Research Article_____

All Value-Added Models (VAMs) Are Wrong, but Sometimes They May Be Useful

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Abstract

In this study, researchers compared the concordance of teacher-level effectiveness ratings derived via six common generalized value-added model (VAM) approaches including a (1) student growth percentile (SGP) model, (2) value-added linear regression model (VALRM), (3) value-added hierarchical linear model (VAHLM), (4) simple difference (gain) score model, (5) rubric-based performance level (growth) model, and (6) simple criterion (percent passing) model. The study sample included fourth to sixth grade teachers employed in a large, suburban school district who taught the same sets of students, at the same time, and for whom a consistent set of achievement measures and background variables were available. Findings indicate that ratings significantly and substantively differed depending upon the methodological approach used. Findings, accordingly, bring into question the validity of the inferences based on such estimates, especially when high-stakes decisions are made about teachers as based on estimates measured via different, albeit popular methods across different school districts and states.

Key Words

teacher accountability, teacher evaluation, teacher effectiveness, teacher assessment, validity/reliability, value-added models (VAMs)

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Statistical Philosophy

In 1976, British statistician George Box remarked: "Essentially, all [statistical] models are wrong, but some are useful." What Box argued was that statistical models have to be understood for what they can do, which is *estimate* that which a scientist is attempting to measure. Indeed, statistical models never yield *true* measures of anything.

This is particularly important in education, as we are currently facing a "data explosion" (SAS, n.d.) where statistical models are being used to measure just about any and all conceivable matters, including teacher performance. Unfortunately, this new data milieu has brought about dangerous applications of data and statistics.

We say dangerous because complex matters are too often drastically oversimplified for measurement's sake, and when we oversimplify complex matters, we run the very real risk of making erroneous inferences that overlook important considerations, conditions, and circumstance that may lead to consequential decisions that are incorrect.

At the same time, however, useful insights can be gleaned from statistical models, even if they do not offer *true* representations of that which they are used to model. It goes without saying that probability-based prediction models are essential tools in other disciplines including business, medicine, manufacturing, and meteorology, just to name a few. Yet, no matter how historically accurate statistical models may be, all statistical predictions are imperfect.

Notwithstanding, as long as those who consume and interpret model output understand the imperfections at play, and they do not exaggerate the degree to which statistical models might provide useful information, then

models can sometimes offer valuable insights about social phenomena. If we accept that statistical perfection is impossible, then we can begin to consider, perhaps and according to Clear (2018), "whether something can be applied to everyday life in a useful manner." A recent study we conducted directly dealt with this provocation, and what we found was that statistical models that measure teacher effectiveness are, in the words of Box, essentially wrong, but sometimes useful when critically consumed or used.

In our study, we explored the use of different value-added models (VAMs, see more forthcoming) to evaluate teachers' measurable impacts on their students' test scores (see also Sloat, Amrein-Beardsley, & Holloway, 2018). Findings should be of great interest to school leaders throughout the U.S. who continue to struggle with what they can and cannot do with these potentially problematic statistical data.

Ideally, findings from this study should help school leaders better understand how VAMs can be used for making important decisions about their schools and teachers, as well as where school leaders might draw the line about the consequences they attach to VAM output. The key takeaway for school leaders is to *not* place high value on these statistical measures, but rather devalue them as much as possible.

Past and Current Circumstances

Since the federal government's Race to the Top (RttT) Act of 2011, and the No Child Left Behind (NCLB, 2001) waivers that excused states from penalties associated with their failures to meet NCLB's 100% student proficiency goals by 2014, most states (and districts) have developed and used teacher evaluation systems that rely in large part on student test scores to "objectively" measure and evaluate teacher effectiveness. While the

federal passage of the *Every Student Succeeds Act* (ESSA, 2016) has since helped curb such educational accountability and reform efforts, particularly at the teacher level, ESSA continues to encourage states to hold teachers accountable for that which statistically matters, including their students' test scores.

Consequently, teacher performance is still being calculated using complex statistical modeling approaches and practices, primarily via VAMs. VAMs, in the simplest of terms, classify teachers' effectiveness levels according to their statistically measurable and purportedly causal impacts on their students' standardized test scores over time.

