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Equity as Infrastructure: Recentering High-Impact Practices in Education 4.0 Frameworks

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ABSTRACT

Education 4.0 frameworks position adaptive personalization, intelligent learning pathways, and competency-based design as structural pillars of the emerging learning ecosystem. Yet a persistent gap in this literature concerns whose learning these architectures are built to serve. By centering technological capacity and institutional scalability, dominant Education 4.0 models risk reproducing and even potentially amplifying the structural inequities that have long characterized formal education. This paper argues that equity is not a supplementary consideration for intelligent learning ecosystems but a foundational design condition, and that the high-impact practices (HIPs) literature offers a theoretically grounded and empirically supported companion to current frameworks. This conceptual paper proceeds through theoretical synthesis rather than empirical inquiry. Drawing on three theoretical anchors, including organizational learning theory, equity-mindedness, and community cultural wealth, alongside a narrative synthesis of empirical research on HIPs and student outcome equity, this paper examines how HIPs (including undergraduate research, collaborative learning, and competency-based capstone experiences) function as design principles with demonstrated efficacy in closing outcome gaps for historically underserved populations. To ground the framework in practice, the paper draws on an illustrative case from doctoral education at a Hispanic-Serving Institution whose higher education leadership program serves predominantly first-generation, working-adult, and minoritized students. The case, presented as an illustrative rather than empirical account, draws on program design records and retrospective survey reflections from former doctoral participants to concretize the conceptual argument. Participant reflections converged on four patterns: relational flexibility functioned as the structural condition of continued doctoral progress through major life disruptions; sustained chair support was unanimously identified as foundational, with the learning community serving as a complementary relational space; technology was consistently described as a useful supplement to, but never a substitute for, the support that mattered most; and participants reported carrying the program's relational principles into their own subsequent mentoring and supervisory practice. The analysis frames HIPs not as discrete interventions, but as design principles for intelligent ecosystems whose equity potential depends on relational infrastructure as a prerequisite condition and not an afterthought. Implications are drawn for instructional designers, institutional leaders, and policy architects working to build learning ecosystems that are not merely intelligent, but just.

Keywords: Education 4.0; high-impact practices; equity-centered pedagogy; intelligent learning ecosystems; active methodologies

INTRODUCTION

Higher education is at a crossroads. The emergence of Education 4.0 frameworks, which are rooted in adaptive personalization, intelligent learning pathways, and competency-based design, promises to transform how institutions understand quality, delivery, and even student success. Aligned with the technological imperatives of the Fourth Industrial Revolution, these frameworks offer alluring visions of intelligent learning ecosystems capable of meeting students where they are, predicting their emergent needs, and scaffolding their progress, all in real time. Generative AI tools have accelerated the associated tension, introducing new pressures on academic literacy, authorship, and the redefinition of assessment that institutions are only beginning to grapple with empirically (Baldrich et al., 2025). The appeal of such ideas is understandable. Yet the growing enthusiasm for Education 4.0 has outpaced scrutiny of its foundational assumptions, and those assumptions carry significant consequences for equity.

A growing body of critical scholarship cautions that technology-centered educational models risk reproducing, or even amplifying, the structural inequities that have long characterized formal education (Attewell, 2001; Reich, 2020; Selwyn, 2016; Williamson et al., 2020). Three decades of evidence, examined in detail below, converge on a consistent pattern: new technologies, even free ones, disproportionately benefit already-advantaged learners, because the social and cultural infrastructure surrounding technology use is itself unequally distributed. These perspectives suggest that the question is not whether Education 4.0 frameworks are innovative, but whether innovation alone constitutes progress, and for whom.

This paper addresses that question by exploring what the high-impact practices (HIPs) literature offers as an equity-centered companion to dominant Education 4.0 models. HIPs (including for example undergraduate research, collaborative learning, and competency-based capstone experiences) have accumulated a robust empirical record of positive effects on student engagement, persistence, and outcome equity (Kuh & O'Donnell, 2013; Kuh et al., 2017). This literature documents not only that HIPs produce beneficial outcomes, but that these outcomes are most pronounced for students from historically underserved populations; this pattern is examined in detail below (Finley & McNair, 2013; Kuh et al., 2017). Critically, this benefit pattern does not reflect a deficit on the part of these students; rather, as Yosso (2005) argues, students from communities of color and other historically marginalized groups bring forms of community cultural wealth (aspirational, navigational, social, linguistic, familial, and resistant capital) that institutional structures often fail to recognize or value. HIPs may produce stronger effects for these students precisely because the structural conditions HIPs create allow these forms of capital to be recognized, mobilized, and built upon. These effects, however, have been documented overwhelmingly at the undergraduate level. The application of HIPs frameworks to graduate and doctoral education remains substantially under-theorized, despite evidence that first-generation and minoritized doctoral students face compounded structural challenges that mirror, and in some respects exceed, those documented in the undergraduate literature (Golde, 2005; Lovitts, 2001; Rivard et al., 2026).

First-generation, minoritized, and other historically underserved students, at both the undergraduate and doctoral levels, are precisely the populations that Education 4.0 governance models are positioned to either serve or further exclude. Yet access to HIPs remains deeply unequal. First-generation students, Black and Hispanic students, and transfer students are systematically underrepresented in high-impact learning experiences (Kuh & O'Donnell, 2013; Kuh et al., 2017), suggesting that the conditions required to make HIPs work are themselves a form of infrastructure that must be deliberately constructed. These conditions correspond to the eight quality conditions Kuh and O'Donnell (2013) identify as constitutive of high-impact learning, discussed below.

This paper argues that equity is not just a supplementary consideration for intelligent learning ecosystems: it is a critical, foundational design condition. The argument relies on three theoretical anchors: organizational learning theory's account of how institutions actually change (Kezar, 2005); Bensimon's (2018, 2024) framework of equity-mindedness, which reframes racialized outcome patterns as evidence of institutional rather than student dysfunction; and Yosso's (2005) community cultural wealth framework, which names the forms of capital that students from historically minoritized communities bring to learning environments and that institutions are not typically structured to recognize. These are supported by a narrative synthesis of empirical research on HIPs and student outcome equity (Finley & McNair, 2013; Kuh et al., 2017). Within this framing, HIPs emerge not as individual programmatic interventions, but as participatory, relationship-centered, structurally-responsive design principles focused on the conditions students actually navigate.

A note on approach is warranted. This is a conceptual paper. Its method is theoretical synthesis: it reads the Education 4.0 literature against the high-impact practices evidence base through the analytical lenses of organizational learning theory, equity-mindedness, and community cultural wealth. The doctoral education case presented later in the paper is offered in an explicitly illustrative capacity. It grounds the conceptual claims in a concrete institutional context and demonstrates what relational infrastructure looks like in practice, but it is not advanced as an independent empirical study, and no generalizable empirical claims rest on it. Details of the case's design, participants, and limitations are provided in that section to make its illustrative use transparent.

The case, which extends the literature on doctoral socialization and departmental responsibility for student success (Golde, 2005; Lovitts, 2001), draws on the design of a doctoral support structure—dissertation learning communities paired with sustained one-on-one chair support—at a Hispanic-Serving Institution's higher education leadership program serving predominantly first-generation, working-adult, and minoritized students, together with retrospective reflections from former participants. This is a population for whom the structural and relational features of doctoral support documented in the case are not supplementary but constitutive of access. The case demonstrates how relational infrastructure makes visible and mobilizable the forms of community cultural wealth (Yosso, 2005) that algorithmic personalization cannot recognize. Using the term relational infrastructure, this paper refers to the sustained, contextually responsive, human-mediated structures of mentoring, peer engagement, and feedback identified by the HIPs literature as essential to equitable learning.

