Educational informatics: designing performance-based measurement systems for rapid response learning environments

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Abstract

This study examines the design and preliminary implementation of a performance data system which utilizes the science of informatics in an educational systemic change setting. Collectively referred to as educational informatics, this performance data system is designed to provide school leaders with real-time data at mega, macro, and micro organizational levels. The theoretical framework, preliminary design, and how it relates to systems thinking and systemic change will be discussed.

Introduction

Educational informatics represents the intersection of three disciplines: teaching and learning, information science, and information communication technologies (ICTs) (Ford, 2004; Haythornthwaite, 2006; Sheffield University, 2011) and has been defined as, "the study of the application of digital technologies and techniques to the use and communication of information in learning and education" (Levy, Ford, Foster, Madden, Miller, Baptista Nunes, McPherson, & Webber, 2003, p. 299). In 2008, Ford further refined the definition to, "the development, use, and evaluation of digital systems that use pedagogical knowledge to engage in or facilitate resource discovery in order to support learning" (Ford, 2008, p. ix). It combines the application of information computing and technology and information management techniques (Kling & Hara, 2002) to the field of education and examines the role information communication technologies play in formal and informal learning (Levy, et al., 2003). As an applied theoretical construct in practice and action research, educational informatics parallels the use of informatics in other fields such as medical informatics, bioinformatics, and health informatics.

The term "informatics" semantically is derived from the Russian word *informátika* and originally defined as, "the study of information processing" (Dictionary.com, 2009) and is considered a synonym for the word information science (Dictionary.com, 2009; Merriam-Webster Dictionary) and has been around since the 1960's (Dictionary.com, 2009; Kling & Hara, 2002; Merriam-Webster Dictionary). The role of information processing or the science of how humans cognitively engage with information takes on similar meanings in diverse fields with a perhaps narrower focus on application and the technologies involved. Kling and Hara (2002) note that informatics, "… is usually coupled with some adjective, such as medical informatics, bio-informatics, chemical informatics, or educational informatics. These "X-informatics fields" are often defined as the application of information and communication technologies (IT) and information management (IM) techniques to "topic X" (Kling & Hara, 2002).

Studying the techniques and impact of "digital technologies" within the context of the "use and communication of information" in educational settings represents an subtantively broad area of study. Focusing on the logical collection and analysis or analytics (Dictionary.com; Merriam-Webster Dictionary) of information can be considered an evaluation and management process seminal to the fields of systems thinking, human performance, and performance technology. Chow (2008) and Chow & Whitlock (2010) introduced an operational definition of educational informatics within a systems framework, "how information technology is used to collect, organize, use, and disseminate information to support and help improve overall performance of the educational system" (Chow, 2008, p. 51). This definition of educational informatics served as a major construct underpinning research on a Georgia model high school founded on systems principles, which requires continuous peformance data be rigorously collected, analyzed, and used for continual improvement (Chow, 2008; Chow & Whitlock, 2010).

Conceptualizing the broader field of educational informatics within an analytics and systems thinking framework, moves the focus squarely on how ICTs are being used to collect data and how organizations are able to translate and use this data in a transformative fashion so that it becomes information they can use to continuously improve current and future decisions and performance in a real-time, dash board fashion. Chow and Lopez-Guerra (2011) have developed the Systemic Educational Informatics (SEI) model that combines the data driven framework of educational informatics with Lopez-Guerra's Impact Evaluation Process (IEP). The result is a model that posits what, how, by whom, and for what purpose data can be identified and collected utilizing ICTs.

Figure 1 projects a potential educational informatics model for a public charter career and technical education oriented high school called the Central Educational Center:

SEI and Systemic Change
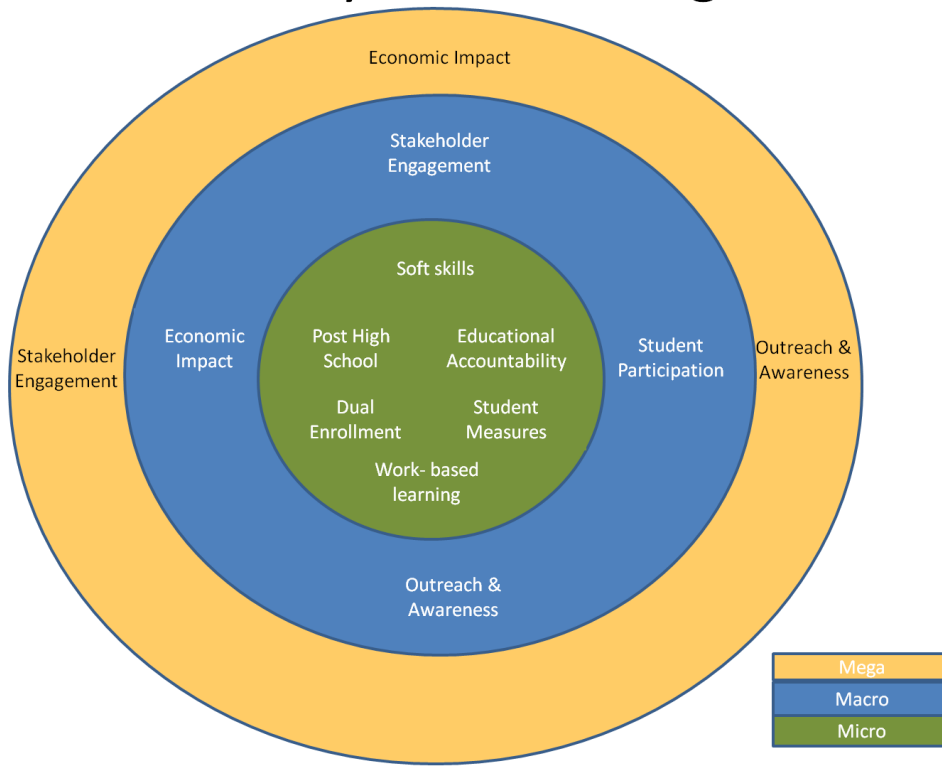

Figure 1 - SEI and Systemic Change

Figure 2 projects Guerra-Lopez's Impact Evaluation Process (2007; 2012) which provides the tactical steps in which to identify and build a customized organizational SEI model.
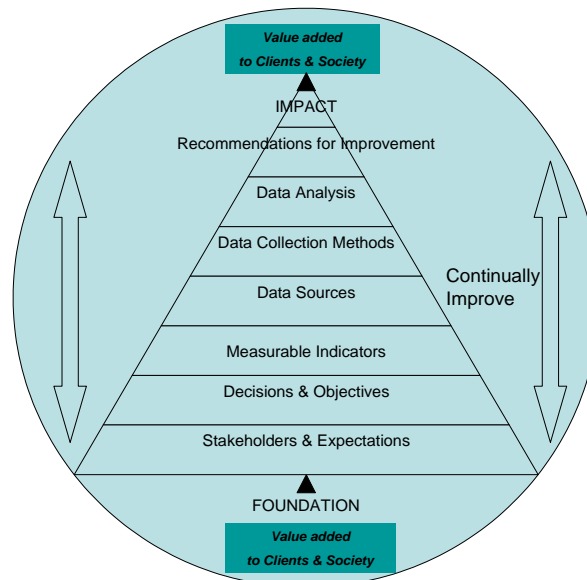

Figure 2 - IEP Model

The SEI model operates at three organizational levels: Mega, Macro, and Micro. The *Mega* level represents the societal level and requires that an organization measures its intended value-added impact of society itself (Of what value are we to society?) to ensure proper alignment. The *Macro* level involves the medium term goals of the organization and stakeholders, the more immediate or direct impact that benefits the organization itself (What does success mean and look like for our organization?). The *Micro* level involves internal building-block results of the organization (What short-term products have to be accomplished by teams and individual organizational members?) (Kaufman, 2006; 2011).

For the Central Educational Center, the m*ega* level is the international, national, and local community which it serves on a day-to-day and long term basis (what indicators would help us manage this, and there must be measured, what data should be collected, how frequently, by whom and for what types of decisions? What information would CEC need to have to make informed decisions about its current and future performance? And what goals and objectives do these relate to?). CEC's *macro* level is more narrowly defined as the set of decisions and goals associated with the CEC's survival and well-being, including charter goals and objectives. Similar to the mega level, a data system must be established to collect the relevant data in as automated fashion as possible. Lastly, CEC's micro level involves its own internal objectives, and operational goals, as well as the unique goals of its internal customers (faculty, staff, and students).