Ideally, VAMs help to identify teachers whose students outperform their projected levels of growth as effective and teachers whose students fall short as ineffective. In reality, however, VAMs often do not work as intended, raising questions about whether VAM-based data can be used as objective measures for teacher evaluation purposes (see, for example, Amrein-Beardsley, 2014).

The Study
To address this concern, we conducted a study comparing the concordance, or rather the agreement of VAM scores across six different VAMs. More specifically, researchers compared the concordance of teacher-level effectiveness ratings derived via six common generalized VAM approaches including a: (1) student growth percentile (SGP) model, (2) value-added linear regression model (VALRM), (3) value-added hierarchical linear model (VAHLM), (4) simple difference (gain) score model, (5) rubric-based performance level (growth) model, and (6) simple criterion (percent passing) model.

For each approach, researchers used the distribution of teacher-level estimates by

subject area to rank teacher effects and then assign them effectiveness ratings. Thereafter, researchers statistically evaluated the level of agreement between and among ratings to examine concordance, with concordance statistically approximated by the extent to which similar results and conclusions were drawn, via these independent methods with common purpose. The overall intent was to examine what impact the choice of the methods implemented, as locally defined, would have on the inferential and potentially consequential judgments of effectiveness made.

The primary research question researchers investigated was to what extent teacher-level ratings significantly or substantively differed depending upon the methodological approaches used, with concordance yielding evidence of criterion-related evidence of validity and a lack of concordance the inverse, while also bringing into question the validity of the inferences based on such estimates especially when high-stakes decisions are to be attached to such estimates.

Researchers defined concurrent concordance via statistical approximations of the extent to which similar results for the same teachers at the same time were drawn via independent, common, and more generalized VAMs (for more detailed, technical information, please see Sloat et al., 2018).

Findings
We found that teachers' ratings significantly differed 18%-59% of the time depending on the VAM used. What this means is that, even when using the same data, from the same tests, for the same students, and for the same teachers, different VAMs produced very different teacher effectiveness scores. That is, a single teacher could be classified differently depending on which VAM was used. This is

critical when considering the *efficacy* and *ethics* of whether VAMs should be used for teacher evaluation purposes. Likewise, not only does the seemingly simple choice of which VAM a school district might use become nettlesome, so too does the question about whether we can trust really any VAM for high-stakes purposes. While the differences in VAM results might not matter as much if used for low-stakes purposes (e.g., making professional development decisions for certain sets of teachers), they certainly matter a great deal if used for matters like teacher tenure decisions, merit pay, teacher probation and termination.

Findings from this study, consequently, bring into serious question the *validity* or *truthfulness* of the inferences based on VAM estimates, especially when high-stakes decisions are made about teachers.

Furthermore, because many school districts, especially small districts, districts located in certain urban or rural areas, American Indian districts, and the like, do not have comparable access to the in-house expertise (e.g., data analytics, statistical methods) or resources (e.g., hard/software, data management systems) necessary to support even a run-of-the-mill statistical model of teachers' effects (i.e., a VAM), different results might also be related to financial and human resources more than teachers' *true* effects.

That some districts will rely upon simplistic metrics of teacher effects is also deeply problematic as how a teacher is evaluated greatly depends on the approach the district chooses. This choice is heavily constrained by the district's technical capabilities, as well as human and technical resources, threatening the core validity of any inference derived from the chosen method. If different methods yield different outcomes,

then the truthfulness of the inferences and any related decisions to be made are warped.

Implications for School Leaders
The fact that different VAMs produce different results is indeed alarming, but there are some important caveats to consider. With ESSA (2016) now legislating that districts can determine which VAM they might adopt, teachers' classifications will depend upon whichever model their district has chosen to implement, making this whole statistical modeling enterprise arbitrary across varying contexts.

However, we are not suggesting that one statistical model be adopted for all districts for purposes of consistency, for there is really no professional consensus that any particular VAM is better or more accurate than any other (although VAM proprietors would likely disagree). Recall that all VAMs are reliant upon statistical models that only *estimate*, as best they can, that which is an accurate representation of *truth*.

