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WHAT WE KNOW ABOUT DATA-DRIVEN DECISION MAKING IN HIGHER EDUCATION: INFORMING EDUCATIONAL POLICY AND PRACTICE

Abstract:

In this paper we review the vast literature on data driven decision-making (DDDM) in institutions of higher education (IHEs). Given increasing pressure for IHEs to use data to inform decision-making, it is important to understand what is known about the opportunities and challenges facing DDDM. To contextualize the literature we briefly review the history of DDDM in education settings. We then summarize how scholars have conceptualized and studied DDDM in IHEs in general, and then regarding curriculum and instruction specifically. Our review found that scholars have examined DDDM in regard to institutional functioning and structures (e.g., total quality management, knowledge management, and strategic planning), supporting institutional decision-making (e.g., decision support systems, data mining, and academic analytics), meeting institutional or programmatic accreditation, quality assurance, developing and honing methods for improving data use, analysis, and distribution, facilitating participatory models of decision-making, and curricular and/or instructional improvements. We found curriculum and instruction specific research on course management, learning analytics, curriculum planning, assisting teaching and learning centers, in-class formative assessment, and post-class data use. We discuss implications of our findings in a framework of considerations related to successful DDDM implementation and study, including review of DDDM in K-12 environments in the US and postsecondary education worldwide. Recommendations for successful DDDM include acknowledging and attending to local realities, ensuring salience of data and DDDM processes to key stakeholders, fostering and capitalizing on local data savvy and collaboration among stakeholders towards meaningful objectives, and formalizing and normalizing adequate data collection and management systems and access. Based on these results we recommend that educators, policymakers, and researchers look to the experiences of K-12 educators in the US and European and Australasian IHEs with DDDM movements, focus on linking larger data systems and policies with local needs and practices and locally derived data, engage in more descriptive research on how local actors perceive and utilize data, and focus on linking larger data systems and policies with these local needs and practices.

Keywords:

Data-driven decision-making, higher education, literature review

JEL Classification: I20, I21, I23

Introduction

A core focus of current educational reform and improvement efforts at both the K-12 and postsecondary levels is the collection and use of data to improve outcomes, or resulting in what some call a "culture of evidence," an environment where institutional and individual reflection and action are supported by data, specifically concerning student and institutional performance (McClenney, McClenney & Peterson, 2007; McClenney, 2003; Millett, Stickler, Payne & Dwyer, 2007). A systematic approach to such efforts is called *data-driven decision-making* (DDDM), a structured approach to the collection, analysis, dissemination of, and acting in response to data. DDDM approaches integrate theories of how people make decisions within complex organizations with the design and implementation of formal data systems in ways that increase the prospects that data will be used to inform decision-making about structures and processes (e.g., educational policies, curriculum and instruction) in a systematic manner.

While U.S. IHEs have long monitored quality of programs per disciplinary and state accreditation requirements (Rhoades & Sporn, 2002), using formal data systems to measure, track, and evaluate performance to comply with national policy has been the purview of the postsecondary landscape in Europe and Australasia as part of the quality assurance movement of the 1990s (Billing, 2004; Harman, 1998; 1994; Haug, 2003). Concerning the K-12 level, U.S. legislation such as No Child Left Behind (Department of Education, 2002) and Race to the Top (Department of Education, 2010) have led states, districts and schools to put considerable effort into creating new data systems. While IHEs in the U.S. have avoided such legislative mandates to date, that may be changing. With the Obama administration's recent emphasis on developing metrics for measuring institutional quality (Whitehouse.gov, 2013) and a general push towards accountability in IHEs by policy makers, accrediting agencies, and the public (Leveille, 2005; McPherson & Schapiro, 2007), there is a growing emphasis on DDDM in U.S. IHEs (Morest, 2009; Reindl & Reyna, 2011). Most notable to date is the *Achieving the Dream* initiative motivating community colleges' routine use of assessments to inform decisions regarding "strategic priorities, resource allocation, faculty and staff development, and improvement to programs and services for learners" (McClenney et. al, 2007, p. 5). Scholars studying Achieving the Dream chronicle and call for more IHEs that implement a "culture of evidence" over a "culture of anecdote" in commitment to supporting, testing, and revising assertions and beliefs about teaching and learning with evidence-based knowledge.

In preparation for a descriptive study on how faculty in IHEs utilize data as part of DDDM procedures, we sought a review of the literature on the topic and discovered that while extensive reviews exist for K-12 settings (see Ikemoto & Marsh, 2007; Mandinach, 2012; Marsh, Pane, & Hamilton, 2006; Coburn, Honig & Stein, 2009; Mandinach & Honey, 2008), none yet existed regarding the postsecondary level. In light of the strong and growing pressure on postsecondary institutions to adopt such systems, we saw a need for a review of the rather vast literature on if/how data are used by IHE leaders and faculty.

Context For DDDM In Education Systems In The US And Abroad

The Quality Assurance Movement In Europe And Australasia

The emphasis on using data for continuous improvement and accountability in education systems in Europe and Australasia pre-dates U.S. initiatives, and it is useful to review this history and related lessons learned. In the 1980s the Australian government began actively promoting quality assurance for IHEs, including efforts to determine standards in specific fields (e.g., Law, Engineering). One of the driving forces behind quality assurance is the perceived value of communicating information to the public and government; making higher education transparent; to inform decision-making as well (Taylor, 2009). IHEs want to ensure that declining public funds and other funds are spent wisely, particularly in an economically difficult context. The 1989 Linke Report developed indicators for the quality of teaching, student progress and achievement and graduate employments. Teaching quality was largely measured through the Course Experience Questionnaire (CEQ), essentially a student satisfaction survey. Later, the Committee for Quality Assurance in Higher Education conducted audits of internal quality assurance procedures as a way to inform funding decisions. The University Grants Committee (UGC) created a Teaching and Learning Quality Process Review (TLQPR) in 1995 that involves external review of institutional activities, including teaching activities and outcomes. Data from these reviews are used to inform funding allocations and strategic planning on a broader basis (Chalmers, 2007). In 2000, the Australian Universities Quality Agency was developed which led to the National Protocols, detailing the criteria and standards for receiving approval for IHEs in Australia and abroad (for Australian students).

The Higher Education Funding Council for England (HEFCE) was created in 1992 to distribute funds to promote high quality research and teaching activities. Specifically, the HEFCE provides funding for ensuring the quality of instruction and teaching and learning activities (e.g., faculty development), and collects data such as student participation and learning outcomes in order to track quality in the sector (Chalmers, 2007). It is through these funding councils that much of the UK policies related to teaching and learning originate. In addition to conducting external reviews of financial matters, the Quality Assurance Agency (QAA), created in 1997, provides technical assistance to the government regarding educational quality (e.g. expected competencies at different degree levels, discipline-specific benchmarks, and a professional code of practice for academic staff) (Chalmers, 2007). Similar to Australian efforts, the QAA audits are particularly interesting as external review of IHE quality via data concerning classroom observations and curricula and staff development programs.

Domestic Education Policy: NCLB and Other History Associated With DDDM In K-12 Settings

The push for the reform of education systems in the US has historically been multifaceted, dependent upon a wide array of stakeholders' interests and policy, practice, and structural norms (Peterson et al., 1999). Of notable focus are the goals of improving teaching practices and the, assumed, concomitant improving of student learning. The call for DDDM in education concerns both of these goals, and is not new. According to March, Pane, & Hamilton (2006), other K-12 school improvement debates and practices involving

multiple stakeholders from the 1970s-80s have shaped the current movement, most notably the "site-based decision making processes dating back to 1970s and 1980s (Massell, 2001)…measurement-driven instruction in the 1980s (Popham, 1987; Popham et al., 1985)… [and] state requirements to use outcome data in school improvement planning and school system efforts to engage in strategic planning in the 1980s and 1990s (Schmoker, 2004)" (p. 2).

The site-based decision-making phenomenon, implemented in a third of school districts in the US 1986-1990, set the stage for the consideration of data and subsequent action of key local stakeholders, namely K-12 personnel overseen by school administration, towards site-based decision-making (Ogawa & White, 1994). Often conceptualized as site-based *management*, given the focus on decentralized and deregulated decision making concerning local concerns, the goals were improving student outcomes/achievement, though models varied greatly across the US regarding "who initiates it, who is involved, what they control, and whether they are accountable to an outside authority" as well as "linkage to an accountability system with consequences tied to student performance…or not" (David, 1996, p. 5). With the advent of high-stakes standardized tests in the 1970s, came measurement-driven decision-making in the K-12 schools. According to Popham (1987), this movement restructured the assessment-teaching relationship in the mind of educators, promoting the wider-spread consideration of learning goals (and related assessment items to test students' meeting of these) as part of planning and implementation of curriculum and instruction. As well, the movement probably prompted the first widespread concern among educators and education theorists about the threats to the K-12 teaching profession that externally imposed assessments could ultimately yield. As with site-based decision-making/management, strategic planning encouraged educators and their administrators to engage in the setting of goals/objectives more broadly applicable to the larger institution/system (Schmoker, 2004). More so than previous movements, strategic planning encouraged educators to plan for the improvement of education environments over the long-term, with greater deliberateness concerning who and how goals would be accomplished (Dooris, Kelley, & Trainer, 2004). The strategic planning movement in education systems has not been the privy of the K-12 level; the practices and research concerning strategic planning regarding IHEs and systems, as will be made more obvious later in this paper, have proliferated since the 1990s.

On the heels of these interrelated movements, in 2002, the US congress approved the No Child Left Behind Act (*NCLB*). NCLB was argued as the remedy for decades of educational reforms in K-12 that yielded too limited progress regarding student achievement and organizational change (Fullan, 2010) via increased pressure on schools, districts, and states to be formally accountable for improvement as demonstrated through regular reports of student achievement data. State and the US federal governments continue to fund NCLB activities; the American Recovery and Reinvestment Act of 2009 allocated $250 million for state analysis of student performance. A critical assumption underlying NCLB, and related initiatives, is that robust data will initiate constructive response to improve the quality of education in areas seen as key to widespread improvement of teaching and learning, such as resource (re)allocation between struggling and more promising systems.

At the core of NCLB, and historical related initiatives, is the call for the use of "evidence" or "data" to inform education innovations and policies. Indeed, for many, education reform these days is synonymous with decision-making regarding improvement of education focused (almost myopically) on data[1].

The Growing Push For A "Culture Of Evidence" In U.S. Higher Education

As early as 1975, Shulman and Elstein notified education researchers of the need for systematic evaluation of student outcomes and relevant response of educators to this data. In response to long-standing critiques concerning the quality of undergraduate education in the US, including educator quality and the resulting degree of learning by postsecondary students and associated adequacy of preparation for the workforce (Arum & Roksa, 2012; Bok, 2012), the 1980s gave way to policy focused on data concerning student impact to inform the nation, states, and institutions (Peterson, 1999). Just one year after publication of The National Commission On Excellence In Education's *A Nation at Risk: The Imperative for Educational Reform* (1983), the National Institute of Education's *Involvement in Learning: Realizing the Potential of American Higher Education* (1984) called for improving undergraduate education, with a key recommendation for institutions to develop a plan for student assessment. The U.S. Department of Education followed with its *Criteria for Recognition of Accrediting Agencies (*1988), requiring agencies dictate that institutions specify goals and objectives and plan for and enact activities to assess their achievement of these (Peterson et al., 1999). Following the 1980s, dubbed *the age of disenchantment* by Barnett (1992) for the public dissatisfaction with postsecondary institutions, came curriculum reform via "continuous quality" (Stark, Briggs & Rowland-Poplawski, 2002). The 1990's was a critical decade in the evolution of relationships between IHEs and governments (Alexander, 2000). While more institutions were engaged in assessment of student learning, and tie to education goals, few had enacted comprehensive institutional plans to judge their overall efficacy; even fewer demonstrated positive change in response to student assessment (Astin, 1991; Johnson et al., 1991; Peterson et al., 1999). With few exceptions (e.g. Bragg, 1992), the literature of this time lacked explicit link between instructor practice, curriculum design, and data use.