The paper concludes by arguing that Education 4.0 governance models must treat faculty development and departmental capacity as prerequisite infrastructure, not afterthoughts, if equitable outcomes are to be realized at scale; this is a claim grounded in decades of higher education change scholarship establishing that institutions are complex cultural systems whose practices cannot be shifted by mandate, funding, or data alone (Henderson et al., 2011; Kezar, 2001; Kezar et al., 2015).

Education 4.0: Mapping the Framework

Education 4.0 is the educational result of Industry 4.0, which is a term used to describe the Fourth Industrial Revolution and its convergence of cyber-physical systems, the Internet of Things, artificial intelligence, machine learning, and ubiquitous data infrastructure (Bonfield et al., 2020; Hussin, 2018; Miranda et al., 2021). While Industry 4.0 has influenced expectations around labor, production, and economic participation, Education 4.0 has emerged as a framework for what higher education institutions (HEIs) must become in order to prepare learners to engage in that transformed landscape. Education 4.0's framework is not a singular principle or idea, but is instead a collection of commitments (disseminated through white papers, policy briefings, and scholarly literature) that all share a common hypothesis: that learning ecosystems in this age must be intelligent, adaptive, networked, and continuous, and that the technologies of the Fourth Industrial

Revolution make achieving this possible (Bonfield et al., 2020; Hussin, 2018; Miranda et al., 2021; World Economic Forum, 2020).

Several works articulating this framework are particularly influential. The World Economic Forum (WEF) (2020), through its Education 4.0 initiative, identifies eight critical shifts in learning content and experience that as a group represent quality learning for the Fourth Industrial Revolution. These include global citizenship skills, innovation and creativity skills, technology skills, interpersonal skills, personalized and self-paced learning, accessible and inclusive learning, problem-based and collaborative learning, and lifelong and student-driven learning. Although this framework was developed with a focus primarily on PK-12 education, it has been widely invoked in higher education literature as foundational to Education 4.0. Miranda et al. (2021), focused specifically on higher education, and proposed a four-component reference framework including competencies (the development of transversal and disciplinary capacities in students), learning methods (active, problem-based, challenge-based, and learning-by-doing approaches), information and communication technologies (artificial intelligence, machine learning, cloud computing, cyber-physical systems, data analytics, and mixed reality), and infrastructure (innovative classroom and institutional facilities, including virtual and hybrid learning environments). Hussin (2018) articulates nine practitioner-facing trends including anytime/anywhere learning, personalized progression, student choice in pedagogical approach, project-based and field-based learning, and increased student independence with educators positioned as facilitators rather than instructors. Bonfield et al. (2020) built on this work using case studies of digital personal assistants and lifelong learning platforms in the UK, Singapore, and Australia. These authors framed their work around the question of whether Education 4.0 is a transformation of the field, or simply an evolution of existing pedagogical practice. Together, these works demonstrate how ideas about what Education 4.0 should look like have begun to coalesce in higher education, even through continued difference in emphasis on technologies, pedagogies, or institutional structures. Their shared emphasis on learner agency, self-paced progression, and educators as facilitators draws on longstanding traditions of higher education theory: heutagogical or self-determined learning frameworks (Hase & Kenyon, 2013), in which the learner directs the trajectory of their own learning, and Barnett's (2004) argument that higher education must prepare students for an "*unknown future*" requiring adaptive capacity rather than fixed content mastery.

Throughout the literature, three elements ground most operational definitions. The first of these is adaptive personalization; this is the use of artificial intelligence and learning analytics to tailor pedagogical pathways to individual learners in real time, calibrating difficulty, sequencing, and feedback to performance data. The WEF (2020) frames this as a shift from standardized to personalized learning, one in which each learner progresses at their own pace through experiences aligned with their individual need. Likewise, Hussin (2018) emphasizes mastery-based sequencing and tailored practice. The second is intelligent learning pathways; these are stackable, modular, and increasingly non-linear progressions through curricula that are supported by data-driven recommendations intended to optimize the learner's acquisition of a given knowledge or skill. Miranda et al. (2021) describe this phenomenon as a transition in which the student becomes an active designer of their own learning, who is empowered (in principle) to construct their own pathway through an institution's offerings. Hussin (2018) similarly positions student choice in pedagogy as a defining feature of the Education 4.0 model. The third element is competency-based design, which is the displacement of classroom time and credit-hour metrics by demonstrated mastery; which can be used as direct replacement for classroom time (Reich, 2020), be micro-credentialed, or involve digital badges or blockchain-verified records that can travel with the learner across institutions and into the labor market (Bonfield et al., 2020). These three elements are typically presented as mutually reinforcing. That is, personalization makes pathways efficient, pathways make competencies achievable, and competencies make personalization meaningful by anchoring it in evidence of learning.

Running through all three elements is an infrastructure of data and intelligence. Learning analytics platforms track behavioral data; predictive systems flag students at risk of failing or stopping out; intelligent tutoring

systems and digital personal assistants offer just-in-time support (Bonfield et al., 2020); and generative AI offers the prospect of personalized instructional content, adaptive assessment tools, and tutoring across disciplines (Luckin et al., 2016; Zawacki-Richter et al., 2019). The advent of large language models and pervasive availability of various applications of that technology have accelerated each of these trajectories and introduced new pressures on institutions that they are only beginning to wrestle with empirically (Baldrich et al., 2025). The theory of change at the heart of Education 4.0 holds that these technologies, if deployed at scale, will resolve long-standing tensions in higher education: between individualization and scalability (Reich, 2020; Selwyn, 2016), between rigor and access (Finley & McNair, 2013; Kuh & O'Donnell, 2013; Selwyn, 2016), and between the particularity of learners and the uniformity of credentials (Bonfield et al., 2020; Selwyn, 2016). The appeal of this framework, then, is arguably the tidy resolution of these tensions. If intelligent systems can attend to individual learners while also achieving efficiency by delivering instruction to many, while verifying mastery beyond the institution, they feel like a modern solution for these longstanding challenges.

It is important to note that Education 4.0 frameworks do not ignore equity. WEF's (2020) characteristics include accessible and inclusive learning as a defining shift, and the framework is explicitly positioned as enabling "*leapfrogging*" for economies whose education systems lag behind global standards (p. 5). Miranda et al. (2021) stress the development of transversal competencies (collaboration, communication, critical thinking) that have clear democratic and civic dimensions. Bonfield et al. (2020) center lifelong learning as a mechanism for continuous equitable upskilling across the workforce. Yet these discussions tend to frame equity as an outcome of technological positioning rather than as a prerequisite or design condition. Education 4.0 posits that intelligent systems, by attending to learners individually, will automatically serve them equitably, and that adaptive personalization, scaled across populations, is inherently inclusive. This conflation of personalization with equity is central to the framework's appeal. It is also, this paper argues, its most consequential weakness. The question Bonfield et al. (2020) pose, whether Education 4.0 represents transformation or merely evolution, turns on this point, and the next section takes it up directly.

Education 4.0 offers a vision of intelligent learning ecosystems that is technologically ambitious, attractive to institutions, and that is economically impactful in ways that resonate with the demands of this Fourth Industrial Revolution. This paper focuses not on whether these systems can be built, but whether they can be just. That question requires us to shift our focus from the structures of the framework to the population it claims to serve.