Consequently, that where a teacher teaches, and what value-added method is used in that district, might matter more than his/her *actual* effectiveness is highly problematic. This in and of itself puts at risk the validity of such teacher-level accountability outcomes. This also places school leaders in a challenging position, as they must be critically aware of not only the different types of statistical approaches from which to choose, but also of how they might consume, interpret, and act upon the outputs drawn from such models.

Truth be told, all school administrators should be aware that all VAMs yield quite varied estimates of teacher effectiveness, none of which are ever actually *true*. Likewise, they cannot afford to be ambivalent about how

VAM output might be used within their schools, especially if high-stakes consequences are at stake.

When VAMs Are Wrong

Across the U.S. are a series of ongoing or recently completed lawsuits where teacher plaintiffs are contesting how they are being evaluated by VAMs. For all of these cases, teacher plaintiffs are targeting the value-added indicators being used, as alleged, erroneously and inappropriately against them. More specifically, plaintiffs are arguing that multiple VAMs (like those analyzed in this study), are grossly imperfect, arbitrary, capricious, irrational, and unfair (see, for example, Paige, Amrein-Beardsley, & Collin, in press).

Related, plaintiffs are arguing that the preponderant use of VAM-based indicators is more egregious when high-stakes decisions are attached to value-added output. As the stakes increase, the more egregious the actions attached to VAM output. The high-stakes decisions at issue across these specific cases include but are not limited to teachers' permanent files being flagged with their VAM-based effectiveness categories (e.g., "highly effective," "effective," "ineffective," "highly ineffective") that has prevented teachers from moving teaching positions across districts; the awarding or revocation of teacher licenses or tenure; salary increases, decreases, or merit pay; and teacher probation or termination.

Most notable across suits, though, are a few cases that quite literally make the case we are making here, about when VAM use is simply wrong, now also as per the courts. In Houston in 2011, 221 teachers were terminated as based predominantly on their VAM scores. A U.S. District Court ultimately ruled in favor of teacher plaintiffs in this case given they had legitimate claims regarding how the VAM

being used by the district violated their Fourteenth Amendment due process protections, more expressly given the district's VAM did not permit district teachers to ensure their VAM scores were accurate. The district got rid of their VAM.

In New Mexico, despite a widespread understanding that teachers' VAM-based data were to be held "harmless" until teachers' VAM data could be studied, vetted, and validated, the state flagged teachers' permanent files, as mentioned prior, with teachers' VAM-based effectiveness categories. This ultimately prevented some teachers from moving teaching positions across districts within the state. This landed the state and its statewide VAM in court.

A State Court judge ultimately granted a preliminary injunction to prevent the state or any district within the state from making any consequential decisions about New Mexico teachers until the state could evidence that such consequences as attached to the state's VAM were warranted, non-arbitrary, legally defensible, and "uniform and objective" as per state constitutional requirements. No such evidence has yet been presented to warrant the attachment of high-stakes decisions to teachers' VAM scores, leaving the state at a standstill in terms of its VAM-based teacher evaluation system since 2015.

In New York, the State Supreme Court viewed the consequences attached to its VAM differently, positioning an "ineffective" teacher effectiveness tag as consequential in terms of public shame and loss of reputation in the professional community. The Court ultimately ruled that the state's VAM-based teacher evaluation system was "arbitrary and capricious," defined as actions "taken without sound basis in reason or regard to the facts"

(State of New York Supreme Court, 2016, p. 11).

These cases demonstrate how the U.S. judicial system has thus far interpreted VAMs and VAM use as legally defensible in practice, when high-stakes consequences have been attached to VAM output. While not all cases have been ruled in favor of teacher plaintiffs (e.g., in Tennessee a U.S. District Court dismissed a case given the state's use of its VAM was "rationally related to a legitimate government interest"), the majority have. In fact, a majority of court rulings have reversed states' and districts' high-stakes use of VAMs in that no defendant has been able to produce evidence demonstrating their VAM can produce outputs that warrant high-stakes use.