With enrollment-based funding models largely the norm across universities worldwide (Jongbloed & Vossensteyn, 2001), talk intensified at the turn of the century about performance-based models of higher education. At that time, according to Liefner (2003), most IHEs enacted some performance-based models. In public universities in the US, performance-based funds still often take the form of public dollars and these are most often directly tied to institutional performance as student-related measurements, as opposed to private or foundational funding which may more likely be tied to faculty research and development productivity (Liefner, 2003). Regardless of source of funding, indicators of student "performance" has most typically been conceptualized (and largely consistent year to year) as student enrollment; related dollar allotment is often still

[1] We provide only a brief overview of the history of movements to improve education via DDDM in K-12 districts and schools. We do this to contextualize IHE efforts related to data use within the broader educational landscape. It is important to note that this is not a comprehensive review of the literature on data use in K-12 settings, which have been conducted elsewhere and is beyond the purview of this paper (e.g., see Coburn, Honig & Stein, 2009).

distributed within an institution by administrators driven by the concept of need (e.g. faculty lines needed to teach students populating a department's course) and not per concerns of student performance (Liefner, 2003).

This funding model still dominates higher education and performance-based funding, even when somewhat redefined, has the power to drive much of the DDDM movement with respect to higher education. Yet in light of recent policies and calls, such as the Obama administration's recent emphasis on developing metrics for measuring institutional quality (Whitehouse.gov, 2013), a stronger tie of funding to other student performance indicators may be coming down the pike. Indeed, a growing population of stakeholders, informed with even more data concerning institutional quality (regardless of the reliability and validity of this data) and pledging a large share of funding to institutions of higher education via tuition and tax dollars (Liefner, 2003), may dictate market forces in way that ultimately enhances the power of performance-based funding in the postsecondary arena.

Still, in contrast to K-12 districts and schools in the US or postsecondary education systems in much of Europe and England, there are few federal, state, or even system-based policies that would yet mandate or indicate adoption of DDDM at US IHEs (Price and Kirkwood, 2011). As such, calls for demonstration of "accountability" of IHEs in the US are not yet accompanied by a widely perceived and substantial threat (such as reduction of allotted resources) if measurements of accountability are not offered or are indicative of lower student success. Closest to this takes the form of requirements of disciplinary and institutional accreditation bodies, followed by institution-specific state review for state-affiliated institutions (Rhoades, & Sporn, 2002). These will be addressed in turn in this review.

Yet policymakers are increasingly suggesting that data-based systems should be instituted as part of accountability systems (Leveille, 2005; McPherson & Schapiro, 2007; Zumeta, 2001).

The argument can be made that U.S. community colleges have already caught wind of and responded to these realities (Gallagher, 2008). Since 2005, over 200 community colleges have been involved in the Achieving the Dream (ATD) initiative funded by the Lumina Foundation for Education (http://www.achievingthedream.org/network/colleges). This initiative aims to "increase the success of community college students, particularly those groups that have been undeserved in higher education" (Lumina Foundation for Education, 2005, p. 1). ATD participation indicates a formal institutional commitment to data use, analysis and response towards improvement of programs, strategic planning, and fiscal management. Types of data deemed important by ATD towards improvements move beyond the typical graduation and retention rates and include indicators of student learning, beyond grades, and via methods to allow for documentation of richer experiences (including focus groups or other qualitative data gathering) from key stakeholders in more boundaried and relevant IHE organizations (e.g. within colleges and programs), broken down by students' race, ethnicity, and socioeconomic status to inform student achievement gap remedy (Jenkins & Kerrigan, 2008). The increasing attention to accountability in community colleges partially stems from the concern that only one in ten students who enter community colleges completes a bachelor's degree within five

years (McClenney et. al., 2007). The ATD initiative, and related activity and commitments, intend to remedy this problem via cultural change to enhanced accountability, transitioning from a "culture of anecdote" to a "culture of evidence" (McClenney et. al., 2007), or an environment where institutional and individual reflection and action are supported by data-driven decision making, specifically about student learning and institutional and unit performance (McClenney & McClenney, 2003; Shavelson, 2007).

Paper Objectives

The goal of this paper is to provide a review of the conceptual and empirical literature on how institutions of higher education are using data to make decisions, both more generally speaking and regarding curriculum and instruction, specifically. The research questions that guided this review are:

1. How has DDDM been conceptualized and studied in higher education?
2. What are the characteristics of DDDM being implemented at IHEs?
3. How are administrators and/or instructors using DDDM for curricular and instructional-related purposes?
4. What are some of the major factors that may impede or support curricular and instructional DDDM in IHEs?

We begin this paper with a brief review of the context of educational reform policy in the U.S. and abroad regarding the history and key characteristics of DDDM. We then detail the methods of our literature review. Next we review the diverse purposes to which researchers and practitioners are using data in IHEs. We then review the literature dealing with curricular and instructional DDDM. Finally, we review scholarship detailing factors and considerations related to successful DDDM at IHEs and provide associated recommendations.

Methodology

Key Definition

Influenced by the fields of decision-support systems/information technologies, business and healthcare studies, and organizational science, we sought literature that detailed *data driven decision-making* in IHEs. We define DDDM as a process of consideration of data towards informed decision-making, resulting in action by stakeholders. We extended our definition to allow for inclusion of literature that detailed "collection, analysis, examination, and interpretation of data to inform practice and policy in educational settings…a generic process that can be applied in classrooms to improve instruction as well as in administrative and policy settings" (Mandinach, 2012, p. 71).

Methods

Our literature review reports on findings within peer-reviewed journal articles and other research reports (including dissertations) published between 1980 and 2013. We selected articles through a succession of inclusion and exclusion criteria. We began by searching

within JSTOR and Google Scholar[2] using the key terms *data driven*, *decision making,* and *higher education*. Our initial JSTOR and Google Scholar search resulted in 108 and 6630 studies deemed relevant by the search engines, respectively. Two researchers reviewed the abstracts of all novel 108 JSTOR articles and the top 500 most relevant studies from the Google Scholar search. Articles clearly concerned solely with the K-12 environment were excluded. An additional two researchers reviewed the resulting list of articles and performed an independent search of abstracts, adding an additional 28 articles for consideration. To our initial examination of the abstracts, we applied the follow-up inclusion criteria of if data (of any sort) was used to inform some sort of decision-making process (of any sort) in a higher education setting; this resulted in a list of articles to be reviewed in their entirety. We then reviewed each of the selected abstracts via an inductive thematic analysis to identify the types of activity being described, examples of these activities, and key factors or considerations regarding implementation. Abstracts were reviewed by at least two researchers. Resulting themes were reviewed and honed by the research team, resulting in more nuanced codes. Works were then reviewed in their entirety by one researcher, during which a few articles were identified via backward referencing. Our final review consisted of 117 articles pertaining to DDDM.

Limitations

It is important to note that this is not an exhaustive review of the literature. In essence, our review is a “30,000 foot” survey, providing a brief overview of a very wide array of literature that details the most common conceptualizations and actions concerning DDDM at institutions of higher education, both more generally speaking and concerning curriculum and instruction, specifically. Thus, our literature review is one of breadth over depth. We explicitly do not detail nuances within the most voluminous bodies of literature informing this topic, such as that concerning instructors’ response to summative assessment. Instead, we seek to provide a representative sample of research articles and reports to illustrate the wide array of scholarship concerning data as part of organizational improvement mechanisms, in general, and for teaching-related practices in particular, in IHEs. We detail representative findings for each sub-body of literature informing DDDM in higher education, with an eye towards informing those interested in fostering more effective DDDM in higher education and, specifically, towards teaching and learning improvements.

Results

DDDM In IHEs Writ Large

Concerning DDDM in IHEs writ large, we identified the following foci of research concerning DDDM in IHEs: general improvement to institutional functioning and structures (e.g., total quality management, knowledge management, and strategic planning), process/ structures supporting institutional decision-making (e.g., decision support systems, data mining, and academic analytics), meeting institutional or

[2] Google Scholar is acknowledged as a reliable source for information. A study by Howland et. al. (2008) found that Google Scholar is 17.6% more scholarly that other materials found only in library databases and there is no statistically significant difference of materials found on Google Scholar across disciplines.

programmatic accreditation, quality assurance, developing and honing methods for improving data analysis, facilitating participatory models of decision-making, and curricular and/or instructional improvements. Main foci in this literature included organizational processes and affordances and barriers to DDDM, although some individual level phenomena were also attended to, especially with respect to barriers to DDDM.

General improvement to institutional functioning and structures (e.g., total quality management, knowledge management, and strategic planning). Institutional commitment/pressure to improve writ large was detailed as the basis of DDDM in one significant body of literature in which we noted advocacy for various types of data, all institution-specific, used towards assessment of institutional goals, as well as certain structures and processes allowing for decision-making activities ranging from institutional dialogue to program improvement to external accreditation bids (Gallagher, 2008).

Johnston and Kristovich (2000) provide a summary of typical data characteristics, artifacts and structures, and related DDDM actions to improve one IHE. These include key stakeholders' actions and responsibilities regarding data and its use, with focus on the brokering role that institutional researchers play in controlling the nature of data, its distribution and, ultimately, how the data is received as information for academic officers, such as department or college heads. Key attention towards fostering movement and use of data to inform decision-making in these complicated organizations included *relevance*, *acceptability*, *timeliness* and *integrity* of data source and transmission, as well as proper data warehouse management (storage and retrieval), redundancy of data collection and analysis methodologies (to limit effort), and presentation of related data in common formats meeting user-specified needs and interests (such as institutional *fact books*), often towards program "self-study" towards various ultimate goals (like accreditation).

Banta, Pike & Hansen (2009) provide a case study of one IHE engaged in a "cyclical model" of DDDM using student engagement data, measured via the National Survey of Student Engagement (NSSE), to meet external accreditation requirements, general accountability to stakeholders, and "internal needs for strategic planning and program assessment" (p. 21). Like others we reviewed, Banta et al's article is largely advocacy for certain structures and actions they found to allow for the institution's DDDM success, presented as a cycle of procedures that begins with involving key stakeholders in goal setting for the institution (e.g. students, faculty, administration, and institutional researchers), identifying measurable goals and associated methods to assess them (at both institutional and unit-level), key stakeholders' evaluation of data towards recommendations for improvement, and documentation of data informing constituents of related improvements. Specifically, these researchers advocate for the use of the NSSE in DDDM, largely via argument of its "psychometric properties, provision of normative data, and perceived face value among administrators and faculty" (Banta et al, 2009, p. 26). They go on to detail the use of the NSSE by four IHEs towards meeting accreditation requirements, two IHE systems for general accountability reporting, four IHES in terms of strategic planning, and one for program assessment.

Some sources detailed specific strategies and ends for institutional improvement where data are utilized to make decisions. Total quality management, knowledge management,

and strategic planning are now reviewed in turn.