The Equity Problem in Intelligent Learning Ecosystems

The conflation of personalization with equity is not merely a slip of the tongue; rather it is a significant error with material consequences. Education 4.0's logic assumes that by attending to each learner individually, intelligent systems naturally distribute educational benefits more equitably across populations. The empirical record of educational technology over the past three decades suggests otherwise. As Reich (2020) demonstrates through his synthesis of decades of learning-at-scale research, new technologies (including free, seemingly democratizing ones) consistently and disproportionately benefit already-advantaged learners. Reich names this dynamic the edtech Matthew effect and identifies three persistent myths it disproves: that technology disrupts systems of inequality, that free and open technologies will democratize education, and that digital divides can be closed by expanding access alone (Reich, 2020). The evidence shows that technology reproduces the inequalities embedded in the systems into which it is deployed, regardless of designer intent.

This pattern's mechanism was first explained by sociologist Paul Attewell (2001), who proposed that educators distinguish between two digital divides. The first digital divide concerns access: students from low-income or marginalized backgrounds have less access to new technologies than more affluent students. The second digital divide, Attewell (2001) argued, is more consequential and concerns usage. Even when access is equalized, students from low-income backgrounds are more likely to use technology for routine drill and

supervised practice, while affluent students use the same technologies for creative, exploratory, and higher-order activities, often supported by adult mentorship. Later research, including Reich's (2020) synthesis of MOOC literature, has repeatedly confirmed Attewell's thesis: the "*global achievement gap*" in massive open online courses persists even when courses are free (p. 158), because the social and cultural infrastructure surrounding technology use is itself unequally distributed. As Williamson et al. (2020) argue, technology cannot fix social inequality; the benefits of digital tools "*vary widely, with those better off tending to benefit more educationally and socially*" (p. 111). Education 4.0's implicit assumption that intelligent personalization will automatically include those it has not yet served is, based on the evidence, structurally unfounded.

What this evidence reminds us is that access itself is a multi-dimensional condition. The dominant Education 4.0 framing treats access as a binary, asking, does the student have a device, a connection, an enrollment, but the empirical record shows that what students do with technology, and what technology does for students, depends on a layered infrastructure of social, cultural, and institutional support that is itself unequally distributed (Attewell, 2001; Reich, 2020). Affluent students bring networks of mentors, family members, and peers who help them navigate institutional expectations, interpret feedback, and convert engagement into advancement. They also enter institutions whose practices, norms, and recognition structures were historically calibrated to learners like them. First-generation students, students of color, and students from under-resourced communities frequently navigate the same institutions without these compounding supports, and within institutional structures that systematically undervalue or fail to recognize the forms of capital they do bring (Bensimon, 2024; Yosso, 2005).

Adaptive systems calibrated to behavioral inputs cannot see this difference. Bensimon (2024) makes the visibility problem concrete: data on participation in "*high-impact practices*," when not disaggregated by race, render invisible "*racialization in access to opportunity*" (p. 4). The question is not only who has access to the technology, but whose access is supported, recognized, and rewarded by the relational, cultural, and institutional infrastructure that converts technology use into educational gain. Treating access as a question of devices and enrollment leaves the actual mechanisms of educational inequity untouched and students unserved.

Beyond the Matthew effect lies a related conceptual problem: the assumptions about what constitutes an equitable educational experience are themselves embedded in the algorithms, training data, and design logics that constitute Education 4.0's infrastructure, and those assumptions are not neutral. Bensimon's (2024) concept of equity-mindedness offers a clear analytical lens here. Equity-mindedness is a cognitive frame that reframes racialized patterns of achievement as evidence of dysfunction within the institution and/or pedagogy rather than as evidence of student deficit. Adaptive systems trained on existing performance data inherit the racialized patterns embedded in that data. This means that predictive risk algorithms flag students whose patterns deviate from a trajectory shaped by historically white, affluent populations. When best practices are disseminated as universal templates, they carry racial consequences that practitioners must be trained to notice (Bensimon, 2024). Bensimon argues that equity-minded individuals must insist that all data be disaggregated by race and ethnicity and must interrogate whether regular practices "*perpetuate racist outcomes*" or "*build on the experience of whiteness*" (2024, p. 3). Adaptive systems are, by construction, designed to optimize toward aggregate population means. They are colorblind by default, and color-blindness, in Bensimon's framing, is not equity but rather the opposite. Beyond colorblindness, adaptive systems carry an additional design flaw: they are calibrated to recognize and reward forms of capital such as academic vocabulary, normative behavioral patterns, conventional engagement signals, that have historically been valued by White, middle-class educational institutions (Yosso, 2005). The aspirational, navigational, social, linguistic, familial, and resistant capital that students from communities of color bring to learning environments (Yosso, 2005) is largely invisible to systems trained on historical performance data, even though, as Yosso argues, these forms of capital are themselves substantial educational assets. This invisibility connects to a broader claim from the cultural foundations of teaching and learning scholarship: learning is not

a universal cognitive process happening to interchangeable learners, but happens through participation in cultural practices, so that educational environments calibrated to a single, privileged pathway systematically misread the diverse ways in which learning actually unfolds (Nasir et al., 2020).

This problem is reinforced by what Zawacki-Richter et al. (2019) identify as a striking gap in the AI-in-education literature itself, which is that there is a dramatic lack of critical reflection on the pedagogical and ethical implications of AIEd, including its equity consequences. Their systematic review of 146 articles found the literature was dominated by computer science and STEM disciplines and quantitative methods, with any critical engagement on social, cultural, and ethical dimensions largely absent from this field. A parallel evidence map of student engagement and educational technology research (Bond et al., 2020) reaches a similar conclusion about the field's uneven attention to social, cultural, and ethical dimensions. Selwyn (2016) cautions that education is far too complex to be reduced to data analysis and algorithms. Yet Education 4.0 proceeds as though it can be. Without critical reflection on what data systems do not see, on whose experiences they cannot represent, and on which forms of educational quality cannot be reduced to behavioral data, Education 4.0's intelligent systems become, in practical effect, colorblind systems operating at scale. The implications of such systems are substantial. The populations most often invoked as beneficiaries of Education 4.0 include first-generation students, students of color, students in under-resourced institutions, and working adults navigating non-traditional pathways (Bonfield et al., 2020; World Economic Forum, 2020); these are precisely those identified by HIPs research as benefiting most from structural educational support (Finley & McNair, 2013; Kuh et al., 2017), and precisely the support that intelligent systems, calibrated to behavioral data and optimized for efficiency, are least equipped to provide.

Adaptive personalization can adjust to a student's responses, but it cannot recognize that a student is a single mother whose study time is constrained by caregiving demands, that a student is the first in their family to navigate doctoral education and lacks the cultural capital their peers bring as inheritance, or that a student's apparent disengagement reflects not deficit but the accumulated weight of life and work and operating within institutional environments designed without them in mind. These are not peripheral cases to be resolved through more granular data or adjustments to an algorithm; rather they are the conditions that define educational experience for the populations Education 4.0 most loudly claims to serve.

What education needs, then, is a framework that can name the supportive conditions necessary for equitable outcomes to arise. That framework must be grounded in empirical evidence around what works for historically underserved populations, it must be attentive to the structural and relational elements of educational experience, and it must be explicit about what institutional infrastructure is necessary to achieve equitable outcomes at scale. The high-impact practices literature, which has accumulated evidence across three decades on engagement, persistence, and equity, offers exactly that. The next section discusses that literature and examines what HIPs offer as an equity-centered companion to intelligent learning ecosystems.

