discussion of the existing literature on developmental math through 2014, but only reviews documents within math education on community college students. In this review, we aim to understand the developmental math literature landscape across all sectors, with a focus on the extent that existing literature examines questions of interest and importance to math education researchers. While a variety of entities write about developmental education, as researchers we specifically focus on original reports. Towards this end, we examine a combination of peer-reviewed journal articles and reports published between 2000 and 2020 by agencies concerned with developmental math to understand:

1. Who is the intended audience of original research on developmental math?
2. To what extent does existing research define the developmental model examined?
3. Which types of developmental math outcomes are the most widely considered?

For these three questions, we also examine how, if at all, the answers have evolved over time and to what extent the body of existing work seems to contribute to an increased understanding of students' mathematical learning in these courses. Ultimately, our aim is to unpack how researchers define developmental math; analyze the types of outcomes typically discussed, particularly as they relate to learning; and build a foundation for new types of questions about developmental math to be investigated by math education researchers moving forward.

Methods

Our initial sample of records was drawn from the EBSCOhost database, which curates documents from a variety of sources, in the summer of 2021. Given the diversity of stakeholders in developmental education, the wide net provided by the EBSCOhost database was well-suited to our purpose. Our final search criteria included documents with a publication date between 2000 and 2020 (inclusive) and a system-listed document type of journal or report. In addition, the associated abstract needed to include either the word "developmental" or "remedial", a word with the stem "math", and one of the following words: college, university, post-secondary, postsecondary, or undergraduate. These search criteria yielded 1,442 documents.

Initial review of the records suggested some of the documents were unrelated to our interests (e.g., developmental psychology). In addition, some records were duplicates or were published in non-journal periodicals. Thus, we engaged in a review of the abstracts for probable inclusion in our final data set. Our final inclusion criteria for this stage of review included articles and reports with abstracts that indicated the document related to developmental math students, instructors or instruction. Articles concerned with broader examinations or descriptions of course delivery options or curriculum pathways that altered or removed developmental coursework for students were included. We included historical treatments or reviews when the focus of the document otherwise fit our inclusion criteria. To keep the focus on postsecondary settings, we did not include reports or articles that examined initiatives that took place while students were still enrolled in high school (e.g., dual enrollment). We also did not include articles that described students entering developmental math, with no other results provided, as these do not shed light on what happens in developmental math, only on the population enrolling in the courses.

After reviewing abstracts, 488 records were identified as meeting the inclusion criteria or needing further review. We then engaged in coding of the abstracts. Because coding demanded that we read abstracts deeply, we often picked up on nuances we had not previously noted and thus sometimes marked a record as incorrectly included. After discussion of these records, we removed an additional 62 documents. This left 426 records in our sample for analysis.

Initial Document Coding

We coded the document abstracts and publishing agencies. Here we discuss only those codes used in this report: Publication Agency, Audience, Outcomes and Developmental Model.

A single team member coded the publication agency and peer-review audience using data within the EBSCOhost record. The remaining three authors coded the abstracts for outcomes and the developmental model. Codes were developed iteratively through collective discussion. Fifty-three percent of the abstracts were coded independently by two team members. The remaining 47% of the abstracts were coded by a single team member. Initial agreement between all double-coded records was greater than 80% (and often greater than 90%) with the exception of coding for "other" categories on the outcomes and developmental model codes, where individuals had to describe what belonged there. Prior to the RUME conference, we intend to reconcile all coding disagreements and update our methods and results.

Publication agency. Publication agency was coded based on publisher information provided by EBSCOhost. In cases without information, we included the record if the abstract met our inclusion criteria and left the publication agency code blank. Six publication agencies were identified and coded for: Federal government agency, school or state agency, non-profit organization, professional society, institute or center, or peer-reviewed journal.

Math education audience. For records that were identified as a peer-reviewed journal, we examined the journal and determined the primary audience of the journal, making note of whether the journal was primarily geared towards a math education audience or not.

Outcomes. Abstracts were coded for the nature of the results, outcomes, or products presented. These outcomes fell into seven categories. *Passing* was assigned to reports examining students' course grades or student success rates in a math class, inclusive of either developmental or non-developmental classes. *Finish* was assigned when outcomes related to students' completion of a math class sequence, a degree, a transfer, or the student was retained. We assigned *Performance* when the outcome related to students' scores on assessments such as tests or final exams. *Knowledge* was assigned when the outcome related to assessing student understanding of mathematical ideas or concepts. *Student outcomes* was assigned when the outcome related to the students' attitudes or referred to students' success or outcomes, but did not provide enough detail to be coded as any other category. *Student experiences* was assigned when the outcome related to students' perceptions or to the climate of their program or school. *Faculty/Instruction* was assigned when the outcome had anything to do with the developmental faculty or instruction generally (e.g., students were not the population of interest). For this report, we omit discussion of "Other", but will clarify this variable prior to the conference.