Total quality management. Total quality management (TQM) models applied to higher education have borrowed from the automotive and electronic industries. *Total quality management* "is primarily concerned with increasing customer satisfaction through an integrated framework that examines the relationships between various system-wide elements and makes data-driven decisions to reduce errors and waste in processes" (Hogg & Hogg, 1995, p. 35). Cole (1995) argues that attention to mechanisms and processes constructed towards enhanced responsiveness to customers' needs and perceptions in a regular and timely manner may help IHEs (re)gain public approval. Beyond the importance of customer feedback to identify problems of design, TQM in IHEs highlights organizational functioning and accountability the assessed via performance data (Grant, Mergen, & Widrick, 2004; Hill & Taylor, 1991; Hogg & Hogg, 1995; Indrus, 1996). TQM necessitates that IHE personnel acknowledge their roles in larger, complicated systems (Cole, 1995; Dais & Somerville, 2006; Hogg & Hogg, 1995), with each individual worker as both a supplier and a consumer/producer in relation to other levels in the system. This type of supplier/customer dual role reinforces shared objectives, pride in services provided, and accountability as individuals or units interact within an organization/system (Hill and Taylor, 1991).

Beyond model replication, TQM in IHES have also been well financed by the business sector. The 1990s saw businesses like Motorola and IBM committing significant funds to institutions of higher education to improve student impact via TQM (Hogg & Hogg, 1995). TQM has been implemented at several universities and university systems (Hogg & Hogg, 1995), generally over multiple years, and concerning the improvement of institutional functioning (usually towards improving interrelated units) or academic offerings (Idrus, 1996, Marchese, 1993). Yet Romero, in 2008) argued that TQM is relatively novel practice across IHEs.

TQM in institutions of higher education, like other DDDM, has been characterized as largely towards meeting external pressures, to secure greater resources/plan for dwindling resources, to measure and improve teaching, and improve employer satisfaction regarding graduates, as well as to assess and improve student satisfaction and services, curriculum, and university general operations (Banta et al., 2007; Grant et. al., 2004; Hogg & Hogg, 1995; Idrus, 1996). The articles reviewed for this work confirm these characterizations with a notable exception of Cole's (1995) article detailing the use of a TQM/DDDM model, and detailed process, by faculty search/hiring committees.

Numerous researchers have documented TQM towards specific program/unit design and improvement (Banta et al., 2007; Banta, Pike, & Hansen, 2009; Chism & Banta, 2007; Dais & Somerville, 2006), Banta et al. (2007) document an institutional research unit's action research to improve functioning in light of impending budget constraints. Ultimately resulting in reflection but little revision to practice/strategy based on data interpretation, the researchers discovered that the academic deans at one university were best positioned to digest and use institutional research and desired data most helpful in planning for these impending cuts (e.g. that would aid in student recruitment and attract more research funding); in contrast they found chairs and associate deans to be minor

consumers of the data they were providing and that, overall, respondents found data pertaining to programs' efficacy concerning student outcomes less meaningful.

A group of sources reviewed highlight the distributed nature of TQM in IHEs. These include Hill and Taylor (1991) who detail the work of inter-organizational and -disciplinary teams that include a combination of administrative and academic staff coalescing and responding to data towards improvement. These teams, and their larger organizations, are conceptualized by some scholars as *learning organizations* (Dais & Somerville, 2006; Freed, 2001), operating within a "systems thinking approach" in awareness of other units, data available, and overall missions of the larger organization (Dais & Somerville, 2006, p. 128; see also Cole, 1995). Researchers claim that TQM unites workers around common mission, safety in risk taking, and commitment to continuous improvement beyond financial achievements (Freed, 2001; see also Cole, 1995). Freed claims, via a case-study of one, that IHEs are capable of quality TQM **if** functioning as learning organizations with the above characteristics and complete with the necessities of strong leadership and collaboration, training for those who need skill development towards learning organization participation, and DDDM regarding institutional functioning and stakeholder needs. Cole (1995) argues that TQM is most effective if an entire institution of higher education is implementing/committed to it.

Many of the works reviewed claim that organizational learning and change have resulted from TQM via related practitioners' commitment to use data to inform decision-making and changes to practices (Banta et al., 2007; Banta, Pike & Hansen, 2009; Dais & Somerville, 2006; Freed, 2001; Griffin, Lewis & Greenberg, 2012). Dais & Somerville (2006) claim these processes result in increased confidence regarding initiating and engaging in inquiry, evaluating data, and commitment of continuous improvement via evidence-based decision making. Griffin, Lewis and Greenberg (2012) detail a DDDM endeavor undertaken by library personnel at one IHE. Specifically detailed is "comprehensive, integrated assessment strategy" in gathering and responding to data from key stakeholders to improve functioning in the special collections department unit via the backdrop of dwindling state financing, institutional desire to demonstrate student satisfaction, career preparation, and matriculation rates, as well as a push among the larger university library community to engage in assessment towards improvement. Data collected over a two-year period was both quantitative and qualitative, and namely concerning use of physical resources (manuscripts and reading room activity) and website traffic, largely via a variety of free library-data specific tracking tools. Amid claims that a holistic assessment strategy is not part of the work culture, library personnel co-analyzed each resulting data set separately and holistically, and make recommendations to improve services accordingly.

Impediments to enacting TQM in institutions of higher education include faculty autonomy, suspicion of applicability of business models (and even terminology) to education systems, a reward system that devalues teaching and efforts to improve teaching, general inertia regarding systematic change, and distributed, decentralized power within organizations of higher education (Cole, 1995; Hogg & Hogg, 1995, Idrus, 1996). Idrus (1996), in his review of TQM in education, elaborates on impediments towards realizing the promises of TQM, including the particularly novel, complex, and problematic delegation of activity and decision-making in organizations of higher

education that results in conflicted senses of purpose of key players and faculty who may not view student perceptions (data) as worthy.

A few researchers have made an argument for use of both qualitative and quantitative data for IHE TQM (Allen, 2004; Chism & Banta, 2007; Griffin, Lewis, & Greenberg, 2012). Chism and Banta (2007) detail typical techniques used to gather formative, qualitative data towards DDDM, regarding improving student service support more generally speaking, institutional effectiveness, faculty development programs, and curriculum and instruction (discussed later in this paper). Hogg & Hogg (1995) argue for the critical importance of valid and reliable statistics in the TQM process. Partially for lack of statistician involvement to help secure and make sense of advanced statistical exploration of problems needing improving and limited commitment of top administrators to the overall process, Hogg & Hogg (1995) also lament that although data that should allow for TQM at IHEs are numerous, they too infrequently drive pertinent action.

Knowledge management/Data warehousing. *Knowledge management* (KM) is a collection of practices that helps to capture and improve the use and sharing of knowledge/data and information for decision-making (Bernbon, 2001; Milam, 2003; Milam 2005; Petrides & Nodine, 2003). A fair number of researchers detailed the resources/structures necessary for effective KM, notably people, processes, and technologies, to collect, use, and share information more effectively, and effective collaborations particularly necessary for effective implementation of KM in the social systems of organizations (Bernbon, 2001, Milam, 2003; Milam 2005; Petrides & Nodine, 2003; Santo, 2005). *Data warehousing* (DW) is one potential means towards KM, uniting people, processes, and technology in bringing disparate data sets at an institution together for informed decision making, predominantly by administration (Heise, 2005; Milam, 2005; also see Briggs, 2006, for a description of less structurally complex systems than typically utilized in DW, called *operational data stores*). Undertaking of both KM and DW have relied overwhelming on budgeting from institutional research units and the *infomediaries* that work within them (Costello, 2000, cited in Milam, 2005, p. 63; see also Heise, 2005). However, arguments have been advanced for more concerted involvement and leadership in KM on the part of provosts towards institutional commitment and widespread meaningful practice of DDDM (Stevenson, 2001), as well has greater adoption of and leadership by colleges of education (Santo, 2005).

Various researchers have documented common motivators of KM and DW include honing, organizing, and accessing data specifically towards decision-making regarding institutional resources management and strategic planning and student recruitment and retention (Briggs, 2006; Guan, Nunez, &Welsh, 2002; Heise, 2005), chronicling of student information (e.g. demographics and majors) (Heise, 2005), breaking down typical (departmental) silos of data (Briggs, 2006), meeting requirements of external agencies (e.g. federal government, state governments), and assessing performance of programs and institutions (Guan, Nunez, &Welsh, 2002). Ultimately, documentation of both KM and DW in the postsecondary arena have largely concerned ensuring an institution's financial viability and increasing its competitiveness Costello, 2000; Heise, 2005; Milam, 2001). Milam's (2001) report on KM in higher education may allude to what he advocated for in 2001, that being utilizing KM to "retain a technology workforce, expand Web-based offerings, analyze the cost effective use of technology, and do other things necessary to

compete" (p. 1). A few works we reviewed for this literature review detailed the use of KM and DW towards specific academic programming or delivery mode. In his report, Milam (2001) advocates for IHEs to adopt a KM model towards better creation and delivery of online course and e-learning environments, with allusion to improve associated curriculum and instruction. Swan (2009) explores a DW tool used at one university for collecting data to inform improvements to teacher preparation, specifically a portal to conduct field observations of pre-service educators.

The strong emphasis on collecting and managing data for sharing with key stakeholders towards improvement makes KM an appropriate framework for DDDM; however researchers have documented associated challenges at the institutional and worker levels. Although advanced information technology for DW and KM purposes is available at most IHEs, decision makers still may lack access to the data needed to make effective decisions concerning finances, staff, and students (Guan, Nunez, & Welsh, 2002; Petride & Nodine, 2003). Other barriers of widespread, effective KM at IHEs include employees' time constraints and lack of understanding of KM principles and associated practices and skills, including how to identify pertinent information within a data deluge, as well as organizations' inability to incentivize and implement KM and DW due to funding, structural, and cultural limitations (Briggs, 2006; Dyer & McDonough, 2001; Milam, 2001; Milam, 2005). These include norms of competition and reactiveness within higher education organizations (Milam, 2005; Santo, 2005), potentially leading to a lack of concerted effort to improve towards current worker and student needs. Those most practiced at facilitating and enacting DW and KM, largely those from offices or units dubbed *institutional research*, are often overburdened with competing work and tasked by others to locate data to confirm preconceived justifications (Milam, 2005). In addition, externally created and marketed KM systems may not deliver on all critical components of such systems, including data gathering and storage, coding/categorization, and distribution/delivery (Chapman, Coukos & Pisapia, 2001). Heise (2005), via survey of 202 "senior decision makers and technology managers" at US institutions of higher education, documented limitations of DW, specifically limited technological capacity and resources for warehousing, data quality, and limited buy-in regarding data use; his findings of somewhat limited use of DW (even in the face of a strong desire and recognized potential regarding DW on the part of university administrators) were most attributed to limited resources and involvement of more upper level administrators. Briggs (2006) documented personnel resistance to using new data management systems, as well as concerns regarding who "owns" the compiled data within it, offering that independent consultants can help alleviate some of these concerns. As such, at least as of 2005, KM may be still relatively under-practiced at institutions of higher education (Milam, 2005).