High-impact Practices as an Equity-Centered Companion

If the preceding section establishes what intelligent learning ecosystems cannot see, the high-impact practices (HIPs) literature establishes what equitable learning environments must contain. HIPs are a set of educational practices identified by Kuh (2008) and elaborated through further research as having particularly strong positive impacts on student engagement, persistence and learning outcomes. Some common HIPs include learning communities, undergraduate research, internships, service learning, capstone projects, collaborative assignments, and ePortfolios, among others. Empirical evidence supporting these practices has accumulated over two decades and across hundreds of institutions (Kuh et al., 2017). What unites these practices into the singular category of HIPs are the conditions under which they produce those positive effects. Kuh and O'Donnell (2013) identify eight conditions that distinguish HIPs from other practices. These include

> "performance expectations set at appropriately high levels; significant investment of time and effort by students over an extended period of time; interactions with faculty and peers about substantive matters; experiences with diversity; frequent, timely, and constructive feedback; periodic, structured opportunities to reflect and integrate learning; opportunities to discover relevance of learning through real-world applications; and public demonstration of competence" (p. 8).

These are the conditions that make HIPs high impact. It is no coincidence that several of these describe forms of holistic human engagement over time rather than simple transactions of content.

There is a well-established empirical record supporting HIPs and equity. Kuh et al. (2017) document what they describe as a compensatory effect; that is, HIPs produce gains in engagement, persistence, and learning outcomes that are most pronounced for students who would otherwise be most likely to disengage or stop out. This translates into disproportionately larger gains or benefits for first generation students, students from historically underrepresented groups, and students less academically prepared at initial enrollment when those groups participate in HIPs, compared to their peers. Finley and McNair (2013) extend and refine this by documenting the equity effects of HIPs participation. Examining NSSE data from thirty-eight campuses across three states, they found that underrepresented minority, first-generation, and transfer students who engaged in multiple HIPs reported gains in deep learning that were equal to or greater than those of their peers, narrowing long-standing gaps in self-reported learning outcomes. Hispanic students participating in five or six HIPs reported deep learning and learning gains 26 percent higher than their non-participating peers, and African American students reported boosts ranging from 11 to 27 percent depending on level of engagement (Finley & McNair, 2013, p. 12). Moreover, the effects of HIPs are cumulative; the more HIPs in which a student engages, the greater the equity effect. These impacts hold across racial, generational, and transfer-status categories. Bensimon's (2024) caution must be considered here: equity effects documented in aggregated data are only meaningful when disaggregated, examined within institutional context, and interrogated for the specific conditions under which they are or are not realized. HIPs produce equity under specific structural and pedagogical conditions, and only when those conditions have been deliberately constructed; the effects are not automatic.

This highlights a critical conceptual understanding about HIPs in the literature: HIPs are not simple programmatic interventions, but rather are design principles for educational experience. Labeling a HIP "*learning community*" or "*service learning*" only produces the desired impact when it embodies those eight quality conditions. Remove those conditions and the same activity fails to produce the effects (Kuh & O'Donnell, 2013). HIPs therefore cannot be scaled through superficial replication of the named practices; they can only be scaled through application of those design principles and replication of the conditions that make them work. Those conditions are inherently relational, structural, and labor-intensive; they are costlier to implement than standard instruction, and difficult to capture in typical measures of institutional productivity (Kuh et al., 2017, p. 14). HIPs are pieces of educational infrastructure that must be, in Kuh et al.'s (2017) phrasing, "*built into the college experience for all who enroll, rather than a supplement or innovation on the margins*" (p. 13); they must be deliberately constructed, resourced, and sustained over time. They are not, in any meaningful sense, automatable, though, as discussed below, they can be meaningfully augmented.

This is where the HIPs framework most directly answers the equity problem identified in the preceding section. Education 4.0's personalization is algorithmic. The matching of inputs to outputs is based on observed behavioral data, and optimized for population-level efficiency. The HIPs literature offers a fundamentally different approach to personalization, one that operates through relational continuity, structural responsiveness to students, and human-mediated judgment about each individual learner's trajectory. When Kuh and O'Donnell (2013) describe "*frequent, timely, and constructive feedback*" as a quality condition, they are not describing AI-fueled, automated correction of student work against a rubric; they are describing

iterative human engagement with a student's developing thinking, focused on where that student is at this moment in this life. When they describe "*interactions with faculty and peers about substantive matters*," they are not describing chatbot-mediated tutoring or dashboard-flagged interventions; they are describing the kind of sustained, whole-person intellectual relationships (Snijders et al., 2022) that, in the doctoral context especially, have long been understood as foundational to scholarly development. These are relationships within which students' aspirational, navigational, social, linguistic, familial, and resistant capital (Yosso, 2005) can be recognized as the educational assets they are. Algorithmic systems calibrated to behavioral performance data cannot perform this recognition; they cannot see what minoritized students bring that does not register as conventional academic engagement. These are precisely the dimensions that the empirical record identifies as producing equity effects for historically underserved populations.

This contrast should not be mistaken for a claim that intelligent systems and relational infrastructure are opposed in principle, or that AI has no legitimate place in equity-centered design. The argument advanced here is a claim about sequencing and priority, not a rejection of the technologies themselves. Indeed, the augmentation literature suggests genuinely hybrid possibilities: Luckin et al. (2016) argue that AI's most defensible educational role is to augment rather than replace human teaching, and several configurations are consistent with the HIPs quality conditions rather than corrosive of them. Learning analytics can function as a prompt for human outreach rather than a substitute for it, flagging a pattern so that a mentor who knows the student's circumstances can respond with contextual judgment. Automated systems can absorb genuinely routine functions (registration reminders, scheduling, resource retrieval), releasing faculty time for the substantive interaction the HIPs literature identifies as consequential. Generative tools can extend the reach of structured feedback between human touchpoints, provided the feedback loop remains anchored in a continuing relationship. What distinguishes these hybrid configurations from the displacement this paper critiques is directionality: in each, the intelligent system is subordinated to, and in service of, a relational infrastructure that already exists. The equity problem arises when the sequence is inverted, when systems are deployed as the infrastructure, and human relationships are repositioned as the supplement. The case that follows illustrates both sides of this distinction.

Yet despite the depth and breadth of the HIPs evidence base, the framework has been developed and tested almost exclusively at the undergraduate level. Its application to graduate and doctoral education remains underexplored, despite evidence that first-generation and minoritized doctoral students face structural challenges that mirror, and in some respects exceed those documented for undergraduates (Golde, 2005; Lovitts, 2001; Rivard et al., 2026). Recent qualitative work reinforces this point; across studies of doctoral students' research experiences, the relational and emotional dimensions of supervisor and peer support emerge consistently as central contributing factors in student progress, rather than peripheral conditions (Droog et al., 2024).

This gap is meaningful; Education 4.0's automation of advising, assessment, and progress monitoring is gaining traction at the doctoral level. The conditions most vulnerable to displacement through application of the Education 4.0 model in doctoral education, sustained mentorship, structured peer engagement, contextually responsive feedback, whole-person attention, and the relational continuity that makes all of these possible, are also those conditions identified in the HIPs research as crucial for equitable outcomes. The illustrative case that follows responds directly to this gap, examining what this relational infrastructure looks like in practice in a doctoral program, serving a population for whom the features of HIPs are not supplementary, but fundamental to access.

An Illustrative Case: Relational Infrastructure in Doctoral Education at a Hispanic-Serving Institution

The argument advanced here is, to this point, a conceptual one: that the relational and structural conditions HIPs scholarship identifies as constitutive of equity are precisely those most vulnerable to displacement under Education 4.0 logics. To ground this argument in a context where its stakes are immediate, this section presents an illustrative case from doctoral education at a private Hispanic-Serving Institution in the Midwest, whose doctoral program in higher education leadership has long served a population for whom the relational infrastructure described above is not supplementary but constitutive of access.