The Impact Evaluation Process (IEP) is a systematic process that articulates data within the context of value-added to both client and society. As part of the SEI model each goal in mega, macro, and micro will follow the same process:

- Identify key stakeholders (and users of the system) for each level, and their expectations and purpose for the information system

- Identify key decisions for improvement and management. Discussion about Mega, Macro, & Micro results critical at this point. May have to modify plans and clarify desired results when alignment or misalignment becomes evident.

- Identify relevant measureable indicators…what will be measured, how often and why. Balance between effort to track the set of indicators and potential value of using them must be established. Also, must set targets for indicators as well as baseline. It will be appropriate to establish targets first for some indicators, while others require the collection of baseline data before sensible targets can be set.

- Set up systemized data collection methodology, that includes sources, instruments, procedures, maintenance, and responsibilities for specific team members.

- System must be programmed for automated analysis, and simple utility. Utility must be embedded as part of a broader performance system. It should be aligned to users' broader performance responsibly and consequences, as opposed to something separate an additional to what they currently do and how they do it.

- System can be developed to provide various levels of guidance from more general guidelines, to more specific decision-making job aids using "If this, then that" logic. That is, the system could be set up to guide the user not only through the identification of performance gaps, but also to causal analysis, and potential solution alternatives (Guerra-Lopez, 2008; 2010).

The SEI model with mega, macro, and micro indicators (See Figure 3) moves the theoretical, research-oriented conceptualization of educational informatics into the action and applied research setting integrating the much more applied concepts of informatics (the science of information) and analytics (logical organization and analysis of information) within systems thinking (ends, goals, and processed) and human performance technology (conditions of optimal human performance). CEC's utilization of the SEI model will reflect its first real-world application, which is consistent and resonates with the school's history and tradition of leadership, innovation, system's thinking, and data-driven decision making for the greater benefit of students, stakeholders, and society itself.

Figure 3 - SEI Model

Design and Development of the CEC Systemic Change Informatics System

The SEI model is being designed in collaboration with the Central Educational Center to ensure validity of mega, macro, and micro measures. Four separate meetings were held to identify appropriate indicators, metrics, and data including a formal presentation in front of the CEC Board of Directors. The SEI system is being designed as a dashboard of critical indicators so CEC is able to view its mega, macro, and micro level performance in real-time.

CEC's Mega Level Goals.

CEC has identified three mega goals – *Economic impact*, *outreach and awareness*, and *stakeholder engagement*. *Economic impact* has initially been operationalized as return on investment ratio calculated through dividing initial capital costs by measured student benefits identified as the total number of students who are enrolled in work-based learning and pursuing a technical college certificate, which on average earn a starting salary of $32,000 minus the same number of students earning minimum wage. As an initial operational definition, this calculation most likely will be refined over time as the model evolves. A second indicator is dropout cost savings, which is the amount of money the local community saves or recoups from the state department of education that allocates a set amount of funding for every student who attends public schools. The preliminary measure that has been identified involves multiplying the number of students retained by state allocation minus the state high school dropout average.

Outreach and awareness reflects the community's sense of value and the importance of enrollment, marketing, and recruitment for charter schools such as CEC, which must recruit student to attend. The preliminary indicator that will be used will be community awareness and perceived value, which will most likely be measured through an online survey disseminated to all school councils, which are comprised of each school's administrators, teachers, parents, and students. The survey will be disseminated in the early part of the spring semester so that CEC will have an opportunity to decide how best to utilize its marketing and publicity resources effectively.

Stakeholder engagement represents an indicator of the overall satisfaction of CEC's primary stakeholders – employers from business and industry, educator administrators, and the CEC board of directors comprised of general school stakeholders. Another online survey will be disseminated to the three formal boards representing the county's economic development commission, chamber of commerce, and board of directors.

CEC Macro Level Goals.