Institutional strategic planning. A few works focus specifically on how DDDM informs the process of *strategic planning* (SP), the determining and assessment of institutional or organizational goals. Two works detail the use of student outcome data to support strategic planning. Gallagher (2008) reports on surveys with 68 California community colleges' chief instructional officers, specifically of their perceptions of how student outcome data informs strategic planning. According to self-reports of respondents at this sample of institutions, strategic plans typically exist at institutions of higher education and drive decision-making regarding mission, goals, and associated actions. While survey

data indicate a lack of concerted consideration of student outcome data in institutional strategic planning writ large, interviews with a limited subsample (n=12) indicated outcome data did inform some strategic planning and related decision-making, notably via the work of faculty working to improve their programs, often in response to external accreditation pressures. Gallagher notes very little tie of student outcome data to a distribution of resources (most often tied to student enrollment numbers). In addition, colleges lack a central student assessment data base/system or formal policies and procedures guiding the gathering of this data. Gallagher notes concern on the part of various IHEs, and their personnel, regarding assessment tools' adequacy in measurement of student outcomes and the appropriate use of this data.

Hossler, Kuh, and Olsen (2001), in their description of various improvements at one IHE, highlight the use of market research and novel institution-specific research to guide strategic planning concerning student recruitment, and how and who to best ensure this DDDM. Important to the success of these DDDM initiatives, both in their initiation and realization of associated positive change, were higher education researchers familiar with relevant literature bases as well as powerful institutional administrators able to push for data-driven changes among reluctant, relevant personnel.

Kinnick (1985) argues for the importance of student outcome data towards meaningful strategic planning and related action towards end results ranging from institutional dialogue to program improvement to external accreditation bids. Kinnick largely details challenges to use of student outcomes data towards strategic planning and how seven IHEs alleviated theses challenges. Kinnick groups affordances into two main categories, the *organizational* and the *technical.* Organizational challenges overcome included limited access to information, general organizational structure including weak connections between data collectors and managers and users, sparse incentives to use and respond to data; technical challenges largely concern limited data integrity, validity, timeliness, and interpretability and the preponderance of data. According to Kinnick, this is accomplished via pertinent external incentives and data that is made more meaningful via disaggregation and more digestible, issue-specific presentation. Kinnick provides a model of successful data-focused strategic planning that, regardless of source of motivation (internal or external to the institution), should normalize ongoing work towards improvement towards common organizational goals, unite and organize diverse stakeholders, formalize unit review, and motivate "bottom-up" desire for improvement.

Processes/structures supporting institutional decision-making (e.g., decision support systems, data mining, and academic analytics). One body of literature details processes regarding data storage and analysis towards enhanced DDDM at IHEs. These processes include decision support systems, data mining, and academic analytics. Baepler and Murdoch (2010) discuss the history and nuances of academic analytics and data mining, ultimately developed in response to the increasing volume of data in higher education. Various works detail the processes of *data mining* at IHEs, including the multidisciplinary methods and paradigms that guide it (Romero, Ventura, & García, 2008). Often academic analytics and data mining are conceptualized within decision support systems.

Decision support systems. *Decision support systems* (DSS) (also called *strategic*

information systems, see Goyal & Vohra, 2013) are technology that "can range from a system to answer simple queries that allow a subsequent decision to be made, to a system that provides detailed querying across a spectrum of related datasets, and further to complicated systems which directly 'answer' questions, in particular high-level 'what-if' scenario modeling"…[ultimately] providing "support for decision makers by bringing together human judgment and computerized information in an attempt to improve the effectiveness of decision-making" (Bresfelean et al., 2009, p. 344). DDS typically include data gathering, storing, analyzing, and reporting functioning. Although of initial significant expense and effort to institutionalize, DDS may be critical towards effective data-mining and academic analytics and, ultimately, towards DDDM (Bresfelean et al., 2009).

Data mining. The concept of data mining originated in the business world and was introduced at IHEs in the mid 1990s. *Data mining* (DM) is an iterative process, multidisciplinary in methodology, and draws from numerous computing paradigms (Romero, Ventura, & García, 2008), allowing meaningful insights via queries regarding a large field of data using specific techniques (Baepler and Murdoch, 2010; Bresfelean et al., 2009; Goyal & Vohra, 2013), such as classification and clustering analysis (Romero and Ventura, 2010). Emerging in the education arena (Goyal & Vohra, 2013). DM may also include methodologies to include regression and psychometric modeling (Baepler and Murdoch, 2010; Yu, Digangi, Jannasch-Pennell, & Kaprolet, 2010).

Largely concerning issues of student enrollment and performance (Goyal & Vohra, 2013), Romero and Ventura (2010), in their review of over 300 papers concerning educational DM, note main trends of using DM in the following education environments and via certain common tools: to assess student usage and interaction with learning management systems/learning platforms (e.g. Blackboard) and other web-based education artifacts; tutoring and other adaptive education systems; via tests/questionnaires and analysis of other content; and in relation to more "traditional" education environments. Romero and Ventura additionally present a top eight categories (drawing from more than 15 works reviewed) of DM research focus, in descending order: providing data feedback regarding specific practices to instructors, predicting student performance, providing recommendations to students towards their enhanced academic performance, analysis and visualization (basic data presentation for digestion by potential users), modeling of students cognitive dispositions/abilities, grouping students by characteristics to aid in creating personalized learning activities/systems, identifying and detecting undesirable student behavior to initiate interventions, and social network analysis regarding group interaction and performance.

A few case studies of DM were also reviewed. Romero et al (2008) provide a step-by-step description of a Moodle-based course that utilized free DM software. Anton and Maltz (2006) chronicle in detail a collaborative DM process between a liberal art's university's admissions office, institutional research office, and a data-mining class for business students that resulted in a model to improve management regarding enrollment and awarding of tuition aid and drove related action in subsequent years. Yu et al. (2010) report on data mining regarding factors associated with student retention at one US IHE, noting correlations (not previously identified using more typical parametric measures) concerning transfer credits, residency, and ethnicity. Arnold, Tanes, and King (2010) detail the perceptions of one large IHE's administration regarding the use of a DM

technology for providing students with formative feedback regarding success in courses, finding that administrators feel the DM platform aided students but may be too difficult to implement across an entire university.

Academic analytics. Baepler and Murdoch (2010) describe *academic analytics* (AA) as "actions that can be taken with real-time data reporting and with predictive modeling which helps suggest likely outcome from familiar patterns of behavior" (2010, p.1), resulting in DDDM mostly towards improving operational functioning at the university or college level, but also applied to student teaching and learning issues (Campbell, Deblois, & Oblinger, 2007). Also called *learning analytics*, AA is a fairly new approach to decision making in higher education that stems from the popular practices of data mining in business and marketing (Beer, Jones, & Clark, 2012). Although, the concept of AA is based on DM, these two approaches differ in several respects. AA is hypothesis-driven; a specific dataset is used to solve a practical academic problem, such as increasing student retention rates. In contrast, data mining does not prescribe a hypothesis and may utilize a greater array of data sets to search for any interesting patterns (Romero et al., 2008), and, it has been argued, may be less biased a process for the researcher (Anton & Maltz, 2006). A shared barrier to both AA and DM is the complexity of methods to undertake either, beyond the training of most educators (Anton & Maltz, 2006; Arnold et al., 2010; Garcia et al., 2011; Romero & Ventura, 2010), financial investment to engage in the processes (Anton & Maltz, 2006; Arnold et al., 2010), the lack of standardization and integration of DM or AA tools and interfaces within learning environments, and their ability to account for educational context (Romero & Ventura, 2010).

Campbell, Deblois, & Oblinger (2007) detail common foci of AA at IHEs via representative case studies, most notably to predict and improve student enrollment and retention and to create early detection warning systems for at risk students. They recommend that to build a successful AA endeavor, IHEs must have knowledgeable staff, administration support towards DDDM, and a "flexible" data management system.

Lonn et al. (2012) detail AA at one US institution on data gathered via an undefined learning management system that resulted in researchers preparing periodic data reports showing student success and risk factors for academic advisors in engineering. Beer, Jones, and Clark (2012) report on AA concerning 80,000 students across three learning management systems at one IHE, raising numerous concerns regarding methodologies, arguing that predictive modeling may be unattainable with respect to IHEs as complex systems interacting with multiple other complex systems. In addition, they raise concerns with potential limited usability of the models that result, arguing that typical models resulting from AA do not allow stakeholders to "see" data at the class or course level. Beer et al. go on to argue that the theoretical framework of complex adaptive systems may help researchers implement more careful and meaningful AA in the postsecondary education environment.

Meeting institutional or programmatic accreditation. Research on DDDM in higher education is often in relation to external accreditation-of institutions, colleges, departments, and programs (Banta et. al., 2009). Launched into existence in the late 1800s (Rhoades and Sporn, 2002) accrediting bodies soon began calling for evaluation and improvement of IHEs on the basis of data (Resnick & Goulden, 1987; Peterson et al.,

1999), notably in business schools. Julian and Ofori-Dankwa (2006) and Romero (2008) best detail business schools attempting to meet accreditation norms. Three pertinent accreditation agencies in the US impel business schools' DDDM informed by "hard" data (e.g., numerical survey data) from "objective" (formalized and quantifiable) assessments, documentation of external accountability to stakeholders, and proof of their engagement in a continuous improvement cycle via self-evaluation (Julian & Ofori-Dankwa, 2006, Romero, 2008). While Romero et al. (2008) praises the positive change accreditation pressures inspire at business schools via DDDM, largely based on anecdotal evidence from a limited group of school administrators, Julian and Ofori-Dankwa (2006), via review of pertinent management literature, claim that accreditation forces business schools into reactionary DDDM, consisting of subpar single-loop (as opposed to double loop learning) and resulting in strategy and action ignorant of the most meaningful data towards improving business schools.

Lattimore et al. (2012) documents the felt need at five community colleges to share the data that demonstrates their accountability, largely with respect to financial issues and functioning, with various entities that hold them accountable, conceptualized as the *market*, the *political*, and the *academic* (borrowed from Burke, 2005), not noting a difference between the degree of influence of these entities as felt by the institutions.

Quality assurance. A body of research concerning *quality assurance* (QA) details efforts of IHEs and units/programs to ensure quality of offerings to consumers, namely students, largely in response to institutional and program evaluation. Given the longer standing QA movement of the 1990s in Europe and Australasia, quite a bit of literature underscores the role of non-US institutions regarding related issues (e.g. Ball & Wilkinson, 1994; Billing, 2004; Grant & Mergen, 2004; Harman, 1998; 1994; Haug, 2003; Jongbloed & Westerheiden, 1994). Research concerning QA has been conceptualized with respect to the specific higher education programs attempting to bolster or secure quality, including nursing education (Suhayda & Miller, 2006), athlete versus non-athlete experiences (Emerson, Brooks, & McKenzie, 2009), and superintendent licensure (Hollingsworth, 2012), and K-12 educator preparation (Swan, 2009).

Emerson, Brooks, and McKenzie (2009) review some of the QA research in their report on the College Sports Project (CSP) across institutions, towards advancing more informed decision-making with respect to athletics at 80 NCAA as Division III postsecondary institutions, for which their study was commissioned. One of the largest studies we identified that detailed using data to inform decision-making at institutions of higher education, Emerson et al share data regarding 200,000 students over five years "to provide summary data and useful information for institutional presidents interested in ensuring good alignment between their academic missions and intercollegiate athletics [and] develop programs aimed at integrating athletics more fully into the academic life of the institution" (p. 68), in essence intending to assure consistent levels of quality of participating institutions in meeting student needs, as well the quality of students being accepted and matriculating institutions. The researchers note that such an undertaking required linking to external data sets (e.g. from The College Board) and complicated IRB assurance processes, but resulted in the positive unintended consequences of participating institutions strengthening data warehouse management and internal organization collaboration. The CSP study authors decided to report data across

institutions to inform their institution-specific reports, assuming that their report readers (institution presidents) could and would respond to the data/information provided as they would see fit. They make no mention of the degree of realization of these assumptions in the 2009 article.