The program serves predominantly first-generation, working-adult, and minoritized students, many of whom are simultaneously employed full-time as higher education practitioners. For these students, the structural challenges Lovitts (2001) and Golde (2005) document at the doctoral level are compounded by family responsibilities, professional obligations, health events, and the institutional environments in which they were never the imagined student. They are, in Yosso's (2005) framing, students whose aspirational, navigational, social, linguistic, familial, and resistant capital does not always register as conventional academic engagement, but who bring substantial educational assets that institutions must be deliberately structured to recognize and mobilize.

The Design

The dissertation phase in this program was supported by two complementary structures. The first was the Writers (a pseudonym) dissertation learning community, a regularly meeting cross-cohort group in which students at varying stages of progress shared work-in-progress, troubleshot methodological and conceptual challenges, and provided mutual encouragement under faculty facilitation. The second was sustained one-on-one chair support, in which the dissertation chair functioned not only as methodological supervisor but as a continuous, contextually responsive presence across the full duration of the dissertation phase. Mapped against Kuh and O'Donnell's (2013) eight quality conditions, the design reflected high performance expectations through dissertation requirements; significant student investment of time over an extended period; substantive faculty and peer interaction; experience with intellectual and demographic diversity within and across cohorts; frequent, contextually responsive feedback; periodic structured reflection; opportunities to apply learning to real-world practitioner contexts; and public demonstration of competence at proposal and defense.

A 2022 Scholarship of Teaching and Learning study at the institution examined the design's effects on doctoral progress, completion, and scholar-practitioner identity formation, documenting positive effects on persistence and on the development of practitioner-scholar identity. In 2026, a follow-up study was launched to examine the longitudinal dimensions of those effects: how former participants, now several years removed from defense and working as higher education professionals, retrospectively understood the role of the program's relational infrastructure in shaping not only their doctoral progress but their subsequent professional practice.

The Follow-up Reflection: Approach and Participants

Consistent with this paper's conceptual purpose, the follow-up data are presented as illustrative material rather than as findings of an independent empirical study. The following details are provided so that readers can assess the basis and boundaries of the illustration. The patterns reported here are intended to concretize the conceptual argument advanced in the preceding sections rather than to establish independent empirical claims.

Sampling and Participation

All former participants in the program's dissertation-phase support structures for whom current contact information could be obtained were invited to participate, yielding an invitation pool of 20. Ten individuals opened the survey and consented; six completed the open-ended items substantively and constitute the reflection sample analyzed here. Partial completion is unsurprising for a retrospective survey administered to working professionals several years post-program, and no inference is drawn from non-completion; however, the possibility that those who responded fully held more positive views of the program than those who did not is acknowledged as a boundary on even the illustrative claims made here.

Participants

Of the six substantive respondents, five identified as first-generation graduate students by the survey's definition (no parent or guardian who raised them having completed a bachelor's degree). Finer demographic disaggregation, including race/ethnicity and gender, is withheld to protect participant identity in a small sample drawn from a single identifiable program; the program from which respondents were drawn serves a predominantly minoritized and working-adult population, as described above. Five had completed the degree at the time of the survey, with completion dates ranging from March 2022 to May 2025; one was completing coursework. Respondents occupy a range of higher education roles spanning faculty positions, executive leadership in teaching and learning centers, academic deanships, and student-facing professional positions.

Instrument

The follow-up instrument was developed by the author from two sources: the constructs examined in the 2022 SoTL study (doctoral progress, completion, and scholar-practitioner identity formation) and Kuh and O'Donnell's (2013) eight quality conditions, which structured the open-ended items on program supports. The instrument combined seven Likert-type items on the importance of the Writers Group and chair-support structures with twelve open-ended items addressing what was most essential to dissertation progress, how supports responded to circumstances outside the program, the role of institutional tools and technologies, what would have been difficult or impossible to replicate in a more automated or standardized format, and how participants' own subsequent mentoring and supervisory practice was shaped by their experience. The survey was administered via Qualtrics in spring 2026.

Analysis and Trustworthiness

Likert items were summarized descriptively given the sample size (n = 6); no inferential statistics were computed or implied. Open-ended responses were analyzed thematically in Atlas.ti, with coding proceeding inductively across two passes and emergent codes subsequently mapped against Kuh and O'Donnell's (2013) eight quality conditions to examine alignment between participant reflections and the HIPs framework. Because a single researcher conducted the analysis, trustworthiness was supported through three practices: an audit trail linking each reported pattern to verbatim response text; a requirement that reported patterns appear across multiple respondents, with singular reflections identified as such; and a deliberate search for disconfirming responses, the results of which are reported rather than omitted, most notably one respondent's strong disagreement regarding the learning community's importance. Consistent with the illustrative purpose of the case, direct quotation is used sparingly and responses are paraphrased to protect participant identity in a small, potentially identifiable sample.

Positionality

The author served as dissertation chair and faculty facilitator within the program described and all respondents were former advisees. This position afforded the contextual knowledge that motivates the case but also constitutes an evident interest in the program's value. Two features of the design partially mitigate this:

responses were collected anonymously through the survey instrument rather than through interviews with the former chair, and the analysis reports variability and dissent rather than uniform endorsement. Readers should nonetheless weigh the illustrative claims with this relationship in view. Both studies were approved by institutional review boards; the first at the original institution and the follow-up study at the author's current institution (The University of Southern Mississippi, IRB protocol 26-322).

Patterns in Participant Reflections

Relational flexibility as the structural condition of access. Across the open-ended responses, participants described life events that, in the absence of relational flexibility, would have ended their doctoral progress. These included the births of children, severe health events, multiple institutional transitions in their professional roles, and the disruptions of the COVID-19 pandemic. In each instance, what participants identified as enabling continued progress was not a recalibrated deadline or an automated nudge but the empathetic and contextually grounded judgment of a chair who knew their circumstances. One participant, reflecting on a period in which professional changes and the birth of a second child made dissertation work nearly impossible, characterized the support received as having met them where they were rather than holding to fixed expectations. Another described an extended break taken after the birth of a child, noting that the relational support structures of the program had felt like spaces in which one could appear regardless of what was happening outside it. A third recounted a severe health event that left her ready to abandon the dissertation, with continued progress possible only because a supportive chair and peer group encouraged her to set her own pace. The pattern was consistent with what HIPs scholarship identifies as a precondition of equitable participation: an institutional structure capable of responding to the actual circumstances students navigate, rather than to the idealized student for whom most academic timelines are calibrated.

Chair as foundation; Writers Group as complementary community. The Likert data showed unanimous agreement on the importance of chair support, with all six respondents either agreeing or strongly agreeing on its centrality to their progress. Importance attributed to the Writers learning community was strong but more variable: four respondents strongly agreed it was important, one agreed, and one strongly disagreed. The open-ended responses help explain this variability. Respondents whose own cohort had developed strong informal subgroups described those peer structures as substituting for some of what Writers Group offered, while still valuing the cross-cohort dimension at moments of dissertation despair, when hearing that more advanced students had reached the same difficult points was clarifying. One respondent, currently completing coursework after Writers Group had been discontinued (with the departure of the supporting faculty member), described initiating an alumni-organized creative group loosely modeled on the Writers Group structure to recover the kind of community-based dissertation support the original program offered. That participant's reflection underscored a pattern common across responses: the value of the Writers Group community lay less in any particular activity than in its function as a structurally guaranteed space for relational continuity across the dissertation phase. Several respondents described the Writers Group space as one that, in the words of one participant, could not be replaced in a more automated or standardized format because human connection and the building of community could not be replicated there. This pattern extends Bensimon's (2024) argument: the conditions under which equity is produced are not merely difficult to operationalize at scale; they are categorically of a kind that algorithmic systems are not designed to construct.

