Using High School Transcript Data and Diagnostic Information to Fine-Tune Placement Policy and Tailor Instruction in Developmental Math

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One of the curiosities of remedial/developmental math education in community colleges is that faculty typically do not have access to the academic background, placement testing, or diagnostic data of their students. The dearth of academic background data is understandable given the general lack of integrated K-12 and postsecondary data and articulation between these systems (Dynarski & Berends, 2015). Community colleges therefore resort to reliance on complex and expensive assessment and placement (A&P) systems to sort students into coursework (Hughes & Scott-Clayton, 2011). However, while over 90% of community colleges use placement tests (Fields & Parsad, 2012), the data from these tests also largely do not make it into the hands of faculty, or even to advising personnel from student support services. They therefore typically begin teaching their courses and advising without many clues as to students' abilities, strengths, and weaknesses – a blank slate.

While this blank slate may be a hallmark of the open-door of the community college model, research suggests that more data may in fact be helpful. Higher education scholars have documented how variables such as high school GPA and prior course-taking are often stronger predictors of college success than test scores (Adelman, 2006; Armstrong, 2000; DesJardins & Lindsey, 2007). Challenging the over-reliance on placement testing, researchers have also found that supplementing or even replacing placement tests with high school transcript (HST) information may improve course placement (Ngo & Kwon, 2015; Scott-Clayton, Crosta, & Belfield, 2014). Further, math diagnostics can also be a potentially valuable resource for math faculty and student support center personnel. In contrast to traditional standardized placement tests, math diagnostics can provide skill specific information about student math skills.[1] Research in middle schools, high schools, and community colleges demonstrates how diagnostic information can improve placement accuracy and help teachers tailor instruction in math classrooms (Ngo & Melguizo, 2016; Betts, Hahn, & Zau, 2011; Huang, Snipes, & Finklestein, 2015).

These findings indicate that while HSTs may be valuable for improving the efficiency and effectiveness of math course placement, the combination of HSTs and diagnostics may be essential to community college math faculty for improving teaching. However, there is limited research that explicitly addresses the role and usefulness of these data in the community college setting. Addressing this gap in the literature, we conducted a mixed methods study to understand whether and how a wealth of background data from HSTs and math diagnostics might improve A&P and be useful to community college math faculty. We examined longitudinal student records from high school to community college in a large California metropolitan area and tested the association between relevant academic background variables from HSTs and students' community college outcomes. For example, the data allowed us to examine the extent to which patterns of high school math course-taking are predictive of college math success, and whether students were placed in the math courses best-suited for them based on their academic preparation.

[1] The benefits of diagnostics are described further below.

This particular exercise would only be relevant for practitioners if community college math faculty or support center personnel found these data to be useful for practice. In the qualitative component of the study we drew upon surveys and interviews of math faculty at one community college where diagnostic data were collected during placement testing but not shared with faculty. This provided an opportunity to gather math faculty members' insight on the usefulness of HST and diagnostic data for improving math placement and for tailoring instruction in math classrooms. Even though this information might be helpful for math faculty and student support center personnel, we focus in this paper on faculty since our interest is on the connection between A&P data and classroom instruction. The study thus sheds light on faculty perspectives about A&P policies and their link to teaching, which have largely been missing from the national debate concerning the improvement of developmental education and assessment practices.

Background

Examining placement testing and the use of data in community colleges is important because community colleges are the entry point to higher education for about 40 percent of all U.S. undergraduates (National Center for Education Statistics, 2016). However, studies of community college students reveal that nearly two-thirds of incoming students take one or more semesters of below college-level math coursework and fewer than one-third of these go on to complete developmental math sequences (Bailey, Jeong, & Cho, 2010). This may explain why low-income students and racial minority students, who are more likely to start at a community college (Carnevale & Strohl, 2010), have lower degree attainment rates than their counterparts at four-year colleges (Aud, Fox, & KewalRemani, 2010; Bowen, Chingos & McPherson, 2009; Melguizo, 2008).

