Data-driven innovation: a model for education transformation

Inovação baseada em dados: um modelo para a transformação da educação

Innovación impulsada por datos: un modelo para la transformación educativa

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ABSTRACT
This paper proposes a continuous, linear data-driven innovation (DDI) model for education transformation grounded in evidence-based tools and data analysis. It advocates prioritizing “big data” and “small data” to inform incremental innovative changes in pedagogical practices. A detailed example of applying this DDI model in a Malaysian primary school is provided, including using exam results and quality standards to select a target school and diagnostic tests to identify issues. An intervention is designed utilizing multiplication tables and evaluated through public exam performance. Subsequent teacher training and student programs emerge. The model catalyzes ongoing localized innovations.

Keywords: data-driven innovation, education transformation, pedagogy, big data, small data.

RESUMO
Este artigo propõe um modelo contínuo e linear de inovação baseada em dados (DDI) para a transformação da educação, fundamentado em ferramentas baseadas em evidências e análise de dados. Defende a priorização de “big data” e “small data” para informar melhorias inovadoras incrementais nas práticas pedagógicas. Fornecem um exemplo detalhado da aplicação deste modelo DDI em uma escola primária malaia, incluindo o uso de resultados de exames e padrões de qualidade para selecionar uma escola-alvo e testes de diagnóstico para identificar problemas. Uma intervenção é projetada utilizando tabelas de multiplicação e avaliada por meio do desempenho em exames públicos. Posteriormente, emergem programas de treinamento para professores e alunos. O modelo catalisa inovações localizadas contínuas.

Palavras-chave: inovação baseada em dados, transformação da educação, pedagogia, big data, small data.
RESUMEN
Este documento propone un modelo de innovación continua y lineal impulsado por datos (DDI, por sus siglas en inglés) para la transformación educativa fundamentado en herramientas basadas en evidencia y análisis de datos. Aboga por priorizar "big data" y "small data" para informar cambios innovadores incrementales en las prácticas pedagógicas. Se proporciona un ejemplo detallado de aplicación de este modelo DDI en una escuela primaria de Malasia, incluyendo el uso de resultados de exámenes y estándares de calidad para seleccionar una escuela objetivo y pruebas diagnósticas para identificar problemas. Se diseña una intervención utilizando tablas de multiplicar y se evalúa a través del rendimiento en exámenes públicos. Surgen programas de capacitación docente y estudiantil subsiguientes. El modelo cataliza innovaciones localizadas continuas.

Palabras clave: innovación impulsada por datos, transformación educativa, pedagogía, big data, small data.

1 INTRODUCTION

Education systems worldwide face immense pressure to transform in order to equip students with essential 21st century information processing and problem-solving competencies (Reimers & Chung, 2016). However, sweeping reforms have often failed to achieve lasting improvements (Elmore, 1995). This highlights the need for a responsive, evidence-based model to catalyze continuous, evolving innovation grounded in school contexts.

The explosion of accessible data, both generalized “big data” and specific “small data,” presents tremendous potential for data-informed decision making to enhance outcomes (Marsh & Farrell, 2015). However, substantial research-practice gaps persist, with scarce models successfully leveraging school-level data to drive relevant innovation (Mandinach & Gummer, 2016). Developing frameworks effectively translating data analytics into actions remains critical for progressive education transformation.

This paper argues that human-mediated data analysis coupled with interpretations of causal relationships and patterns can elicit significant, measurable innovations in teaching and learning (Berland et al., 2014). It proposes an actionable continuous data-driven innovation (DDI) model using “big” and “small” data feedback loops to enact incremental, localized innovations addressing context-specific education issues (OECD, 2015).

After defining DDI methodology and theoretical grounding, a detailed application in a Malaysian primary school tests the model’s utility for engendering ongoing
pedagogical innovations and broader transformation. The paper concludes by evaluating limitations and potential for organically propagating evidence-based, evolutionary educational improvements across systems. Overall, it presents a promising model for kick-starting and sustaining data-driven innovation dynamics.

2 THEORETICAL BACKGROUND

The theoretical basis for utilizing a data-driven approach to spark innovation in education transformation draws from a range of learning theories and change management models.

Constructivist learning theories, especially social constructivism, support the conceptual framework grounding pedagogical innovations in evidence derived from authentic educational contexts and learner experiences. Constructing understanding in situated contexts aligns with using data-based findings to drive relevant innovations (Brown, Collins & Duguid, 1989). Change theories also provide theoretical grounding. Fullan’s model of change explicitly advocates using data to identify problems, set goals and measure improvements while building collective capacities for ongoing growth (Fullan, 2006).

Defining innovation is complex with myriad interpretations across contexts. In education, Esdal (2017) pragmatically frames it as adaptively “doing things in new ways” without strictly requiring novel inventions. This aligns with Dewey’s (1938) conception of incremental progress through flexible evidence-based decision-making. There is also substantial focus on innovation cultivating skills for uncertainty and leveraging technology advancements (OECD, 2016).

Overall, education innovation scholarship emphasizes a process-orientation using data and collaborative inquiry to systematically refine practices, not just develop disruptive solutions (Bocconi et al., 2016). This evolving, human-centered approach intersects with constructs like double-loop learning (Argyris & Schon, 1978), considering underlying assumptions driving actions. There is clear resonance between continuous improvement models and data-informed iterative innovation.

Using data is integral for meaningful innovation, revealing understanding about complex educational contexts. However, the relationship between data ecosystems and innovation dynamics remains underexplored, despite enthusiasm about learning analytics and educational data mining (Ifenthaler & Widanapathirana, 2014). There are widespread
calls to develop frameworks and leadership capacities for translating analytics into innovation (Mandinach & Jackson, 2012).