The research concerning DDDM towards QA is notable for its critiques of external bodies judging the worth of institutions of higher education on flawed or incomplete data (Beer et al., 2012; Gallagher, 2008). As these also concern curriculum and instruction related issues, we will return to related concerns later in this document.

Developing and honing methods for improving data gathering, analysis, presentation, and distribution. Various works we reviewed alluded to developing and honing methods for improved data gathering, analysis, presentation, and distribution; these include some mentioned above in preceding sections. This is an explicit focus of others' research. Ahren, Ryan, and Massa-McKinley (2008) report on interviews with two-dozen managers responsible for administering the NSSE (project managers) at various IHEs, detailing guiding principles towards more meaningful DDDM and related action, including the collaboration of key campus stakeholders on the analysis, communication of, and response to evaluation results with respect to predetermined, collaboratively created goals. They highlight the prevalence, at the most successful institutions, of collaborations involving faculty, student affairs educators, and institutional researchers, stressing the particularly important role of the institutional researcher who can most easily help translate data into themes, and foster trust and investment regarding NSSE data. Ahren et al also found that campus NSSE data managers were effective at conveying the potential use of the data to instructors when the manager met personally with the instructors armed with "attractive reports for each of those individuals to highlight results that pertained to their specific duties" (Ahren et al., 2008, p. 30). Ahren et al also argue that triangulation between NSSE data and other student data both validation and context for NSSE results.

Lattimore et al. (2012), via case studies at five community colleges, documents the need for IHEs to inform the various levels that hold them accountable regarding financial issues and functioning: the market, the political, and the academic (Burke, 2005). According to Lattimore et al., although the power in allocating resources is often at the college level, departments are most primed to demonstrate financial accountability and that this could, in fact, "trickle up" through the larger system usually is ready to receive the data and that, in turn, ultimately grants the departments otherwise almost complete autonomy.

Rasmani and Shen (2006) advance a detailed methodology of data analysis, arguing for the relative superiority (over typical methods) of data-driven fuzzy rule induction, complete with inference mechanism and algorithm methodology to evaluate student academic performance.

Participatory models of decision-making. Additionally, we identified a body of literature advancing how data collection/analysis, and related decision-making activities, can be more *participatory*, in involving key personnel in the evaluation of their own practices and subsequent revision to these. Some of these have been described in the above sections; for instance Dais & Somerville (2006) who reported on a participatory

models of decision-making via action research undertaken by library personnel. Additional articles we reviewed document/argue specifically for a model of participatory DDDM in higher education. Two detail collaborative action research-like activity, involving personnel working at institutions of higher education engaging in inquiries regarding practices and structures relevant to their work (Bensimon et al., 2004; Hansen & Borden, 2006). Bensimon et al. (2004) conceptualize DDDM within the *practitioner as researcher* model in which researchers adopt a stance counter to the typical ideal of a "researcher," disassociated and objective with respect to problems and inquiry. Similar to various notions of education practitioner inquiry, where educators engage in iterate study regarding their own teaching practices informed by critical others (Bouwma-Gearhart, 2007), the practitioner as research model involves organizational affiliates that have a vested practical interest in discovering and investigating problems to be actively remedied by them and colleagues; in Bensimon et al.'s article, improvements were made to institutions' success regarding participation and advancement of racial and ethnic minorities. Hansen and Borden (2006) detail two action research projects involving multiple stakeholders at one university, one towards improving new student orientation and the other campus climate for enhanced diversity. The authors claim that resulting knowledge and revision to associated future practices and structures were greatly enhanced by the participation of diverse stakeholders.

For Hashim, Alam, and Siraj (2009; 2010a; 2010b) participatory decision-making is firmly tied to action by choosing between alternative actions in response. According to Hashim et al.'s model, decision-making is distributed in groups comprised of stakeholders who share their needs and preference for alternatives informed by different perspectives, resulting in stronger courses of action (e.g. engaging lecturers in collective decision making alongside faculty).

Yet, while Hashim et al. advocate for a distributed DDDM model, they also insist that such a model that is still rare in practice (p. 385). Hansen & Borden (2006) also detail potential barriers to participatory decision-making, including role ambiguity and work overload, and offer potential alleviations of these barriers, including making obvious to all participants the goals, division of labor, and time and resources commitment involved in such processes.

We now turn to detailing the literature regarding DDDM in higher education pertaining more specifically to curriculum and instruction.

Curricular And Instructional-Related DDDM In IHEs

Overall, we found a significant literature base about DDDM specifically concerning curriculum and instruction in IHEs, but limited in key respects. Predominantly, our search unearthed literature attending to course management systems and learning analytics, curriculum planning, centers of teaching and learning and other campus units assisting instructors in DDDM, in-class formative assessment, and instructors' out of-class data use. In contrast, we found scant attention to how teachers actually use data from a practice-oriented perspective; the little we did found was largely anecdotal and non-empirical.

Course management systems and learning analytics. A growing body of research (e.g., Lonn and Teasley, 2009; Morris, Wu & Finnegan, 2005) details data mining and academic analytics as informing curriculum and instruction decision-making based in e-learning platforms, notably course management systems (CMS) (e.g. Moodle or Blackboard) that institutions spend millions to buy, implement, and support (Baepler & Murdoch, 2010). Most of these articles detailed cases of auditing CMS, largely through learning analytics/data mining. Largely still a new practice, Baepler and Murdoch (2010) claim that auditing provides instructors and administration with pertinent data regarding the purposes and functions of CMS per instructor use (e.g. used to store syllabi, grades, and readings versus initiating knowledge construction or peer-to-peer discussion or assessment), can provide useful data about faculty course design, and determine correlations between student participation and various measures of success. For instance, Black, Dawson, and Priem (2008) used Moodle CMS data logs to predict student's sense of community among 67 U graduate students towards future online offering improvements. Lonn and Teasley (2009) investigated the usefulness of CMS at the University of Michigan, via user log data, to determine correlations of what faculty and students value as capabilities against actually use of a CMS. They noted that document management and broadcast-oriented communication tools were highly valued and most commonly used and that interactive tools were not as valuable and least used. They also noted that faculty were more likely than students to think information technology (IT) improves teaching and learning, offering that students may view CMS as spaces predominantly for document management and basic communication, something to potential work to remedy.

Morris, Wu and Finnegan (2005) detailed learning analytics implemented at one IHE resulting in an algorithm, allowing administrators to predict and make decisions concerning student completion and withdrawal rates in an online course. Findings revealed an algorithm of 74% prediction accuracy regarding likelihood of online course completion, with GPA, SAT scores, students' motivation and financial status as predictive variables. The authors argued for usefulness of early and frequent assessments for course developers towards changing student study habits and overall success in introductory courses.

Yu, Digangi, Jannasch-Pennell, & Kaprolet (2008) detail a study of a data warehouse at one IHE, exploring the most salient factors that predict online course enrollment, via multivariate adaptive regressive splines. The researchers noted that age and discipline were the most relevant factors and that younger students and those in education and the fine arts were most likely to enroll in these offerings, shedding light on audiences to target and how to better meet enrollee needs.

One article by Garcia, Romero, Ventura, and Castro (2011) provides a tutorial of a data mining tool that allowed its developers and a small group of instructors to ascertain student interactions with e-learning environment resources. Users reported high interest and motivation with respect to the tool's use as it allows for creation and testing of models based on instructors' initial values of low, medium, and high interactions with course resources via association rule mining.

Mattingly, Rice, and Berge (2012) offer a review of academic analytics on distance education programs based on cases at five IHEs. Accompanied by a review of pertinent literature, the authors provide a list of considerations/recommendations for successful analytics projects to best inform faculty and administrators. Towards allowing instructors and developers insights regarding the most effective curriculum and instruction, key objectives need to be defined, collaboration enhanced, roles defined, and participants trained in successful analytics, including how to protect participant privacy and security, and how to effectively present and access data. Campbell, Deblois, & Oblinger (2007) detail similar findings concerning academic analytics at IHEs via representative case studies, including detail of a case of the creation of early detection warning systems to identify and aid at risk students per IHE-experience-specific data such as undergraduate GPA, as well as socio-cultural indicators such as lower socio-economic status.

Centers of teaching and learning (and other campus units) assisting instructors in DDDM. One body of literature detailed specialized units on IHE campuses assisting educators in DDDM. Acknowledging that centers for teaching and learning (CTL)-like units typically interact with individual faculty concerning their "isolated courses" and not necessarily with respect to DDDM concerning their curriculum and instruction, Wolf's 2007 article details the evolution of one CTL unit's practice in helping individual faculty or academic programs gather and respond to data relevant towards improving curriculum and instruction, insisting that the focus intensified as more and more faculty become aware of the center's ability to help them regarding curricular and instructional focused DDDM.

Dais & Somerville's (2006) document library personnel at one IHE meeting with departmental units and surveying pertinent departmental curriculum and instruction-related documents (including syllabi, curriculum plans, and accreditation documents). This allowed for the creation of discipline-specific research guides to attend to students' needs. The process also resulted in library personnel serving as consultants to faculty and departments to improve course information resources for use by students and considering and responding to data regarding student use and felt usability of the library website.

As mentioned previously, institutional research offices have been recognized by many researchers as key to DDDM at IHEs, and this includes DDDM concerning curriculum and instruction. Associated articles largely detail best practices of institutional research personnel in adding DDDM regarding curriculum and instruction. Stark, Briggs, and Rowland-Poplawski (2002) advocate for institutional researchers to assist department chairs with better sensing of curricular changes needing to be made via relevant data and more regular guidance. Ahren et al's article (2008) details interviews with two dozen educators responsible for administering the NSSE (project managers) at various IHEs to determine how data from the NSSE were being used. The authors found that campus project managers (often institutional researchers) of NSSE were effective at conveying the potential use of assessment data to instructors when the manager met personally with the instructors armed with "attractive reports for each of those individuals to highlight results that pertained to their specific duties" (p. 30).

Research from Banta et al. (2009) describes cases of potential roles of institutional

researchers and other assessment directors in DDDM. According to the authors, these individuals helped identify sources of appropriate direct and indirect evidence to assess instructors' C&I related goals, as well as tools to gather this evidence. The most convincing claim of successful instructor impact were via description of instructors using the NSSE to assess and respond to student learning outcomes at three IHEs via teams of faculty and institutional research representatives and other administrators. Administrators encouraged instructors to deliver the NSSE and analyze and respond to data towards collegiate and unit-level improvements. However, although the majority of descriptions allude to instructors implementing the NSSE and responding to data, little description of course or programmatic impact was actually detailed and no empirical data was offered backing up the claim that instructors at any institution studied by Banta et al. (2009) were, themselves, delivering, analyzing, or responding to the NSSE; institutional self-study and other accreditation reports were often cited as the presentation/evidence of institutional NSSE data and institutional response to it.

Curriculum design/planning. Another line of inquiry that sheds light on DDDM is research on course planning. Some of this research has demonstrated a dearth of DDDM with respect to course planning, including Yu, Digangi, & Jannach-Pennell (2008) and Garcia et al (2011) advocate for methods of data mining to identify the most salient student characteristics towards informing more immediate feedback loops desired by instructors for course planning.