Community colleges typically place students into college-level or remedial courses on the basis of performance on a standardized placement exam (Bailey, 2009). By way of complex and expensive A&P systems, these students are identified and their needs assessed, and then they are typically placed into a variety of developmental courses which they must pass before enrolling in college-level courses.

Yet despite the ubiquity of the use of standardized placement tests, recent research shows that test-based placement may be problematic. First, the use of commonly-used placement tests (e.g., ACCUPLACER; COMPASS) frequently results in placement errors (Scott-Clayton et al., 2014). This leads to students being placed into courses that are not the appropriate level for them, often into courses that are too elementary relative to their academic preparedness. Second, students are often not aware of the high stakes nature of placement tests and do not adequately prepare for them (Avery & Kane, 2004; Safran & Visher, 2010; Venezia, Bracco, & Nodine, 2010). This suggests that placement test results may be an inaccurate reflection of students' math skills and knowledge and should be interpreted with some caution. Third, faculty and administrators typically use standardized tests as enrollment management tools in ways that increase the number of students in remedial classes both because they believe it reduces variation in academic preparation of students in the higher level classes and also because it is easier to hire staff to teach at lower levels (Melguizo, Kosiewicz, Prather, & Bos, 2014). If this is true, then students may be needlessly placed into low-level remedial courses that do not count towards academic degrees, discouraging them and burdening them with additional tuition costs that hinder their progress towards college completion (Melguizo, Hagedorn, & Cypers, 2008).

Given these problems with test-based placement, there has been increasing interest in using alternative or additional measures to improve placement decisions. Recent research both for California and the nation suggests that an alternative way to place students is to capitalize on information from high school transcripts (Fain, 2013; Scott-Clayton et al., 2014). This stems from a long line of research that has shown that high school grades and course taking are strong predictors of postsecondary success (e.g., Adelman, 2006; Armstrong, 2000; DesJardins & Lindsay, 2007). Indeed, using such measures as HSGPA and prior math course taking during assessment and placement can increase student access to higher-level courses without compromising success in those courses, particularly for African-American and Latina/o students (Ngo & Kwon, 2015).

In addition, there is growing evidence that using diagnostic tests can result in more accurate placement in secondary school and in community colleges (Ngo & Melguizo, 2016; Betts, Hahn, & Zau, 2011; Huang, Snipes, & Finkelstein, 2014). In contrast to the single scores produced by commonly-used computer-adaptive placement tests such as ACCUPLACER, diagnostics identify student preparedness in a number of math skill-areas such as fractions, algebra, and graphing, among others (Stigler, Givvin, & Thompson, 2010). They therefore have the potential to provide faculty with rich information about student math skills.

Whether and how math faculty might use this information to tailor instruction and target remediation is less well-understood. In particular, there is scant research examining the "black box" of teaching practices in community colleges (Cox, 2015; Grubb, 1999; 2012), and, most pertinent to this study, the link between assessment and placement processes and how faculty, or even counselors or students themselves, might use the information collected to tailor instruction in these classrooms or enhance student support efforts. Studies of K-12 classrooms have noted the benefit to students of teaching practices that build on students' existing math knowledge (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989l Schoenfeld, 2014). However, qualitative work with community college faculty has revealed that placement test information rarely makes it to the hands of faculty for classroom use (Melguizo et al., 2014). Since diagnostic information could be useful to faculty, a chief aim of the study is to directly ask faculty about how the quality and quantity of information available during assessment and placement processes could specifically be provided and utilized for classroom instruction.

Conceptual Framework

Our qualitative inquiry into how faculty might use A&P data is guided by research concepts in data-driven decision making (DDDM). Scholars of DDDM, which in the K-12 setting generally refers to the use of student achievement data, have described processes by which data first provides information, then becomes actionable knowledge, and finally is used to inform decisions (Coburn & Turner, 2012; Marsh, Pane, & Hamilton, 2006). However, just because data are available does not mean they will result in improved student outcomes. DDDM research has highlighted the need to consider the experience and perspective of the data users

(Dunn, Airola, Lo, & Garrison 2013). For example, teachers' confidence in their data analysis and interpretation skills impacts their likelihood to use data to inform classroom decisions, and teachers with higher than average confidence for working with data are most likely to use student data for instructional decisions (Bernhardt, 2009; Datnow & Hubbard, 2016). Similarly, anxiety about data use – which may be related to the feeling of "drowning in data" – can also undermine the potential benefits of the available data (Marsh et al., 2006). These concepts inform our inquiry among faculty about how data from HSTs and from the A&P process may be used to tailor instruction in math classes.