The proposed DDI model contributes an exemplar for interweaving multilevel data flows with innovation processes, using evidence to systematically guide incremental enhancements. It attempts to bridge research gaps by outlining an actionable approach for activating data-driven innovation in situated school settings to drive ongoing, evolving improvement.

Additionally, the DDI model’s continuous incremental approach based on action research cycles reflects Dewey’s theory of pragmatic educational progress through flexible evidence-based decision making (Biesta & Burbules, 2003). It also integrates systems thinking for organizational development, using data feedback loops to adaptively inform change. Senge’s learning organizations theory applies, emphasizing elevating collective evidence gathering and reflection to shift cultures (Senge, 1990).

Overall, major learning and change theories substantially intersect to provide a robust theoretical framework for data-driven incremental innovation through constructive analysis of authentic evidence, targeted improvements and continuous collaborative growth. The DDI methodology closely integrates these key elements of using context-specific data to fuel ongoing, evolving and ultimately transformative enhancement.

3 DATA-DRIVEN INNOVATION FRAMEWORK

The DDI model uses primary school national exam results and Malaysian Education Quality Standards (SKPM) spanning leadership, management, human resources and outcomes as “big data” to select target schools. Additional “small data” diagnostic tests within underperforming schools identify specific issues. The model then designs a tailored intervention, evaluates through updated “big data” metrics, and replicates successful innovations through cascading “small data” studies producing ongoing transformations (see Figure 1).
4 IMPLEMENTING DDI IN A PRIMARY SCHOOL

The District Education Office placed specialist coaches in underperforming Kuching schools based on 2018 baseline data. School A was selected for poor Year 6 math exam performance – only 11.8% achieved minimum mastery versus national, state and district targets. All other SKPM quality aspects were satisfactory, isolating math pedagogy needs.

Diagnostic testing of School A’s 122 Year 6 students revealed issues recalling multiplication tables quickly. The team innovated an “Easy & Quick Table” (EQ Table) intervention (see Figure 2) enabling students to reference answers rather than memorize. Teachers worked with groups over two months to complete tables using patterns. Students spent five minutes filling them out before using them on the 2019 exam.

The intervention significantly raised School A’s math mastery to 49%. Ongoing small data studies successfully replicated it across lower grades. It also catalyzed teacher training sharing best practices and new student exploration camps. Additionally, more School A teachers participated in the District’s Innovative Educator Competition. The iterative, localized DDI process sparked continuous innovation and transformation.
5 DISCUSSION

The proposed continuous linear DDI model entails targeted stages leveraging data to inform incremental innovation. It was adapted from OECD’s (2015) broader DDI framework encompassing accessing, analyzing and applying data for economic and social value. This education-focused model interlinks “big data” feedback on systemic progress with localized “small data” insights to enact contextualized enhancements.

The first phase uses aggregated performance data and quality standards to pinpoint focus schools requiring intervention. Additional diagnostic assessments generate granular comprehension of specific problem areas. This “funneling” process concentrates understanding of critical student needs warranting attention.

DDI’s data-centered emphasis enhances objectivity, revealing genuine issues. Rather than rely on assumptions or evaluations expressing blame, evidence provides neutral problematic area identification allowing supportive improvement prioritization (Datnow & Park, 2018). The model builds shared focus and urgency essential for buy-in.

The second phase channels data-derived knowledge into designing targeted, tested interventions aligned with improvement aims for high-need student groups. Rapid prototyping and iteration principles apply, adapting quickly based on measured efficacy (OECD, 2016). Solutions should demonstrate flexibility for modification while upholding core instructional design principles.

For instance, the school example created reusable templates for an “Easy & Quick (EQ) Table” so new groups can be continually added. Progressive refinement balances responding to emerging requirements with sustaining fundamental coherence and quality for users.

The final stage examines post-intervention data signals to determine effectiveness. Successful solutions propagate through replication with additional cohorts and context-specific calibrations fueled by iterative data dives. Failed trials require rapid replacement guided by fresh diagnoses. Overall continuous evolution is enabled via interacting data feedback loops revealing performance patterns that subsequently direct improvement priorities.
6 CONCLUSION

This paper presented a continuous, linear DDI model using multilevel data flows to stimulate incremental, evolving innovation in education systems. The school-based application demonstrated efficacy catalyzing pedagogical improvements, teacher development and student programming for sustained advancement. However, limitations temper discussing potential applications.

The tightly-coupled stages enable responsive evidence-based decision-making but restrict flexibility for extensive customization across diverse settings. Additionally, the linear rather than cyclical sequence focusing on replacement over iteration of failed innovations limits learning from initial trials. Both constraints arise from pressing transformation timelines that may force abandonment of interventions showing initial promise given refinement.

Further research should test adapting DDI’s core mechanisms of data-driven diagnosis, intervention and evaluation to open systems permitting more context-specific tailoring and deliberate revision based on emerging insights. Exploring integrating cyclical review processes allowing revisiting and optimizing promising but initially inadequate trials could prove fruitful.

Conceptually, additional work might frame transformations as gradual collective capability advancement versus rigid outcome improvement targets that impose counterproductive haste (Hall & Hord, 2020). Taking a developmental view could enable retaining and evolving innovations showing potential but not instantly revolutionizing systems.

On the whole, the proposed DDI model offers a solid starting framework for leveraging school-level data ecosystems to activate innovation. While requiring adjustment for variable settings, the basic flow holds substantial promise for kickstarting collaborative, sustainable data-driven educational improvement journeys that expand over time. With careful implementation and community stewardship, it can seed continuous progress.
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