Stark's study (2000), involving over 2000 instructors across eleven fields of focus, found that a little less than half considered or analyzed a particularly ubiquitous type of data - student evaluations - in their course planning. Of the 42% of instructors claiming to "examine previous student evaluations" in the process, only 1% cited it as the first step in their course planning, with the majority of participants claiming a first step to be selecting content to convey to students.

Briggs, Stark, and Rowland-Poplawski, in the early 2000s, lamented that continuous evaluations of quality in higher education were mostly confined to higher administration units and that most faculty did not link departmental or programmatic evaluation with their responsibilities. Briggs and colleagues asked "could we find models of department-level curriculum planning that engaged groups of faculty members in frequent reappraisal of the content, processes, resources, and outcomes of their program curricula?" (2003, p. 362). Their inquiry led to interviews with chairs and faculty from 44 departments, across diverse disciplines and institutional types, identified by their respective provosts as "especially attentive to curriculum planning at the program level" (2003, p. 364). From this Briggs et al. (2003) offer a framework to assess the regularity of program-level curriculum-planning efforts and associated DDDM, focusing on groups "frequent information gathering and group discussions that may lead to especially responsive decision making and implementation" (2003, p. 364).

Stark, Briggs, and Rowland-Poplawski, in a 2002 article, detail the many roles that department chairs fill with respect to curriculum/course design. While more intimately involved in curriculum development and implementation, chairs admitted less preparation, knowledge, and participation regarding curriculum assessment, all the while acknowledging impending pressures requiring more of this with respect to their programs.

The data claimed of use by chairs concerning curricular decisions was noted as largely informal (often concerning trends noted at peer institutions), not that meaningful (such as that regarding graduate satisfaction), and not applied systematically in curricular decision-making.

A case studies of successful DDDM to inform curriculum design and planning was noted in Harper & Lattuca's 2010 article that found that attention to a variety of data by faculty, via a process of continuous quality improvement is correlated with student success in engineering programs. In comparing programs where faculty were more collaboratively engaged in assessment activities and related curricular and instructional planning, faculty worked towards curricular connectivity and that student experiences, in turn, within such programs were more cohesive, requiring students to rely less on individual instructor efficacy to reap educational rewards.

Holme et al. (2010) detail the various tools typically used to inform postsecondary educators' DDDM, ultimately advocating for a model of intertwined course and assessment(s) development and use. Relying on literature review and personal experience, the authors contend that the best assessments allow use to inform various curricular and instructional strategies beyond those of the initial developer and assessing student outcomes beyond content knowledge acquisition. The best assessment, in turn, involves use of multiple assessment tools to allow for more accurate and richer investigation regarding student outcomes.

In-class formative assessment. A significant body of literature details in-class formative assessment occurring at IHEs, the gathering of data to ascertain students' ongoing progress, potentially allowing for DDDM towards meeting students' most timely needs (Hargreaves, 2008;Vonderwell, Liang, & Alderman, 2007). Recently emerging in the literature is an emphasis on formative feedback to students towards their better self-regulation of learning, ultimately decision-making regarding their learning in response to data demonstrating their current accomplishments and limitations (Yorke, 2003). Nicol and Macfarlane-Dick (2006) provide a review of this literature, ending with a model consisting of several principles of good feedback practice on the part of instructors; these include: clarifying students' understanding of learning outcomes, provide timely focused data to students, involving students in self and peer assessment, and using assessment to inform pedagogical practice.

Formative feedback provided by peers, and related DDDM on the part of the student receiver of this feedback, has gotten some notice (see Dorchy, Segers & Sluijsmans, 1999 for a review). Research has explored students' DDDM regarding this feedback with respect to skills as specific as writing (Topping et al, 2000) and job skills (Cassidy, 2006), and as general as students having access to data that demonstrate more successful peers' learning. This research has largely noted overall positive student impact, as well as how instructors may better foster more helpful peer feedback and related decision-making (van den Berg, Admiraal, & Pilot, 2006; Orsmond, Merry, & Reiling, 1996), notably appropriate spacing of feedback in relation to that coming from the instructor, small student groups, and verbal as well as written feedback. A more limited research body has explored the relative impact of peer versus instructor feedback on students' associated DDDM (see Falchikov, & Goldfinch, 2000 for review).

The largest body of literature on in-class formative feedback concerns instructors gathering and reflecting on student outcomes data towards informing their in-the-moment or more temporally removed (i.e. concerning the next class) decisions regarding their pedagogical practices. Some sources detail the interplay of instructors' chosen pedagogical methods with assessment. These include works reviewed in Gijbels et al. (2005) meta-assessment arguing for the enhanced importance of assessment in light of problem-based learning methods towards frequent feedback of data, and related DDDM on the part of the instructor.

A growing body of research has examined electronic means towards gathering formative assessment. These have included assessment conducted in totally online courses, with the assumption that this may be novel in nature (Vonderwell, Liang, & Alderman, 2007). To gather data regarding both processes and products of learning (Vonderwell et al., 2007). Gikandi, Morrow, & Davis (2011) argue that qualitative formative assessment helps to alleviate a felt concern of instructors to use data towards decision making, that being perceived threats to reliability and validity to data gathered in online courses. Quoting Hargreaves (2007) who stated, "validity of an assessment for learning depends on how far the interpretation and use of the assessment actually leads to further learning" (p. 186), Gikandi et al. summarize research on what may make online assessment valid in the eyes of potential users of the data, namely that formative feedback should be timely, continuous, and easy to understand by potential decision-makers. Gikandi et al. go one to describe others' research documenting the use of a variety of authentic assessment towards ensuring assessment reliability towards student and instructor ability to use and respond to data, including obvious learning outcomes measured by authentic and diverse assessment experiences. Meaningful case studies at the higher education level include Mackey (2009) documenting online professional development for teachers as data/experience catalysts for reflection and revision to their professional practices, Wang (2009) who details the positive effects (reflection and modification of individual student work) of on-line, collaborative pre-service educator portfolio development, and Van der Pol, et al. (2008) in detailing the relationships between the nature of online peer feedback in a blended class and use in decision-making on the part of the student-receiver.

Electronic means towards formative assessment may also happen in face-to-face classes. The use of course-specific learning management systems (i.e. clickers) as temporally proximate feedback systems in providing instructors more immediate data regarding their practice and towards informing students with formative data regarding their progress is the focus of an emergent body of literature detailing effects on students and instructors, best practices, and associated risks, The ECAR national study of undergraduate students and information technology (as detailed in Dahlstrom, et al., 2011) found that 95% of institutions of higher education utilized in-class learning management systems such as clickers. Numerous works have reviewed the research, and implications, of clickers towards formative assessment in higher education (see Caldwell, 2007; De Gagne, 2011; Kay & LeSage, 2009; MacArthur & Jones, 2008 for just a few of these). These reviews, and actual clicker use for formative assessment reported in the literature, seem largely nature and health-science dominant.

Largely, research studies have show that students approve clicker use for the afforded immediate formative feedback with an anonymous environment (Knight & Wood,

2005; Patterson, Kilpatrick, Woebkenberg, 2010) as well as motivation and engagement regarding formative assessment (MacArthur & Jones, 2008). In addition, research has showed positive faculty impact via their use, including feelings that they allow for effective assessment (Stevenson, 2007), notably enhanced insights regarding what students do and do not know (d'Inverno, Davis, & White, 2003; Schackow et al., 2004), and reduces, or eliminates, (the monotony) of lecture (Knight & Wood, 2005). The nature of formative assessment clicker questions has been explored by Caldwell (2007) who found that these are largely meant to uncover students' (mis)understanding of current and previous lecture material, students' ability to apply new material, as formative assessment means for students, and to help the instructor determine the direction of lecture. Some research documents instructors' decisions to use clickers even in after realizing their lost time in content coverage (Beatty, 2005; Elliott, 2003).

Some studies have explored how complicated enacting good formative assessment may be, due to instructors' difficulty in conveying assessment criteria/learning outcomes (Rust, Price & O'Donovan, 2003; Gikandi, Morrow, & Davis, 2011; Vonderwell et al., 2007).

Out-of-class data use for teaching/course improvement. A few articles documented, and advocated for, faculty moving beyond using grades as the sole assessment of student outcomes, arguing for consideration of data, both qualitative and quantitative, about student satisfaction and engagement data to inform DDDM regarding curricular and instructional offerings. In 1999, Peterson et al reported on a national survey of institutional support for student assessment. Their monograph explored how student assessment data as "activities other than traditional end-of-course grading…to measure a diverse array of dimensions of student performance or development", p. 3) was used at postsecondary institutions. At the time they dubbed this emergent-field literature as

> primarily descriptive or prescriptive in nature. Many of the documents reviewed consisted of descriptions of student assessment practices at single institutions or prescriptive guidelines for how institutions should support student assessment efforts. Little empirically-based literature and even less evaluative, conceptual or theoretical writing has been produced on this topic.…with little more than anecdotal information on the institutional uses and impacts of assessment. (p. 4-5)

In response, they called for more institutional support of student assessment towards DDDM on the part of stakeholder faculty.

Allen, in 2004, still impelled faculty to move beyond using grades as the sole assessment of student outcomes, arguing for consideration of data, both qualitative and quantitative, about student satisfaction and engagement data to inform DDDM regarding curricular and instructional offerings. It seems that some faculty may have taken up this call. Chism and Banta (2007) detail often used out-of-class assessment techniques, and resulting data sources, used at IHEs to inform instructors' decisions regarding teaching practice, including: peer teaching review via student interviews, instructor reflection, and course document analysis; student think-alouds as they interact with course materials; student reflection narratives and portfolios documenting student learning outcomes and impactful course material and experiences; case-studies of students engaged in problem- or project-based learning; institutional/programmatic exit interviews to discern student views of quality of experience and preparation; student and alumni surveys, student and faculty

focus groups, and student transcript analysis.

Jenkins and Kerrigan (2009), in their study on the impact of the Achieving the Dream initiative at community colleges found that more than half of their study's community college participants at the community college level annually used "data" (typically once per year) "other than grades." For administrators, data was mostly pertaining to finances, such as enrollment data (84% claiming) and college budget and finances (75%), although the next most claimed types of data consulted was research by the college (68%) and outside research on effective practices (66%). For faculty, data consulted was most often grades (90%), retention rates (72%), placement test scores (69%), outside research on effective practices (69%), graduations rates (64%), research by the college (58%), and other measures of student learning other than grades (55%). Faculty, independently, most used data to make decisions regarding a somewhat generic "teaching practices" (82% claiming "at least some" of this, 24% indicating doing this "a lot"), followed by "advising students" (81%; 23%), "identifying students who are struggling academically" (78%; 22%), and "curriculum" (76%; 18%). 78% of faculty and 64% of administrators claimed to participate in college discussions "on topics related to improving student success" at least once per year. At the same time, over one third of faculty participants never consulted data beyond student grades or evaluated data regarding achievement gap considerations, a main tenant of ATD. ATD may, in fact, be increasing the engagement of instructors in DDDM regarding C&I, partially as a result of the professional development provided at their institutions with 58% participating in PD on "program evaluation and/or assessment" and 35% participating in PD on "institutional research and data analysis" in the year prior to completing the survey.

Chou (2007) details instructor and student preference at one IHE regarding closely related assessment tools to discern skill acquisition of new language learners; both groups preferred tools with more elaboration for assessment categories, even at the expense of efficiency of rating process. Chou acknowledges a timeless concern in assessment carried out by multiple individuals, that being the tension between providing tools that allow for common understanding of disciplinary-valid constructs to assess, but that still allow efficiency in assessment. Although not acknowledge by Chou, this tension may have implications for the feasibility and success of DDDM relying on common assessment instruments.