Developmental model. A variety of developmental math content delivery models have emerged over the last 20 years. We coded for named initiatives, including *Pathways, Accelerated*, *Online (Emporium)*, *Corequisite*, or *Bridge*. In addition to these named initiatives, we had additional model codes: *Traditional*, *Online (Regular)*, *Policy change*, *Not Stated*, or *Other.* We only assigned Traditional when the abstract explicitly used "traditional" to describe the developmental classes discussed. This decision reflects the fact that traditional is often used to describe instruction as teacher centered and lecture heavy. However, instructional practices can vary widely (e.g., Mesa et al., 2019), even within named initiatives. When the developmental model was not named or described, we assigned "Not Stated". When the model was described, but did not fit one of the other categories, we assigned "Other".

Results

Research Question 1: Intended Audience

We first considered the proportion of research on developmental math by publication type, graphed in Figure 1. As expected, given our search criteria, a large proportion of research appeared in peer-reviewed journals; however, roughly 40% of the research on developmental math appeared in reports instead (Figure 1a). We note also that the peer-reviewed journals in this category included not just journals intended for a research audience, but also a large number of journals for practitioners (in future analysis we plan to further break down our analysis based on the intended audience of the journal, e.g., researchers vs. practitioners). Of the research on developmental math published in peer-reviewed journals over the last decade, less than 20% has been published in math education journals, even when including practitioner journals in this total (Figure 1b). Accounting for reports, the total proportion of developmental math research published in math education journals (practitioner- or researcher-focused) is then roughly 10%.

Research Question 2: Developmental Models Examined

Next, we considered the specific developmental math model mentioned in research reports over time (Figure 1c). The proportion of research articles on developmental math that did not name the developmental model decreases over time, which is likely explained by the various initiatives sparked by the American Graduation Initiative (The White House, 2009). While we might expect some "types" of developmental math to go out of fashion and others to emerge as more dominant over time, this does not seem to be the case. Rather, there currently appears to be no dominant model of developmental math in the literature, and the landscape appears to be getting more complex over time. We also note that the focus of most of these models is on providing different instructional approaches, modes of instruction, or curricular sequencing at the institutional level (e.g., how many courses do students need to take, or how many credits are attached?) rather than on the content students engage with. The Carnegie Pathways models (Hoang et al., 2017) come the closest to engaging with learning, by modifying the content students were taught (primarily removing algebra content that was viewed as difficult); however, even for this model we noticed that in our analysis of outcomes that the focus of published reports was primarily on course completion and college progress. Measures of students' learning (e.g., of specific mathematical concepts) have been less prominent.

Research Question 3: Outcomes Examined

Our examination of the proportion of outcomes shows that the most commonly measured were passing and finishing, which made up roughly half of the outcomes; the next most common was student "outcomes", with all three combined making up 71.7% of the total (Figure 1d). Only 3.2% of studies overall measured student mathematics knowledge (i.e., specific mathematical concepts or ideas). However, when considering outcomes just for peer-reviewed journals based on discipline (Figure 1d), we noted interesting differences. Articles from math education journals focused attention on students' performance or knowledge, whereas articles for other audiences tended to focus on passing and completion rates (Figure 1d). In math education journals, roughly 14.3% of research measured student learning, compared to only 1.6% in other journals. We note that the focus on learning in math education journals is relatively low compared to other outcomes; however, it is almost 9 times higher than at non-math education journals where the bulk of the research is currently published. Therefore, increasing coverage of developmental math research in math education journals could increase reforms focused on student learning.