Data

The setting for the study is a large urban community college district (LUCCD) in California that serves a diverse student population of over 100,000 students per semester. At the time of the study, some of the colleges used computer-adaptive placement tests (e.g., ACCUPLACER; COMPASS) to make developmental placement decisions, and some the Mathematics Diagnostic Testing Project (MDTP), a math diagnostic developed by the University of California and California State University systems. This variation in test choice provided us the opportunity to understand the potential benefits of using diagnostic information relative to computer-adaptive tests.

We have constructed a linked dataset that includes enrollment, assessment, and transcript data from the LUCCD and data from the feeder large urban unified school district (LUUSD). The dataset tracks every LUUSD student that took a placement test in math or English and subsequently enrolled in the LUCCD between 2005 and 2014, thereby allowing us to also study the potential benefits of high school transcript information. The variables across the two districts include student demographic information (e.g., race/ethnicity, sex, free/reduced lunch status, ELL status), high school records (e.g., CAHSEE, CST, and EAP assessment results), college placement testing results, and high school and college transcripts (e.g., course and grades). The data includes 89,950 LUUSD-LUCCD students for the 10 academic year cohorts between 2005 and 2014.

Methods

We use a mixed-methods approach to investigate how combining information from high school transcripts and math diagnostics can be leveraged to fine-tune placement policy and tailor instruction in developmental math. Employing both quantitative and qualitative methods enables us to increase the breadth and depth of our inquiry. Specifically, the mixed methods approach can facilitate the discovery of paradox and contradiction (*initiation*) with respect to the usefulness of assessment and placement data (Greene, Carcelli, & Graham, 1989). The quantitative analyses are underway and described below. The first stage of the qualitative study is completed, and the preliminary results are presented thereafter.

Predictors of college math success

The rich LUUSD-LUCCD panel data allows us to conduct a series of exploratory quantitative investigations of the associations between selected variables from high school transcripts (e.g., grades in math courses, gaps in math course-taking, GPA), assessment and placement measures, and student outcomes such as persistence through the developmental math sequence, completion of college math, and subsequent college credit attainment. An illustrative baseline regression model is given in equation (1).

$$\mathrm{Y_i} = \pi_\mathrm{i} + \pi_\mathrm{i}\mathrm{PS_i} + \pi_\mathrm{i}\mathrm{HSTr_i} + X'_i\beta + \varepsilon_i \quad (1)$$

The models are run within developmental math course levels (e.g., elementary algebra/2 levels below transfer) for each college to understand the factors that are predictive of success in math courses. The base model accounts for prior achievement using the placement score (*PS*) score for the student (i.e., the score on the respective placement test plus any multiple measures[2] added by the individual college). We will then use different combinations of data from high school transcripts (*HSTr*) to test their associations with the particular outcomes of interest (*Y*) and test whether the total variance explained by the model increases. We include additional controls (X_i) such as age, gender, and race/ethnicity to increase precision of the estimates. A set of these preliminary quantitative analyses will be presented at the conference.

Improving math placement

We are also interested in whether HST combined with diagnostic information might improve math course placement relative to standardized placement tests. One way to make this determination is to estimate the rate of successful placement and erroneous placement in each A&P context, following procedures described in Sawyer (1996; 2007) and most recently by Scott-Clayton et al. (2014). The estimation strategy results in the overall proportions of students *placed successfully* and students *placed in error* for each level of math. Students placed successfully are those who were either placed into a math class level they were predicted to pass or those who were placed into one level below a math class they were predicted to fail. Students placed in error are those who were either *over-placed*, placed into a math class that they were predicted to fail, or *under-placed*, placed into one level below a math class that they were predicted to pass. The novelty of using this approach with these data is that we have rich information from HSTs along with math diagnostic scores with which to estimate placement accuracy and error. This therefore builds upon the work of Scott-Clayton et al. (2014) in important ways by including complete HS transcript data and the dimension of math skill as assessed via math diagnostics.