Accordingly, understanding the value of some of the on-the-ground consequences of VAM use is germane to our collective understandings about these statistical models, in some ways regardless of the different estimates that different models yield. This is also important, again, as many states and districts continue to employ VAM-based evaluation systems despite the serious measurement and pragmatic issues at play, especially when consequential decisions are also at play.

When VAMs May Be Useful

As we noted prior, different VAM-based results (as evidenced in our study) might not matter as much if VAM-based output are used for low-stakes purposes, such as making professional development decisions. Hence, we also want to emphasize, particularly for school leaders, that VAMs may still be useful despite their (oft-gross) statistical shortcomings.

Susan Moore Johnson, professor of education at Harvard University, and some of her colleagues recently published an important

article regarding how teacher evaluation systems might actually be useful within school districts. Explained in their article titled *Investing in Development: Six High-Performing, High-Poverty Schools Implement the Massachusetts Teacher Evaluation Policy,* Reinhorn, Moore Johnson, and Simon (2017) "studied how six high-performing, high-poverty [and traditional, charter, under state supervision] schools in one large Massachusetts city implemented the state's new teacher evaluation policy" (p. 383).

They aimed to learn how these "successful" schools, with "success" defined by the state's accountability ranking per school along with each school's "public reputation," approached the state's teacher evaluation system and its system components. They also looked at how the educators in these schools used their evaluation data to promote more opportunities for development.

They found that across the six successful schools that they studied, school administrators "responded to the state evaluation policy in remarkably similar ways, *giving priority to the goal of development over accountability* [emphasis added]" (p. 385). In addition, most school administrators of said successful schools went above and beyond to provide teachers with more frequent observations, feedback, and teacher evaluation supports than any state or district policy required. "Teachers widely corroborated their principal's reports that evaluation in their school was meant to improve their performance and they strongly endorsed that priority" (p. 385).

Overall, the researchers concluded that "an evaluation policy focusing on teachers' development can be effectively implemented in ways that serve the interests of schools, students, and teachers" (p. 402). This is

especially true when (1) evaluation efforts are "well grounded in the observations, feedback, and support of a formative evaluation process," which could include the use of VAM-based data for formative versus summative (e.g., outcome-or accountability-based) purposes; (2) when school administrators focus on "capacity building;" and (3) when states and districts do not take Draconian (i.e., strict or drastic) but judicious and admonitory approaches to teacher evaluation systems and the data they derive.

Developmental and formatively-focused teacher evaluation systems work, they conclude perhaps most importantly, when schools are led by highly effective school leaders. This "is probably the most important thing district officials can do to ensure that teacher evaluation will be a constructive, productive process" (p. 403).

Findings from this study matter in that they offer evidence that teacher evaluation works *if* used for developmental and formative purposes, perhaps in lieu of summative and despite high-stakes purposes and demands.

Current evidence also suggests that post-ESSA (2016) nearly all states are moving in this direction (Close, Amrein-Beardsley, & Collins, 2018). States' new teacher evaluation plans make note of providing data to teachers as a means of supporting professional development and improvement, essentially shifting the purpose of the evaluation system away from summative and toward formative use.

Final Remarks

Despite ESSA, many teacher evaluation systems still include VAMs. What is important is that as long as the output are consumed and interpreted critically in terms of VAM's strengths and weaknesses, and they are used for formative versus summative or punitive purposes by school leadrs, then teacher evaluation can work. Of key priority should be that VAM-based and other teacher evaluation data are understood and used relative to their potentials and limitations, and, most importantly, for developmental and formative purposes only.

While the type of statistical modeling used within VAMs is still often referred to as the most sophisticated means for measuring the amount of influence an individual teacher has on his/her students' achievement test scores, as Lingard (2011) argued "The knowledge we produce is … partial, positioned and provisional with limitations when applied as an evidence base" (p. 358). This caveat is important to keep in mind when considering the implications of VAM-based use, especially by school administrators at the district level.

While the data produced by VAMs might be statistically sophisticated, contextual factors will *always* affect how VAMs play out in practice; hence, school administrators and teachers should be armed with as much knowledge as possible about when, why, and how VAMs should be used.

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