Technology as supplement, not substitute. When asked about institutional tools and technologies, respondents consistently described technology as auxiliary to, rather than constitutive of, the support that mattered most. A learning management system, qualitative analysis software, citation managers introduced early in the program, and AI-based writing tools each appeared as useful infrastructure for specific instrumental tasks: source organization, data management, draft polishing, time tracking. None was described as having played a role in the dimensions of support participants identified as essential. One respondent contrasted automated reminders with chair availability, observing that automated messages serve well for

routine logistical functions like registration deadlines but cannot substitute for the knowledge that one's advisor is reachable at any hour. Another framed the same distinction by separating tools that helped with the writing process from the relational space in which progress was actually discussed and supported. A third noted that her chair's responsiveness, with feedback typically returned within twenty-four to forty-eight hours, served as her clearest signal of progress, with longer turnaround times themselves carrying interpretive meaning within the relationship; a level of communicative texture that automated systems are not designed to produce. The pattern is consistent with the framing developed in the preceding sections: technology can extend the reach of relational infrastructure but cannot construct it.

Propagation into subsequent practice. Perhaps the most striking pattern from the follow-up data concerned the durability of the program's relational principles in participants' subsequent professional practice. Without prompting toward this theme, multiple respondents described having carried specific features of their doctoral support experience into their own mentoring, teaching, and supervisory work. One respondent, now teaching in a faculty role, described drawing explicitly on her chair's interactions with her when navigating difficult conversations with colleagues and supervisees, attempting to emulate a relational mode that she described as not coming naturally but that she had experienced as transformative. Another, now working in dissertation editing in addition to a primary administrative role, described carrying forward the practice of meeting students within their actual circumstances rather than imposing a uniform standard. A third, in a senior teaching-and-learning leadership position, described having developed a more consistent practice of disaggregating her attention to individual students after experiencing what differentiated support had made possible in her own doctoral experience. A fourth, currently completing coursework, had founded a community of practice for creative alumni at her institution explicitly modeled on the Writers Group structure. These reflections suggest that the equity effects of relational infrastructure extend beyond the dissertation phase into the institutional practices that participants subsequently shape; a generative pattern that any account of return on investment for relationally-grounded doctoral education must take seriously.

Synthesis: What the Case Demonstrates

The case is consistent with the broader argument advanced in this paper in three specific respects. First, the conditions that made the design effective were precisely those Kuh and O'Donnell (2013) identify as quality conditions for HIPs, and those conditions were inherently relational, structural, and labor-intensive. Second, the equity effects participants described were not effects of personalization in the algorithmic sense; they were effects of contextually grounded human judgment that could recognize and mobilize forms of capital, ranging from familial and navigational capital to the resistant capital of students continuing despite institutional structures not built for them, that adaptive systems trained on conventional engagement signals would have rendered invisible (Yosso, 2005). Third, the structural features that participants identified as having been critical to their progress were the same features that, in their explicit retrospective judgment, would have been most difficult or impossible to replicate in a more automated or standardized form. The case does not argue that technology has no role in doctoral education; the data show that it does. The case argues, rather, that the conditions under which equity is produced at the doctoral level are not technological in nature, and that their displacement under Education 4.0 logics would carry predictable equity consequences for precisely the populations Education 4.0 governance models most loudly claim to serve.

IMPLICATIONS: TOWARD EQUITY-CENTERED INTELLIGENT LEARNING ECOSYSTEMS

The argument presented in this paper has direct implications for the design of intelligent learning ecosystems. If equity is indeed a structural, relational achievement rather than an outcome of algorithmic personalization,

then Education 4.0 must be reorganized around the conditions proven to produce equitable outcomes. The implications are organized into four sections below: implications for governance models, for practitioners and instructional designers, for institutional leaders and policy architects, and for what an equity-centered intelligent ecosystem looks like in practice.

Reframing the Governance Model: Faculty Development and Departmental Capacity as Prerequisite Infrastructure

Perhaps the most consequential implication of this analysis is that the governance models guiding Education 4.0 implementation must treat faculty development and departmental capacity as prerequisite infrastructure rather than downstream considerations. The change literature is unambiguous on this point. Henderson et al.'s (2011) analytic review of undergraduate STEM instructional reform documents that top-down dissemination of "*best practice*" materials and prescriptive policy-making are among the least effective strategies for shifting instructional practice. What works, by contrast, are strategies that engage faculty beliefs over sustained periods, treat the institution as a complex system, and develop shared visions of teaching and learning across communities of practice (Henderson et al., 2011, p. 952). Kezar et al. (2015) build on this finding by demonstrating that implicit theories of change, particularly an overreliance on funding and data at the expense of attention to institutional and political dynamics, have hampered STEM reform efforts and produced predictable patterns of failure even in well-resourced initiatives.

These findings carry direct warning weight for Education 4.0's implementation, as its approaches directly mirror the implicit theories Kezar et al. (2015) identify as least effective in STEM reform: an over-reliance on funding to drive change, an over-reliance on data to convince stakeholders, and a corresponding under-attention to the organizational and political conditions under which faculty actually change practice. The result, then, is the domestication Reich (2020) describes, with new technologies absorbed into existing instructional patterns, reproducing rather than transforming the structural inequities they purport to address. To avoid this, the typical sequence must be reversed: faculty development and departmental capacity-building must come first, followed by technological deployment. Unless practitioners are equipped in advance to recognize, construct, and sustain the relational and structural conditions HIPs research identifies, no quantity of intelligent technology will produce equitable outcomes at scale.

Design Principles for Practitioners and Instructional Designers

This analysis surfaces several key design principles for consideration by practitioners and instructional designers working within Education 4.0 contexts. First, technology should partner with and complement relational infrastructure, not replace it. Adaptive systems can usefully extend the reach and application of structured feedback, enable asynchronous engagement, and support faculty in tracking individual student progress, but only when these systems and tools are deployed in support of sustained relational continuity rather than as substitutes for it. The hybrid configurations sketched above (analytics as prompts for human outreach, automation of the routine in service of the relational) offer concrete design patterns for this partnership. There is also a developmental dimension to this principle: self-regulated learning (the capacity to direct one's own learning over time) is itself learned, primarily through observation, social guidance, and progressively independent practice (Zimmerman, 2002). Adaptive systems that calibrate pacing, sequence difficulty, and deliver correction on the learner's behalf may produce strong engagement metrics while bypassing the scaffolding through which self-regulatory capacity actually develops (Reich, 2020). This concern is particularly pronounced in doctoral education, where the transition to independent scholarly work is precisely where students without adequate support falter (Lovitts, 2001).

Second, equity-mindedness must be embedded in design processes from the start, not assessed or integrated after work has begun. Designers can apply Bensimon's (2024) framework through a modified version of her

critical questions. Drawing on her approach asking practitioners to interrogate whether commonplace practices "*perpetuate racist outcomes*" or "*build on the experience of whiteness*" (p. 3), and on Yosso's (2005) framework for recognizing community cultural wealth, designers can ask parallel questions about the systems they build: Whose experiences are represented in the materials and training data? Whose patterns are normative in the algorithms and whose are not? What forms of student experience are systematically invisible to this system? Asking these questions during design is qualitatively (and importantly) different from auditing for bias or equitable practice after implementation.