We perform the procedure outlined below using different combinations of HST and placement tests, including diagnostic scores in the colleges where diagnostics were used. For example, in the case of college-level math (CM), the respective logistic regression models are shown in equations (2) and (3).

$$\mathrm{logit}[Fail\ CM]_i = \alpha_0 + \beta_1 HST_i + \beta_2 TEST_i + \boldsymbol{\gamma}' X_i + \varepsilon_i \quad (2)$$
$$\mathrm{logit}[Pass\ CM\ w/B\ or\ better]_i = \alpha_0 + \beta_1 HST_i + \beta_2 TEST_i + \boldsymbol{\gamma}' X_i + \varepsilon_i \quad (3)$$

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[2] "Multiple measures" are additional indicators used by each college in the A&P process. There is variation across the LUCCD schools in terms of the measures used, ranging from HS GPA, HS math course-taking information, college plans, and indicators of student goals and aspirations. These measures are converted to points that are added to the placement test score to determine final course placement. See Ngo and Kwon (2015) and Ngo, Chi, and Park (forthcoming) for a more complete description of the A&P practice.

Here HST_i are various relevant variables from the high school transcripts (e.g., grades in math classes, state standardized test scores, HS GPA), and $TEST_i$ are placement tests scores or the sub-skill scores provided by the MDTP diagnostic. The MDTP provides skill-specific scores for topical areas in arithmetic, algebra, and advanced math. To increase the precision of the estimates we also include $\boldsymbol{X}$**,** a vector of student level demographic characteristics, including age, race, gender, language, and residence status, added as controls for factors that may be associated with college success.

Continuing with this particular example, the obtained coefficients are extrapolated to students placed in the course below (e.g., intermediate algebra is one-level below college math) to predict each student's probabilities of success and failure in college math. We use the probabilities to identify students placed successfully and students placed in error at each level. Specifically, we identify *severe placement errors*, defined by two criteria: 1) students predicted to fail the upper-level course they were placed into, or 2) students predicted to pass the upper-level course with a B or better, but were placed into a course one level below. We estimate the proportion of severe placement errors at each level of math in the developmental sequence for each college, thereby enabling comparison across A&P contexts.

Since we are interested in comparing various placement scenarios, we calculate the percent of severe placement errors using different combinations of measures:

1) with HSTs alone
2) with placement test scores/math diagnostic information alone
3) with both HSTs and test scores/math diagnostic information

This analysis will allow us to determine whether high school background and diagnostic data – a more holistic academic profile – can improve upon placement results based on placement tests/diagnostics alone by estimating the amount of error in existing placement policy.

Informing math instruction

The goal of the qualitative component of the study is to examine the link between placement assessment data and classroom instruction by asking which data faculty believe to be useful. Focusing on one math department in a college where a math diagnostic is used for placement testing, we conduct surveys and interviews with the goal of documenting ways in which student knowledge is or is not assessed and utilized to inform instruction in math courses. We have already conducted an initial survey and received the responses of all full-time math faculty at a math department meeting (21/24 faculty; 87.5%). Questions from this survey ask faculty to report on the information received from the A&P process; their perceptions of placement tests; instructional practices related to identify prior knowledge, and other relevant topics. We also conducted follow-up interviews and focus groups to corroborate these survey results and explore other relevant areas (Desimone & Le Floch, 2004). Together, the survey and interview results provide important faculty perspective on the data gathered at the start of college. Specifically, we can examine whether the factors most strongly predictive of success in math courses are also the ones that faculty believe to be important.