Hogg and Hogg (1995) detail numerous IHEs' enactment of total quality management/continuous quality improvements to curriculum and instruction informed by student satisfaction and career preparation data.

Factors That Impede Or Support DDDM Regarding Curriculum and Instruction In IHEs

The ability to transform data into instructional action is called *pedagogical data literacy* (Mandinach, 2009) or *instructional decision-making* (Means et al., 2011). It entails combining the pedagogical content knowledge (Shulman, 1986) that teachers bring to an instructional event and their knowledge about how the data can be used to impact classroom practices and instruction to affect change in student learning and performance" (Mandinach, 2012, p. 73). Key to effective systems of DDDM is a cycle of feedback and continuous improvement so that leaders can learn from prior experience and draw on

data to intentionally redesign activities in order to achieve desired goals (Ikemoto & Marsh, 2007; Mandinach & Honey, 2008). Under larger frameworks concerning organizational *culture*, research of DDDM in the K-12 setting indicates that accountability policies, technologies, and human capacity and leadership and are some of the main factors that influence how DDDM unfolds in practice. We found some of these reflected in the literature regarding IHEs.

Potential barriers. Limited evidence concerning DDDM in US IHEs mimics findings concerning DDDM abroad and in the U.S. K-12 education system, namely that developing and implementing effective DDDM systems is much easier said than done. The consensus is that the mere collection and provision of data does not automatically lead to high quality decisions or educational improvement (Harris, 2001; Ikemoto & Marsh, 2007; Kuh & Ikenberry, 2009). Additionally, some researchers are raising questions about the potentially deleterious effects the "culture of evidence" approach is having on postsecondary education (Browne & Rayner, 2013; Kim, 2012). The research bodies concerning the tie of DDDM in IHE to their programs/units, attempting quality assurance and to meet accreditation are the most critical of all bodies of literature reviewed regarding potential distractions of achieving successful DDDM. We detail these briefly here.

Challenges regarding quality assurance. Researchers studying attempts for quality assurance, largely practiced in overseas postsecondary IHEs, suggest that associated external reviews are deeply unpopular as institutions and staff perceive threats to autonomy and unnecessary burdens on their time (Anderson, 2006; Chalmers, 2007; Taylor, 2009). In addition to these barriers to DDDM, as was seen with the external audits conducted by the Quality Assurance Agency in the UK, "critics believe that, similar to institutions, agencies and peer reviewers do not have the tools required to define and measure the quality of teaching" (Henard, 2010, p. 33). The Linke Report argued that quality is best measured "using multiple indicators that are sensitively attuned to the specific needs and characteristics of particular disciplines, and which adequately reflect the underlying purpose for which the assessment is required" (Performance Indicators Research Group, 1991, p. 129-130). We suggest that researchers and policymakers in the U.S. pay close attention to the experiences of those engaged in DDDM-related initiatives overseas.

Challenges regarding attempts to meet accreditation. Researchers raise several concerns regarding the negative influences of accreditation, ultimately contributing to dysfunctional and poor strategic decision-making**.** Julian and Ofori-Dankwa (2006) raise several concerns regarding the negative influences of accreditation, ultimately contributing to dysfunctional and poor strategic decision making in business schools. Specifically, they claim that *accreditocracy* unduly influences staffing, research, and curriculum policies of these schools. In addition, they argue that DDDM influenced by accreditation pressures makes it even more time consuming. Exacerbating this problem is that related decisions are often based on outdated evaluations on program quality and relevance as indicated by alumni, all resulting in potentially outdated decisions regarding reform. Julian and Ofori-Dankwa (2006) also report faculty and administrators going "through the motions" of data collection and analysis without adequate consideration of meaning. Simply put, faculty and administrators may respond to pressure by documenting results at the expense of actually analyzing and responding to the data themselves, a

condition the researchers dub “documentation fetish” (p. 229). We propose that these concerns regarding accreditation expectations could be generalized to various types of departmental and institutional environments in higher education where the scope and influence accreditation agencies is profound. We recommend that the field attempts to document successful cases of response to accreditation needs alongside meaningful DDDM informing curriculum and instruction.

Challenges with technology and human capacity. Mandinach (2012) hones in on technological tools and human capacity as the most significant components of DDDM, ultimately limiting interaction and usability complicated and voluminous data. The lack of qualified IHE staff possessing competencies or efficacy to effectively analyze data (Jenkins & Kerrigan, 2008) and lack of recognition of DDDM as a professional responsibility (Blaich & Wise, 2010) are identified as human capacity impediments to DDDM at IHEs.

Potential alleviation to barriers to DDDM in IHEs. We now turn to factors identified by researchers as contributing to successful DDDM, including: acknowledging and attending to local realities, ensuring salience of data and DDDM processes to key stakeholders, fostering and capitalizing on local data savvy and collaboration among stakeholders towards meaningful objectives, and formalizing and normalizing adequate data collection and management systems and access.

Acknowledge and attend to local realities. K-12 researchers have noted that the utilization of data towards decision-making and improvements is influenced by local contextual factors and practices that may influence how people interpret and actually use data (Spillane, 2012; Coburn & Turner, 2012). Acknowledging institution-specific realities may allow for better ultimate realization of DDDM; for instance, for those with heavy teaching loads, data grounded in more micro-levels of practice may be most meaningful (e.g., in-class formative data regarding efficacy of in-class).

Concerning the post-secondary level, McClenney and McClenney (2003) suggest that a culture of evidence requires systematic, timely, useful, and user-friendly information about student experiences (persistence, learning, and attainment) to individuals who are responsible for institution’s planning and decision-making processes. To foster this environment, a system’s or data base’s usefulness must be determined; towards this the intended audience must be known.

Various barriers towards DDM have been noted. Some may be context specific. For instance, Jenkins and Kerrigan (2008) found that only one in four community college faculty claimed to be part of “heavy users of data” departments and one in five were, independently, indicating that they use data “a lot.” These researchers found that many community college faculty (32%) claim teaching responsibilities a time constraints that impede their use of data. Acknowledging content-specific realities may allow for better ultimate realization of DDDM in IHEs. For those with heavy teaching loads, data grounded in more micro-levels of practice may be most meaningful (e.g., in-class formative data regarding efficacy of in-class).

Ensure salience of data and DDDM processes to key stakeholders. At the heart of concerns about the limitations of DDDM systems, K-20, is whether or not the people who

are most impacted by accountability policies and data use (which are often classroom educators), are either involved in the design of DDDM systems, or are in a position to make use of the results (Blaich & Wise, 2010; Coburn & Turner, 2012; Spillane, 2012). Blaich and Wise express an explicit hope in extending DDDM efforts beyond the typical small group of campus decision makers, administrators involved in institutional student assessment initiatives, directly curriculum and instruction related rarely and, most often, focused on meeting accreditation milestones. Their vision is well founded. Barriers concerning administrators' work and their contribution to C&I related DDDM have been noted. Chairs rarely lead curriculum evaluation, instead "monitor[ing] compliance with mandates such as institution-wide assessment, program review, or accreditation standards" (Stark & Lattuca, 1997, p. 346). Even chairs representing departments nominated by college/university administrators as being significantly involved in continuous planning may feel their job to be more about "sensing" a need for curricular changes and supporting their faculty members' good ideas toward their purview (curriculum planning), as opposed to leading change themselves. Simply put, IHE administrators do little to encourage DDDM (Stark, 2002).

A majority of the articles reviewed demonstrate that curriculum and instruction-related DDDM processes are still undertaken mostly by institutional researchers and other small committees or interest groups. The involvement, and research regarding, other key stakeholders appears lacking (Jenkins & Kerrigan, 2008; Petrides & Nodine, 2005). Researchers (Blaich & Wise, 2010; Wolf, 2007; Jenkins & Kerrigan, 2008) cast doubt on the meaningfulness of upper administrators' involvement in DDDM (and decision-making in general), stressing the importance of instructors and departmental/disciplinary focus on decision-making concerning curriculum and instruction.

Overall, research shows that data and DDDM must be perceived as valid by local actors with respect to professional practice (Copland, 2003; Halverson, Grigg, Prichett, & Thomas, 2007; Ingram, Louis, & Schroeder, 2004; Wolf, 2007). Various researchers stress the collaboration of key campus stakeholders on the analysis and communication of and response to evaluation results with respect to goals is predictive of local improvement success (Banta et al., 2009); Ahren et al., 2008). For Ahren et al. (2008), teams of "broad representation" were indicative of institutions successfully involved in DDDM, although they did not define their "broad representation" championed.

Faculty members' commitment to developing and assessing measures of student achievement may even heavily influence strategic planning (Gallagher, 2008). This faculty commitment was, in turn, dependent on the resource of faculty time and relevant training and pedagogical conversations, often fostered by other more knowledgeable and practiced faculty and external experts. McClenney and McClenney (2003) suggest the necessity of governing board members, administrators, faculty, staff, and students to thoroughly examine and openly discuss institutional performance regarding students' experiences. MeClenney et. al. (2007) assert the crucial importance of open discussion by stating that colleges should create an environment that tolerates negative results (specifically referred to as "bad news") about institutional performance and include "tough minded reviews of instructional and student services and strategies" (p. 2). Hansen and Borden (2006) offer that an action research provides a constructive framework to ensure that critical information is used by key stakeholders who are involved in implementing

data-driven interventions for academic improvement.

Key to much of this work is collectively agreed upon goals towards which data is to be collected and considered. Banta et al's (2009) model of data use has as a first step *achieving consensus regarding goals* (although they caution that goal consensus on a campus by key stakeholders can take years.) They insist that various stakeholders must be involved in planning goals to study and improve upon, including faculty (who influence curriculum), student affairs professionals (who influence co-curricular experiences), students (whose experience is being considered), institutional research professionals (who may support/lead improvement initiatives and supply relevant data) and campus administrators. Banta et al (2009) insist that "ensuring that the campus community actually uses evidence…to make improvements…stakeholders must be convinced that institutional goals are sufficiently important to implement. Individuals and committees must be charged with the responsibility to oversee and coordinate implementation activities. Appropriate measures must be connected to each of the goals in order to track progress. Individuals must analyze, interpret, and present data from measurement methods such as administration of the NSSE in ways that shed light on important questions about implementation. The likelihood that campus community members see assessment data as a guide for improvement action is increased substantially and is an important step for an institution on its way toward developing a culture based on evidence when all of these prerequisites are in place" (p. 24-25).

Balancing of competing goals is also necessary. Macro-level policies and procedures that operate at the institutional or college levels, such as knowledge management, continuous improvement mechanisms, accreditation can be useful and effective in tracking and measuring certain variables. But to inform DDDM, these policies and procedures must be clearly linked to user needs, whether they are Dean's strategic visions or a classroom teacher's local needs to meet accreditation requirements (Blaich & Wise, 2010; Lattimore, 2012). While institutional and state and federal policies often motivate DDDM (Ikemoto and Marsh, 2007), organizational leadership plays a key role in balancing external accountability and internal usefulness of data in practice, as well as towards building effective DDDM systems and capacity (Halverson et al., 2007). Several barriers make it challenging to use and share data and information effectively. One of these includes a lack of leadership as many postsecondary systems experience high turnover rates among upper level managers, leading to inconsistency in interpreting and sharing data and information (Petrides & Nodine, 2003). At the same time, organizational leadership has great potential to encourage DDDM. Patrides and Nodine (2005), via their longitudinal study of community college administrators and faculty members' DDDM in response to student outcomes data, concluded that external mandates for accountability had little impact on DDDM and that, instead, DDDM was more impacted by organizational leadership.