CEC's macro goals are defined specifically by its charter with the state board of education, which identifies a series of goals it must address in order to maintain its legal charter status. 13 macro goals, all charter objectives, have been identified as part of the SEI model which focuses on student or school performance and growth:

1. Student performance will meet or exceed the federal average test scores for reading and language arts.
2. Student performance will meet or exceed the federal average test scores for math.
3. Student graduation rate will meet or exceed the state average.
4. An increase in students who attempt and achieve Certified Work Ready (WorkKeys) status.
5. The Chamber of commerce has a growth goal for CEC.
6. The Board of Education has a growth goal for CEC.
7. The Technical College has a growth goal for CEC.
8. Increase in physical growth of CEC or project co-location.
9. Increase of CEC network of state-wide replications.
10. 90% placement rate of graduates who earned a technical college certificate.
11. Students will meet or exceed state average for end-of-course test scores.
12. 90% placement rate of graduates from work-based learning program.
13. Decrease county dropout rate.

All 13 organizational goals are already being measured. The current issue, however, is that the data for each goal is not archived or organized in such a way that CEC leadership can quickly analyze and identify potential problem areas that will inform future decisions. The CEO feels the SEI system will promote the use of relevant data and save his organization time in collection and organization of data so they can spend more time in translating it to information that can be used in making informed decisions.

CEC Micro Level Goals.

CEC's current micro goals are defined specifically by its legal charter to increase overall student enrollment for:

1. Dual enrolled students
2. Dual enrolled students who successfully earn a certificate
3. Work-based learning students
4. Internships, apprenticeships, clinical, or job shadowing
5. High school senior participation
6. Overall enrollment
7. Overall technical college enrollment

Similar to the macro goals, all current micro goals are already currently measured. By bringing together this data in one central location, CEC will be able spend less time gathering it and more time using it to inform future decisions.

SEI Model v.1: A performance dashboard

Google Analytics software is able to collect and report user web activity to a granular level in a dashboard format that allows organizations to identify user information such as location of their web hits, the type of browser, type of monitor resolution, whether they were referred by a search engine or through a direct URL, how long they view pages, which pages they clicked on, etc. Designers are able to utilize this centralized information to make informed decisions about their website.

The SEI system in close consultation with CEC is designed in a similar format. The current articulation of the SEI model for CEC organizes mega, macro, and micro indicators in a performance system dashboard organized in six columns – indicator, metric, data type, data, person responsible, and status of data collection.

MEGA	Indicator	Data Source	Data	Responsibility	Status
1. Economic Impact (return on investment of school, data includes economic development and cost savings for decreased dropout rate)	1A. CEC ROI (cost vs. benefit); Initial costs for CEC (capital); The number of students in WBL and number of students in dual-enrollment. Savings would be #of students who save dollars by getting to the workplace and college earlier. Cost of the gap (avg. salary vs. minimum wage salary)?	WBL Students			
		Dual Enrolled Students			
		CEC Capital Cost			
		ROI (Cost divided by Benefit)			
	1B. Dropout cost savings - Cost per dropout x number of dropouts annualized; District level created formula. Dropout rate pre CEC compared to annualized drop out rate since CEC opened.	Pre CEC county dropout raw numbers			
		Current CEC county dropout raw numbers			
		State funding per student			
		Dropout Cost Savings (Pre/Post comparison)			
2. Outreach and Awareness (% randomly selected stakeholders aware of the school, data will be results of an online survey)	2A. CEC Board Ratings (twice a year - start of a board year and end of a board year; all stakeholders are on this); Economic Development (Development authority board; chamber board) - once a year; School leaders (partner schools plus all schools)	School Council Survey (High School)			
		School Council Survey (Middle School)			
		School Council Survey (Elementary School)			
		School Council Survey TOTAL			
3. Stakeholder Engagement & Value (engagement scale, data includes engagement scale and school leader ratings)	3A. CEC Board Ratings (twice a year - start of a board year and end of a board year; all stakeholders are on this); Economic Development (Development authority board; chamber board) - once a year; School leaders (partner schools plus all schools)	CEC Board Rating (Fall)			
		CEC Board Rating (Spring)			
		Economic Development			
		School Leaders (High School)			
		School Leaders (Middle School)			
		School Leaders (Elementary School)			