Third, the quality conditions of HIPs (Kuh & O'Donnell, 2013) should function as design guidelines for evaluating any technology-mediated learning experience. Does the technology support substantive faculty-student interaction or undermine it? Does it enable structured reflection or replace it (intentionally or inadvertently)? Does it facilitate public demonstration of competence? These questions reframe the design question from "*what can this technology do*?" to "*what does this technology do to support the relational conditions that produce equitable outcomes?*"

The illustrative case demonstrates these principles in both directions: technology extended relational infrastructure when deployed in its service (citation and analysis tools under sustained chair guidance; the pandemic-era shift to online modality preserving access), and fell short precisely where it was asked to substitute for contextual knowledge. Technology earns its place in equity-centered design when it augments the relational infrastructure HIPs research identifies as constitutive of equitable outcomes, and forfeits that place when asked to stand in for it.

IMPLICATIONS FOR INSTITUTIONAL LEADERS AND POLICY ARCHITECTS

A prevailing position around application of intelligent technologies in Education 4.0 implementation is that they are cost-reduction strategies that replace labor-intensive instruction with scalable automation. This analysis reframes that question. The HIPs literature suggests that position is backward for the populations Education 4.0 claims to serve. Kuh et al. (2017) document that HIPs are costlier per credit hour than standard instruction but more cost-effective per completion for the populations who benefit from HIPs most, including first-generation students, students of color, and others for whom relational infrastructure is constitutive of access. Institutional leaders considering Education 4.0 implementation as a cost-reduction strategy may then exacerbate equity gaps rather than mitigating them. The task for leadership is to resist this framing and invest in the necessary relational infrastructure identified by the HIPs literature as essential. This includes faculty time, mentoring capacity, sustained advising relationships, and structured peer engagement, among other opportunities.

The implications are even more stark for policy architects. Initiatives (including at the federal, state, and institutional levels) must build accountability metrics that go beyond measuring the deployment of intelligent technologies and capture the conditions under which equitable outcomes are produced. Disaggregated outcome data, faculty-to-student ratios, evidence of structured mentoring, and indicators of institutional investment in faculty/educational development should anchor accountability frameworks alongside (or in place of) metrics tracking technology adoption. Without accountability infrastructure, policy will continue to incentivize the technological investments that are easy to measure while leaving the relational investments that actually produce equity unfunded and undocumented.

Equity-Centered Intelligent Ecosystems in Practice

Taken together, these implications suggest that an equity-centered intelligent learning ecosystem is not, at its core, a technological achievement. Rather, it is an institutional achievement that uses intelligent technology as one element among many. At its center is what this paper has called relational infrastructure: the operational elements, recognizable from the HIPs literature, through which equitable learning is actually produced. These include substantive faculty-student relationships sustained over time; structured peer engagement around shared scholarly work; feedback that is responsive to student context as well as to student work; institutional flexibility to accommodate the realities of working adult learners, caregivers, first-generation students, and post-traditional students; and explicit institutional commitment to disaggregating outcomes and interrogating practice for the racial, gendered, and class-based consequences that "*race-neutral*" systems otherwise ignore.

Within this institutional infrastructure, intelligent technologies can play a meaningful role: extending the reach of structured feedback, supporting faculty in tracking student progress, enabling asynchronous collaboration across distance, providing learners with tools that augment their own scholarly work. What they cannot do, and what they should not be asked to do, is substitute for the relational and structural infrastructure that HIPs research, equity-mindedness scholarship, and the case shared here demonstrate to be the actual conditions of equitable doctoral education.

CONCLUSION

Education 4.0 frameworks promise an educational future built on intelligent personalization, adaptive pathways, and competency-based credentialing; this is a vision aligned, in principle, with Barnett's (2004) argument that higher education must prepare students for "*an unknown future*" that no fixed curriculum can anticipate. This promise is incomplete in a way that matters. Equity, as the high-impact practices, equity-mindedness, and community cultural wealth literatures make clear, is not an emergent property of intelligent systems attending to learners individually. It is a structural and relational achievement that is dependent on conditions that algorithmic personalization is poorly positioned to recognize, let alone construct.

This is demonstrated through three decades of educational technology research. From Attewell's (2001) foundational discussion of the second digital divide through Reich's (2020) synthesis of learning-at-scale evidence, and Williamson et al.'s (2020) analysis of the pandemic-era pivot to digital learning, this pattern is consistent: educational technology, deployed without attention to the surrounding social, cultural, and institutional infrastructure, reproduces rather than transforms embedded systemic inequities. This is precisely the pattern within which Education 4.0 operates, despite efforts by its proponents to wrap it in inclusive rhetoric. Education 4.0 treats access as a binary, and personalization as simple technical achievement, and contends that equity will automatically follow from intelligent design. None of these assumptions holds up to empirical scrutiny.

The high-impact practices literature tells a different story, using a different vocabulary and sound theory of what equity requires. HIPs research identifies eight specific quality conditions (sustained relational engagement, structured peer interaction, contextually responsive feedback, opportunities for reflection and integration, public demonstration of competence, among others) (Kuh & O'Donnell, 2013) under which equitable outcomes are measurably produced. These conditions are not superficial, nor can they be implemented by simply labeling something "*high-impact practice*." They represent educational infrastructure that must be intentionally constructed, resourced, and sustained over time. HIPs are relational, structural, and labor-intensive. They are not automatable. And they are exactly the conditions under which the community cultural wealth that students from marginalized communities bring to higher education (Yosso, 2005) becomes recognized and educationally generative.

The illustrative case presented here grounds these claims in a particular institutional and demographic context. At a Hispanic-Serving Institution serving predominantly first-generation, working-adult, and minoritized doctoral students, a design built around sustained one-on-one chair support and a cross-cohort dissertation learning community produced not only completion but the capacity in former participants to construct similar conditions of support for the students they subsequently serve. Participants' own retrospective accounts converge on a single conclusion: the dimensions of support that mattered most were precisely those that could not have been delivered by an automated or standardized system, because their effectiveness depended on contextual judgment, sustained relationship, and recognition of the full circumstances within which doctoral work was occurring. The case is illustrative rather than exhaustive, but it concretizes a more general claim drawn from the broader HIPs and equity-mindedness literatures: that relational infrastructure is not an inefficiency to be optimized away under Education 4.0 logics but the condition under which equitable outcomes are actually produced.

The implications are clear for both institutional and instructional design. Education 4.0 must treat faculty/educational development and departmental capacity as prerequisite infrastructure rather than as a later consideration, must integrate equity-mindedness into design from the start rather than when bias arises, and must resist over-focusing on the cost-reduction framing that substitutes algorithmic personalization for the relational infrastructure that research has shown actually produces equitable outcomes. When and where intelligent technologies are deployed, they should supplement rather than replace the structural and relational conditions HIPs research has demonstrated are essential. The opportunity for leaders is not to choose between intelligent systems and equitable outcomes, but to recognize that intelligent systems cannot deliver equitable outcomes without the infrastructure under which equity is actually produced.

This argument is offered with full awareness of the structural and political pressures under which institutional decisions about Education 4.0 implementation are being made. Budget constraints, declining enrollment in some sectors, the proliferation of generative AI tools, and policy environments increasingly oriented toward technological metrics of innovation are real and consequential. None of these pressures, however, alters the empirical record on what produces equitable outcomes for the populations Education 4.0 frameworks most prominently invoke as their beneficiaries. The risk of treating relational infrastructure as a luxury rather than a foundation is not abstract: it is the risk of deploying intelligent systems in service of the same patterns of differential opportunity that have shaped every previous wave of educational technology. The empirical record gives no reason to expect that this wave will be different unless institutions deliberately make it so.