Foster and capitalize on local data savvy and collaboration among stakeholders towards meaningful objectives. IHEs may be swimming in useable data, yet most goes unused or unknown to those who could most benefit from it (Banta et al., 2009; Blaich & Wise, 2010; Petrides & Nodine, 2003). Why? Mandinach (2012) hones in on technological tools and human capacity as the most significant components of DDDM, ultimately limiting interaction and usability (as well as management of) complicated and voluminous data.

Technological limitations (and proposed remedies) are reviewed in the next section. Others have elaborated on specific human capacity barriers, including:

1. Lack of qualified IHE staff possessing competencies or efficacy to effectively analyze data (Blaiche & Wise, 2010; Jenkins and Kerrigan, year; Petrides & Nodine, 2003)
2. Lack of recognition of DDDM as a professional responsibility (Blaiche & Wise, 2010; Jenkins and Kerrigan, year)
3. Concerns regarding data validity and distrust of use. Many faculty members have witnessed the manipulation of data (Petrides & Nodine, 2003) and are hesitant of processes and procedures that would have their work, class outcomes, or other activities for institutional decision making purposes (Ikemoto & Marsh, 2007; Jenkins and Kerrigan, year).
4. Lack of ability to translate data findings/analysis into action. From interviews with faculty and chairs from 44 departments thought to be engaged in ongoing program improvement, Briggs et al (2003) found quite a few departments that collected, but did not respond to data. Regardless of expressed levels of and practices and views concerning collection and response to data, the researchers found that few faculty and chairs felt comfortable analyzing and responding to evaluation. Johnston and Kristovich (2006) report that one of the reasons that institutions have difficulty turning data into information is because they don't understand the distinctions between them. According to them, "datum is an item's measurement; information is a user-directed presentation of that measurement" (p. 6).

Towards remedy of this situation, expert individuals must be available to help translate data into actionable knowledge (Ikemoto & Marsh, 2007; Mandinach, 2012). For some researchers, experts most obviously take the form of institutional research office personnel (Gallagher, 2008; Johnston and Kristovich, 2006). Ahren et al. (2008) highlight the prevalence, at the most successful institutions, of "collaborative relationships among faculty, student affairs educators, and institutional researchers," stressing the important role of the institutional researcher who "works with numbers every day. This person can help translate numbers into understandable information and assist in identifying important themes" (p. 30). Ahren et al allude to the important role of institutional researchers in growing faculty/instructors' "trust and understand[ing] the data" (p. 30). In order to further illustrate the role of the institutional research office, the Johnston and Kristovich (2006) cite McLaughin, Howard, Balkan, and Blythe's (1998) impressions of the three roles that the institutional research office plays the when providing support needed to convert data to information: "a custodian or keeper of the data, as broker of the process of transferring data into information, and as manager or processor of the information and application to a situation" (p.4). It is the institutional researchers responsibility to make information available to administrators in a timely manner and educate them on to how to interpret the information.

Yet, regardless of their position, experts' support work is bound by their work capacity, largely a function of time allotted to such work (Ikemoto & Marsh, 2007). Banta et al. (2009) encourage the establishment of "campus wide communities, and in some cases discipline-specific counterparts, to oversee and coordinate programs and activities

designed to achieve the goals" with institutional research professionals playing a key role of "attending meetings, listening to deliberations, and contributing ideas for solutions, institutional research staff can determine the kinds of analyses that can yield the information these groups need to inform their decisions" (p. 24). Time must be allocated for such important work. Additionally, in some situations, training individuals to serve in these capacities may be necessary.

Formalize and normalize adequate data collection and management systems and access. Timely data must be adequately managed, analyzed, and shared, all of which benefits from efficient technical and administrative support systems (Copland, 2003; Halverson, Grigg, Prichett, & Thomas, 2007; Ingram, Louis, & Schroeder, 2004).

Although, advanced information technology for management purposes have been at IHEs for two decades, decision makers have often still lacked access to information to make effective decisions concerning finances, staff, and students (Guan, Nunez, and Welsh, 2002; Hansen & Borden, 2006; Petride and Nodine, 2003). Petrides and Nodine (2003) note that certain improvements may allow for more effective data warehousing and, thus, more effective DDDM:

- Normalize data collection. Institutionalize software, definitions, and other means to collect and organize data, which causes significant issues in analysis and use.
- Integrate technology towards data use cognizant of professional realities. Many faculty and staff implement a "hands-off" approach to technology and expect the "experts" who know a lot about hardware but very little about the information needs of the organization to deal with technology issues concerning data collection.
- Identify clear priorities. Collect and analyze information aligned with the mission of the organization.

From interviews with faculty and chairs from 44 departments thought to be engaged in ongoing program improvement, Briggs et al (2003) identified indicators underlying collection and analysis of data, promoting decision-making and change, these being:

- formally organized and implemented data collection procedures
- varied types and time points of data demonstration direct (e.g. student evaluations of teaching) and indirect measures of success (e.g. employer surveys)
- Awareness and consideration of others' experiences that can inform curricular and instructional decision-making.

Implications

For Practice and Policy: Acknowledge The Power Of External Influences Of DDDM At IHEs, But Cater To More Local Needs, Especially Regarding Effective DDDM At IHES Concerning Teaching And Learning

DDDM in IHES has largely concerned organizational functioning and improvement. Related to this finding, from our review it is clear that external influences, and a quest towards organizational isomorphism (DiMaggio & Powell, 1983), ultimately drives a

significant amount of DDDM related activity at IHEs, influencing motivation to create structures for and engage in DDDM, as well as actual planning for data gathering, analysis, reporting, and attempts to enact and disseminate change in response to data. These external influences seem to act as critical levers of DDDM at IHEs. Alongside common challenges among IHEs to respond to these external levers, noted above, we must also acknowledge the potential positive impact to education offerings that such external influences may ultimately afford as almost all articles we reviewed pertaining to external motivators of DDDM advanced that any evaluation of efficacy should or could result in institutional or program/unit development and improvement alongside meeting of external body requirements.

At the same time, the research shows that more "organic" or "grassroots" motivation to engage in DDDM towards IHE improvements may be fostered and that IHE personnel input in DDDM processes and their adequate training/access to data and managements systems can help to ensure local, practical improvements to curriculum and instruction. Indeed, even when ultimate focus of DDDM is organization/institutional improvement/response, identified barriers to DDDM can be very individual-bound, thus necessitating individual-focused strategies to alleviate barriers. We recommend that U.S. postsecondary educators, decision-makers, policymakers, and researchers become aware of research and related DDDM experiences concerning U.S. K-12 education and European and Australasian IHE systems, to better link larger data systems and data-use movements and policies with local practices and needs, including IHE educators' need to interact with locally derived data within locally created interaction structures.

For Advancement of the Scholarly Field: The Field Needs More Research And Diversity Of Researchers

Like others, we recommend that researchers engage in more descriptive research on how local IHE actors perceive and utilize data in light of local needs and practices (Chou, 2013; L'Allier, 2013; Spillane, 2012); we add to this a consideration of more nuanced disciplinary practices of educators towards the design and implementation of more effective DDDM systems. Overall, we note a dearth of rigorous research in the arena of how individual and groups of IHE educators use data and engage in DDDM to make changes to curriculum and instruction specifically. As Stark noted over a decade ago with respect to the course planning literature, we noted a plethora of "logical analysis and anecdotal observations rather than [reporting of] empirical results" (2000, p. 418) concerning DDDM regarding curriculum and instruction. Even as late as 2008, Jenkins and Kerrigan lamented having "only a handful of larger-scale empirical studies on evidence-based decision making in higher education" (p. 5), and this still seems the case. Specifically with respect to DDDM concerning curriculum and instruction in postsecondary environments, the dearth of empirical studies, even small-scale descriptive or practice-based case studies, is notable with much of the literature existing as scholarship in advancing arguments for the use of data, but without adequate proof on concept. We identified only our larger-scale empirical studies that touch on DDDM at IHEs: Briggs, Stark, & Rowland-Poplawski, 2003; Jenkins & Kerrigan, 2008; Petrides & Nodine, 2005; and Stark, Briggs, & Rowland-Poplawski, 2002. We recommend moving beyond research, while important, "based on informal case studies or on the professional experience of the authors" (Jenkins & Kerrigan, 2008, p. 5).

Similar gaps have been noted concerning the literature of DDDM in K-12. Acknowledging the field of DDDM in education is still emerging (Mandinach, 2012) several limitations have been noted. Concerns are in regards to research methodology, with a general low level of rigor noted across DDDM in education studies (see Hamilton et al., 2009) as well as concerns regarding generalizability of studies that are, predominantly across the field, descriptive case studies (see Mandinach, 2012; March, Pane, & Hamilton, 2006), evaluations, and implementation studies (see Mandinach, 2012). Additionally, there are concerns with documenting processes and effects of DDDM, specifically how data is being utilized in decisions concerning teaching and learning and any effects of such utilization (March, Pane, & Hamilton, 2006). According to Ikemoto & Marsh (2007), most scholarly writing concerning education DDDM attends to whether K-12 educators are using data and not how the data has been used. March, Pane, & Hamilton, in their 2006 review of literature concerning DDDM across K-12 settings, conclude that most studies actually focus on "implementation," that is data collection through decision-making, but largely without attending to effects of DDDM on relevant outcomes, such as outcomes for students (although with some focus on organizational change more broadly speaking). Others have pointed out an over-focus on student achievement data and related recommendations (such as Hamilton et al., 2009; Mandinach, 2012). In relation to these realities, a call for more descriptive work to more reliably illuminate the trajectory of policy/prescriptive research to meaningful DDDM reality in education settings has been noted (Spillane 2012).

An additional conundrum emerges after reviewing this body of literature concerned with postsecondary DDDM, namely concerning who is best disseminating findings in this field and who is not. In privileging empirical studies allowing for the most potential for generalizability of findings, we (and the greater field of education research, in general) may be missing important findings and findings reflected in other works. The articles reviewed for this review were mainly written by researchers from the education sciences. Although these researchers often played the role of participant-researcher in their study, there is a notable absence of faculty and administrators writers not explicitly connected to colleges and departments of education or campus teaching and learning centers. Dowd and Tong, in a 2007 article, made the argument that practitioner inquiry should be seen as "an essential component of an accountability-driven research agenda" (p. 90). They laid out a plan for university *Evidence-Based Inquiry Councils* (EBICs), structures they maintained would motivated practitioner inquiry as well as organizational learning and change via identification of goals, data gathering and analysis and related changes to curriculum and instruction (and the training and settings regarding these), and rich, multifaceted summative evaluation based on mixed methods, ultimately leading to a widespread *culture of evidence* among IHEs. Bensimon (2007) has added to the argument that postsecondary educators, over education researchers, are better positioned to study and make decisions regarding curriculum and instruction for their students.

Coburn and Turner, in an introduction to a 2012 special edition of the American Journal of Education concerning data use in education, argued that across all levels of education, "in spite of all of the policy and reform activity focused on data use in education, empirical research on data use continues to be weak. In particular, we still have shockingly little

research on what happens when individuals interact with data in their workplace settings" (p. 99). Overall, we found the impact of DDDM on teaching and learning practices at IHEs with respect to the use of a wide array of data, in particular by faculty and administrators, is ripe for more rigorous, and larger-scale, exploration.

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