Preliminary Findings

The initial survey results are illuminating. When asked to rank the factors most predictive of success in college math, most faculty members reported that high school transcript information, particularly grades in math courses, were the best predictors, even higher than placement tests. At the same time nearly half reported knowing very little about incoming student math background and math skills. Just under two-thirds said they gather information about student math skill in their classes. Interestingly, several indicated they did not want to receive additional information about student skills and were skeptical about the quality of additional information they would receive. In this regard, the majority of faculty expressed what appeared to be satisfaction with the status quo of placement testing. Interestingly, younger faculty members were more likely to express dissatisfaction with the status quo along with a desire to reconsider placement measures used, whereas faculty who had been teaching for a longer time believed that placement tests were the best measure. The results of the quantitative analyses are forthcoming.

Discussion & Conclusion

The preliminary results of this study provide much needed information related to the potential of using HST and diagnostic information in the A&P process to improve student placement and support classroom instruction. There are substantial efforts nationwide to improve placement in developmental math (e.g., California, Texas, Florida, etc.), and this project contributes to these efforts by focusing on key issues – diagnostics and use of data to improve teaching - that have been absent from the national debate (Burdman, 2012). The mixed-methods approach we take provides a nuanced look at whether combining diagnostic with high school transcript information is indeed a better way to place students in developmental math, which has yet to be tested. We also explore how putting this information into the hands of faculty could enable them to tailor instruction and target remediation for developmental math students. If our hypotheses are correct – that using information from high school transcripts and math diagnostics can improve placement accuracy and can support faculty in tailoring instruction in developmental math – then the results have the potential to transform the nature of student learning opportunities in community colleges.

References

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. Washington, D.C.: Office of Vocational and Adult Education,

Armstrong, W. B. (2000). The association among student success in courses, placement test scores, student background data, and instructor grading practices. *Community College Journal of Research and Practice, 24*(8), 681-695.

Aud, S., Fox, M. A., & KewalRamani, A. (2010). *Status and Trends in the Education of Racial and Ethnic Groups. NCES 2010-015*. National Center for Education Statistics.

Avery, C., & Kane, T. J. (2004). Student perceptions of college opportunities. The Boston COACH program. In *College choices: The economics of where to go, when to go, and how to pay for it* (pp. 355-394). University of Chicago Press.

Bailey, T. (2009). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New Directions for Community Colleges*, *2009*(145), 11-30.

Bailey, T., Jeong, D. W., & Cho, S. W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review*, *29*(2), 255-270.

Bernhardt, V. L. (2009). Data Use. *Journal of Staff Development*, *30*(1), 24-27.

Betts, J. R., Hahn, Y., & Zau, A. C. (2011). *Does Diagnostic Math Testing Improve Student Learning?* Public Policy Institute of California.

Bowen, W. G., Chingos, M. M., & McPherson, M. S. (2009). *Crossing the finish line: Completing college at America's public universities*. Princeton University Press.

Burdman, P. (2012). *Where to begin? The evolving role of placement exams for students starting college*. Boston, MA: Jobs for the Future.

Carnevale, A. P., & Strohl, J. (2010). How increasing college access is increasing inequality, and what to do about it. *Rewarding strivers: Helping low-income students succeed in college*, 71-183.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C. P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. *American Educational Research Journal*, *26*(4), 499-531.

Coburn, C. E., & Turner, E. O. (2012). The practice of data use: An introduction. *American Journal of Education*, *118*(2), 99-111.

Cox, R. D. (2015). "You've got to learn the rules": A classroom-level look at low pass rates in developmental math. Community College Review. doi:10.1177/0091552115576566

Datnow, A., & Hubbard, L. (2016). Teacher capacity for and beliefs about data-driven decision making: A literature review of international research. *Journal of Educational Change*, *17*(1), 7-28.

DesJardins, S. L., & Lindsay, N. K. (2007). Adding a statistical wrench to the "toolbox." *Research in Higher Education*, *49*(2), 172-179.

Desimone, L.M., & Le Floch, K.C. (2004). Are we asking the right questions? Using cognitive interviews to improve surveys in education research. *Education Evaluation and Policy Analysis 26*(1), 1-22.