Bonfield and colleagues (2020) framed their inquiry into Education 4.0 with a question: is it transformation, or evolution? The evidence offered in this paper suggests that the answer to that question depends less on what technologies are adopted by institutions, and much more on the infrastructure they choose to build around those technologies. Without the conditions HIPs scholarship identifies as constitutive of equitable learning, the cognitive frame Bensimon's equity-mindedness work demands of practitioners, and the recognition of community cultural wealth that Yosso's framework insists institutions extend to the students they enroll, Education 4.0 will reproduce the persistent inequities of every previous wave of educational technology. With those conditions in place, intelligent ecosystems may yet contribute to a higher education landscape that is not merely intelligent, but just.

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REFERENCES

Attewell, P. (2001). Comment: The first and second digital divides. *Sociology of Education*, *74*(3), 252-259. https://doi.org/10.2307/2673277

Baldrich, K., Pérez-García, C., & Santamarina-Sancho, M. (2025). Artificial intelligence in academic literacy: Empirical evidence on reading and writing practices in higher education. *Frontiers in Education, 10*, Article 1701238. https://doi.org/10.3389/feduc.2025.1701238

Barnett, R. (2004). Learning for an unknown future. *Higher Education Research & Development*, *23*(3), 247-260. https://doi.org/10.1080/0729436042000235382

Bensimon, E. M. (2018). The remaking of my research practice: From creating knowledge to creating equity-minded competence. In A. Kezar, Y. Drivalas, & J. A. Kitchen (Eds.), *Envisioning public scholarship for our time: Models for higher education researchers* (pp. 78–90). Stylus. https://www.routledge.com/Envisioning-Public-Scholarship-for-Our-Time-Models-for-Higher-Education-Researchers/Kezar-Drivalas-Kitchen/p/book/9781620367766

Bensimon, E. M. (2024). What is equity-mindedness? *USC Center for Urban Education*. https://cue.usc.edu/equity/equity-mindedness

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education*, *17*, Article 2. https://doi.org/10.1186/s41239-019-0176-8

Bonfield, C. A., Salter, M., Longmuir, A., Benson, M., & Adachi, C. (2020). Transformation or evolution? Education 4.0, teaching and learning in the digital age. *Higher Education Pedagogies*, *5*(1), 223-246. https://doi.org/10.1080/23752696.2020.1816847

Droog, A. A., Weaver, K. D., & Brady, F. (2024). Along for the journey: Graduate student perceptions of research. *College & Research Libraries*, *85*(6), 826-852. https://doi.org/10.5860/crl.85.6.826

Finley, A., & McNair, T. (2013). *Assessing underserved students' engagement in high-impact practice with an assessing equity in high-impact practices toolkit*. Association of American Colleges and Universities. https://files.eric.ed.gov/fulltext/ED582014.pdf

Golde, C. M. (2005). The role of the department and discipline in doctoral student attrition: Lessons from four departments. *The Journal of Higher Education*, *76*(6), 669-700. http://dx.doi.org/10.1353/jhe.2005.0039

Hase, S., & Kenyon, C. (Eds.). (2013). *Self-determined learning: Heutagogy in action*. A & C Black. https://www.bloomsbury.com/us/selfdetermined-learning-9781441142771/

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*(8), 952-984. https://doi.org/10.1002/tea.20439

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92-98. http://dx.doi.org/10.7575/aiac.ijels.v.6n.3p.92

Kezar, A. (2001). Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations. *ASHE-ERIC Higher Education Report, 28*(4), 1-8. https://files.eric.ed.gov/fulltext/ED457763.pdf

Kezar, A. (2005). What campuses need to know about organizational learning and the learning organization. *New Directions for Higher Education*, *2005*(131), 7-22. https://doi.org/10.1002/he.183

Kezar, A., Gehrke, S., & Elrod, S. (2015). Implicit theories of change as a barrier to change on college campuses: An examination of STEM reform. *The Review of Higher Education, 38*(4), 479-506. https://doi.org/10.1353/rhe.2015.0026

Kuh, G. D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Association of American Colleges and Universities. https://books.google.com/books/about/High_impact_Educational_Practices.html?id=j-QlAQAAIAAJ

Kuh, G. D., & O'Donnell, K. (2013). *Ensuring quality & taking high-impact practices to scale*. Association of American Colleges and Universities. https://books.google.com/books/about/Ensuring_Quality_Taking_High_impact_Prac.html?id=JhGpngEACAAJ

Kuh, G.D., O'Donnell, K., & Schneider, C. G. (2017). HIPs at ten. *Change: The Magazine of Higher Learning*, *49*(5), 8-16. https://doi.org/10.1080/00091383.2017.1366805

Lovitts, B. E. (2001). *Leaving the ivory tower: The causes and consequences of departure from doctoral study*. Rowman & Littlefield. https://eric.ed.gov/?id=ED462026

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson. https://www.pearson.com/content/dam/one-dot-com/one-dot-com/global/Files/about-pearson/innovation/open-ideas/IntelligenceUnleashedSPANISH.pdf

Miranda, J., Navarrete, C., Noguez, J., Molina-Espinosa, J. M., Ramírez-Montoya, M. S., Navarro-Tuch, S. A., Bustamante-Bello, M. R., Rosas-Fernández, J. B., & Molina, A. (2021). The core components of education 4.0 in higher education: Three case studies in engineering education. *Computers & Electrical Engineering*, *93*, Article 107278. https://doi.org/10.1016/j.compeleceng.2021.107278

Nasir, N. S., Lee, C. D., Pea, R., & McKinney de Royston, M. (Eds.). (2020). *Handbook of the cultural foundations of learning*. Routledge. https://doi.org/10.4324/9780203774977

Reich, J. (2020). *Failure to disrupt: Why technology alone can't transform education*. Harvard University Press. https://www.hup.harvard.edu/books/9780674278684

Rivard, J. K., Wilson, V., Alexander, M., & Pang, J. (2026). Mentorship for agency: A co-constructed case study of doctoral students as partners in course development. *International Journal for Students as Partners*, *10*(1), 322-331. https://doi.org/10.15173/ijsap.v10i1.6080

Selwyn, N. (2016). *Is technology good for education?* John Wiley & Sons. https://www.wiley.com/en-gb/shop/cultural-studies-general/is-technology-good-for-education-p-9780745696461

Snijders, I., Wijnia, L., Kuiper, R. M., Rikers, R. M., & Loyens, S. M. (2022). Relationship quality in higher education and the interplay with student engagement and loyalty. *British Journal of Educational Psychology*, *92*(2), 425-446. https://doi.org/10.1111/bjep.12455

Williamson, B., Eynon, R., & Potter, J. (2020). Pandemic politics, pedagogies and practices: Digital technologies and distance education during the coronavirus emergency. *Learning, Media and Technology, 45*(2), 107–114. https://doi.org/10.1080/17439884.2020.1761641

World Economic Forum. (2020). Schools of the future: Defining new models of education for the fourth industrial revolution. *Platform for Shaping the Future of the New Economy and Society*. https://www.weforum.org/publications/schools-of-the-future-defining-new-models-of-education-for-the-fourth-industrial-revolution/

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, *8*(1), 69-91. https://doi.org/10.1080/1361332052000341006

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1), Article 39. https://doi.org/10.1186/s41239-019-0171-0

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, *41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2