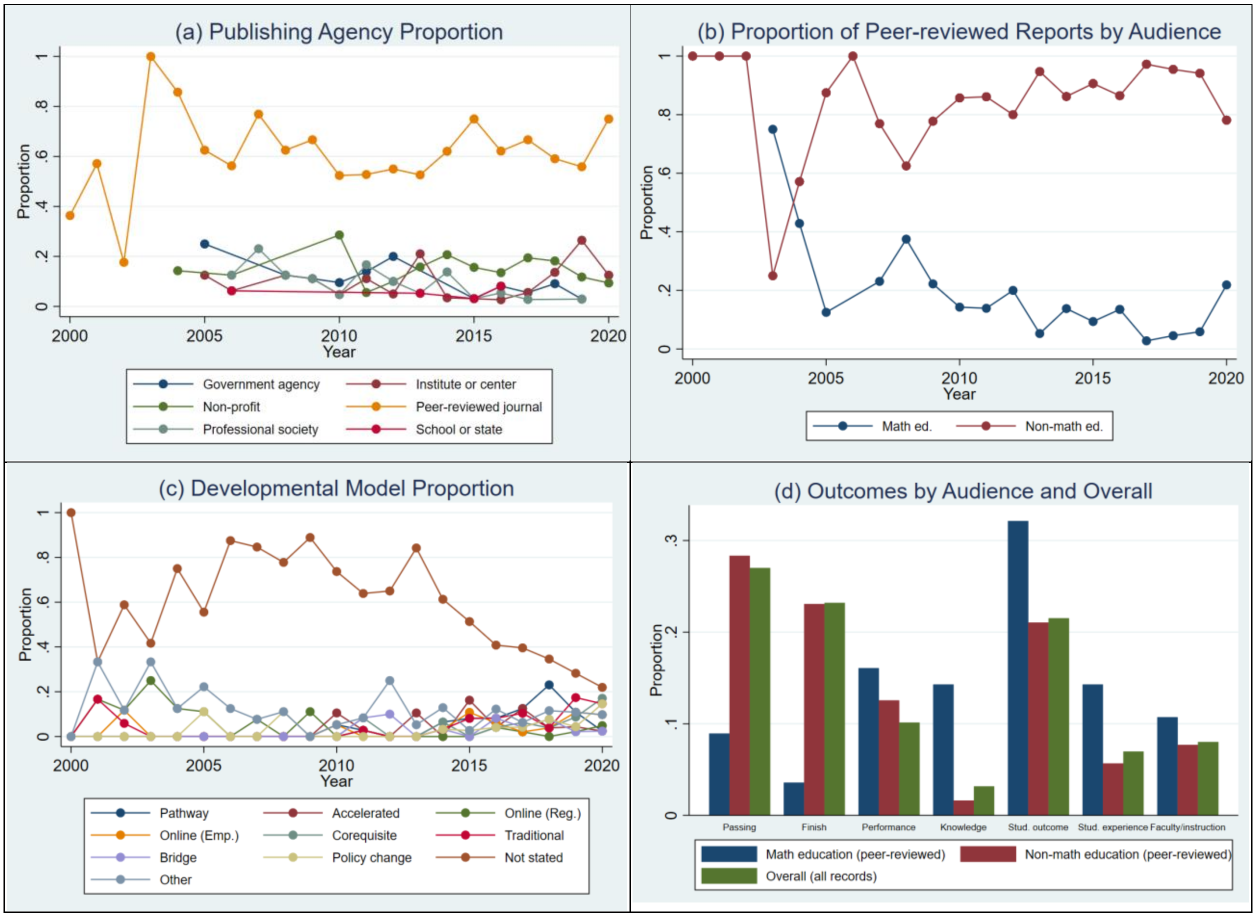

Figure 1. Audience, Developmental Model, and Outcomes Over Time

Discussion, Next Steps, and Questions

All together, these combined results suggest that many models for delivering developmental math content are being implemented, which are perhaps under informed by research on how and what students are learning within development math courses. We are intrigued by these initial results and the questions they raise. As our research continues, we intend to add additional codes where necessary after recognizing the repeated use of "other" codes for the same topics (e.g., credits, enrollment); if anything, this may mean that the incidence of reports which focus on learning are actually currently overcounted. We are currently coding the data for measures of equity, use of deficit language, and how developmental math is defined and operationalized.

Audience Questions

- Are there other analyses that we should consider that we haven't done yet?
- If you currently do research in developmental mathematics, what kind of analysis of existing research would most help further your research?
- If you have not yet done developmental mathematics research, what kind of analysis of existing research would be most helpful to you in starting to work in this area?

References

A. B. 705, Seymour-Campbell Student Success Act (CA. 2018). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB705.

Blair, R., Kirkman, E. E., & Maxwell, J. W. (2018). *Statistical abstract of undergraduate programs in the mathematical sciences in the United States: Fall 2015 CBMS Survey.* American Mathematical Society.

Chen, X. (2016). *Remedial coursetaking at U.S. public 2- and 4-year institutions: Scope, experiences and outcomes* (NCES 2016-405). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S Government Printing Office.

Davis, R. J., & Palmer, R. T. (2010). The role of postsecondary remediation for African American students: A review of research. *Journal of Negro Education, 79*(4), 503–520.

Hoang, H., Huang, M., Sulcer, B., & Yesilyurt, S. (2017). Carnegie math pathways 2015-2016 impact report: A five-year review. *Carnegie Math Pathways Technical Report.* Carnegie Foundation for the Advancement of Teaching.

Jaggars, S. S., & Bickerstaff, S. (2018). Developmental education: The evolution of research and reform. In *Higher education: Handbook of theory and research* (pp. 469-503). Springer, Cham.

Melguizo, T., Bos, J., & Prather, G. (2011). Is developmental education helping community college students persist?: A critical review of the literature. *American Behavioral Scientist, 55*, 173–184.

Mesa, V. (2017). Mathematics education at public two-year colleges. In J. Cai (Ed.), *First compendium for research in mathematics education* (pp. 949-967). National Council of Teachers of Mathematics.

Mesa, V., Duranczyk, I., Watkins, L. (2019, February). *The structure of EQIPM, a video coding protocol to assess the quality of community college algebra instruction.* Eleventh Congress of the European Society for Research in Mathematics Education, Utrecht, Netherlands.

Parker, S. (2012). *From roadblock to gateway: Improving developmental education for student success*. Grantmakers for Education.

S. B. 1720 (FL. 2013). https://www.flsenate.gov/Session/Bill/2013/1720/?Tab=BillText.

The White House, Office of the Press Secretary. (2009, July 14). *Investing in Education: The American Graduation Initiative* [press release]. https://obamawhitehouse.archives.gov/blog/2009/07/14/investing-education-american-graduation-initiative

Twigg, C. A. (2003). New models for online learning. *Educause Review*, (September/October), 28-38.