Figure 4 - SEI Mega Level

MACRO	Indicator	Data Source	Data	Responsibility	Status
1. Meet or exceed Perkins (Federal) Reading/Language Arts (Charter Objective 1)	Already collected by state; distributed to the superintendent; sent via email.	Reading CEC			
		Reading Federal			
		CEC Reading Differential (+/-)			
		Language Arts CEC			
		Language Arts Federal			
		CEC Language Arts Differential (+/-)			
2. Meet or exceed Perkins (Federal) Math (Charter Objective 1)	Already collected by state; distributed to the superintendent; sent via email.	Math CEC			
		Math Federal			
		CEC Math Differential (+/-)			
3. Meet or exceed Perkins (Federal) Graduation Rate (Charter Objective 2)	Already collected by state; distributed to the superintendent; sent via email.	Graduation Rate CEC			
		Graduation Rate Federal			
		CEC Graduation Rate Differential (+/-)			
4. Increase # Certified Work Ready (WorkKeys) (Charter Objective 5)	Collected internally over two semesters - increase in students who attempted and achieved.	WorkKeys CEC students (fall)			
		WorkKeys CEC student certified (fall)			
		WorkKeys CEC students (spring)			
		WorkKeys CEC student certified (spring)			

Figure 5 - SEI Macro Level

MICRO	Indicator	Data Source	Data	Responsibility	Status
1. Increase # Dual-Enrolled WGTC (Charter Objective 3)	Actual and projected. Growth goals in the spring.	Actual # Dual-Enrolled			
		Previous # Dual-Enrolled			
		Change (% +/-)			
2. Increase % Dual-Enrolled WGTC who complete TCC (Charter Objective 3)		Actual % Dual-Enrolled			
		Previous % Dual-Enrolled			
		Change (% +/-)			
3. Increase # Work-Based Learning (Charter Objective 4)	Actual and projected. Growth goals in the spring.	Actual # WBL			
		Previous # WBL			
		Change (% +/-)			
4. Increase # intern + apprenticeship + clinical + shadow (Charter Objective 4)	Actual and projected. Growth goals in the spring.	Actual #			
		Previous #			
		Change (% +/-)			
5. Increase H.S. Senior Participation Rate (during h.s.) (Charter Objective 13)	Annual from previous year. Projected in the spring.	Actual #			
		Actual % of county			
		Previous #			
		Previous % of county			
		Change (# +/-)			
		Change (% +/-)			
6. Increase High School Enrollment (Charter Objective 13)	Annual from previous year. Projected in the spring.	Actual #			
		Previous #			
		Change (% +/-)			
7. Increase Technical College Enrollment	Annual from previous year. Projected in the spring.	Actual #			
		Previous #			
		Change (% +/-)			

Figure 6 - SEI Micro Level

The SEI model is characterized by four primary characteristics: *system indicators*, *real-time data*, *automation*, and *performance improvement focus (*primarily gap identification and causal analysis*), .* The initial SEI model as conceptualized will provide a dashboard of real-time data around Organizational Elements Model (OEM) (Kaufman 2006; 2011) mega, macro, and micro system layers designed in collaboration with CEC leadership. The initial automation will utilize a Google document which will allow various data to be entered directly into the dashboard while other data points will need to be manually entered. The overall value the SEI model in terms of supporting organizational performance in terms of data driven decision making is still undetermined and will be followed over the 2011-2012 academic year.

Systemic Change and the Systemic Educational Informatics (SEI) Model

In 1997, Joe Harless envisioned what a public school implementing his Accomplishment-Based Curriculum Development (ABCD) system might look like (Harless, 1998); that school, the Central Educational Center (CEC), opened its doors just three years later, in 2000. While not representing total fidelity to his vision, CEC represents an approximation of Harless's need and customer-driven vision of education largely made possible through the

flexibility allowed through charter schools; the ultimate customer of public education is society itself and these needs inform what and how public education teaches. The major stakeholders of society could be more precisely identified and served: employers, parents, students, educators, and post-secondary educators.

CEC's charter serves as a legal contract with the state Department of Education that precisely identifies the accomplishments it has pledged to fulfill. *Educational informatics* utilizes the science of information and computing technology to collect, organize, and disseminate real-time data to inform decision making in the educational setting to improve teaching and learning on an organizational, management level. CEC leadership views this emerging science as a way to make identifying and gathering the data necessary to make informed decisions more efficient and streamlined so more time can be dedicated to analyzing and utilizing this data so it can impact real-time performance decisions. Reigeluth (1994) views systemic change as a paradigm shift that requires formal education to refine itself in order to meet the growing changes and needs of society at all levels of education. The SEI model represents the first applied application of educational informatics, integrating contemporary technological advances in computing and information science, within a systemic change context.

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