Dunn, K. E., Airola, D. T., Lo, W. J., & Garrison, M. (2013). What teachers think about what they can do with data: Development and validation of the data driven decision-making efficacy and anxiety inventory. *Contemporary Educational Psychology*, *38*(1), 87-98.

Dynarski, S., & Berends, M. (2015). Introduction to special issue. *Educational Evaluation and Policy Analysis*, *37*(1 suppl), 3S-5S.

Fain, P. (2013, February 19). Redefining college-ready. *Inside HigherEd*. Retrieved from: http://www.insidehighered.com/news/2013/02/19/two-community-colleges-get-serious-about-working-k12

Fields, R. & Parsad, B. (2012). *Tests and cut scores used for student placement in postsecondary education: Fall 2011*. Washington, DC: National Assessment Governing Board.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis, 11*(3), 255-274.

Grubb, N. W. (2012). *Basic Skills Education in Community Colleges: Inside and Outside the Classroom*. New York, NY: Routledge.

Grubb, W. N. (1999). *Honored But Invisible: An Inside Look at Teaching in Community Colleges*. New York: Routledge.

Huang, C.-W., Snipes, J., & Finkelstein, N. (2014). Using assessment data to guide math course placement of California middle school students (REL 2014–040). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education

Hughes, K. L., & Scott-Clayton, J. (2011). Assessing developmental assessment in community colleges. *Community College Review, 39*(4), 327-351.

Marsh, J. A., Pane, J. F., & Hamilton, L. S. (2006). *Making sense of data-driven decision making in education*. Santa Monica, CA: The RAND Corporation.

Melguizo, T. (2008). Quality matters: Assessing the impact of attending more selective institutions on college completion rates of minorities. *Research in Higher Education*, *49*(3), 214-236.

Melguizo, T., Hagedorn, L. S., & Cypers, S. (2008). Remedial/developmental education and the cost of community college transfer: A Los Angeles County sample. *The Review of Higher Education*, *31*(4), 401-431.

Melguizo, T., Kosiewicz, H., Prather, G., & Bos, H. (2014). How are community college students assessed and placed in developmental math? Grounding our understanding in reality. *The Journal of Higher Education, 85*(5), 691-722.

National Center for Education Statistics. (2016, May). Characteristics of Postsecondary Students. Washington, D.C.: National Center for Education Statistics. Retrieved from https://nces.ed.gov/programs/coe/indicator_csb.asp

Ngo, F., & Kwon, W. (2015). Using multiple measures to make math placement decisions: Implications for access and success in community colleges. *Research in Higher Education, 56*(5), 442-470.

Ngo, F., & Melguizo, T. (2016). How can placement policy improve math remediation outcomes? Evidence from community college experimentation. *Educational Evaluation and Policy Analysis, 38*(1), 171-196.

Safran, S., & Visher, M. G. (2010). Case studies of three community colleges: The policy and practice of assessing and placing students in developmental education courses. *National Center for Postsecondary Research and MDRC*.

Sawyer, R. (1996). Decision theory models for validating course placement tests. *Journal of Educational Measurement, 33*(3), 271-290.

Sawyer, R. (2007). Indicators of usefulness of test scores. *Applied Measurement in Education*, *20*(3), 255-271.

Schoenfeld, A. H. (2014). What makes for powerful classrooms, and how can we support teachers in creating them? A story of research and practice, productively intertwined. *Educational Researcher*, *43*, 404-412. doi:10.3102/0013189X14554450

Scott-Clayton, J., Crosta, P., & Belfield, C. (2014). Improving the targeting of treatment: Evidence from college remediation. *Educational Evaluation and Policy Analysis, 36*(3), 371-393.

Stigler, J. W., Givvin, K. B., & Thompson, B. J. (2010). What community college developmental mathematics students understand about mathematics. *MathAMATYC Educator*, *1*(3), 4-16.

Venezia, A., Bracco, K. R., & Nodine, T. (2010). One shot deal? Students' perceptions of assessment and course placement in California's community colleges. *San Francisco, CA: WestEd*.