ICT4D and Education: Challenges, Opportunities, and Evidence from the Global South

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Article

ICT4D and Education: Challenges, Opportunities, and Evidence from the Global South

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Abstract

Information and Communication Technology for Development (ICT4D) initiatives are of critical significance in addressing socio-economic development challenges in the developing world. Within the wide ICT4D theme, education is a central sector to develop human capital, provide universal access to knowledge, and enable people with knowledge and skills for an evolving global economy. This paper provides a critical evaluation of ICT4D solutions for education in the developing world. Taking a qualitative case study perspective, it examines the One Laptop Per Child (OLPC) and Kenya's Digital Learning Program (DLP) with a view to deriving valuable lessons. The conclusions emphasize the point that successful integration of ICT calls for an integrated, context-oriented approach to infrastructure, teacher professional development, suitable content, sound financing, and strong political will.

Keywords: ICT4D; digital learning program; education; One Laptop Per Child (OLPC); teacher professional development

1. Introduction

Information and Communication Technologies for Development (ICT4D) initiatives are a concerted attempt to leverage technological innovation in addressing very grave socio-economic issues, particularly in the Global South (Ooko & Cheptegei, 2025). Education is just one of the several areas where ICT4D can make a revolutionary impact. Its significance comes from the capacity to develop human capital, open up education for knowledge to all, and equip individuals with the competencies required to thrive in a fast-digitized and interconnected world (Goosen, n.d.; Heeks, 2017; Ndulo & Assié-Lumumba, 2020). This paper undertakes a critical examination of the various challenges and the profound opportunities of merging ICT4D solutions into the education sector. The particular contexts and specific urgencies of the Third World are the primary focus, with empirical findings based on close studies of key case studies.

2. ICT4D Implementation Issues in Education

Implementation of ICT4D within education systems in less developed countries is a complex and interdependent mesh of long-term issues (Bon, 2020; Heeks, 2017). Despite the fact that there is vast scope for technological innovation to close education divides and enable inclusive learning, certain structural, institutional, and socio-cultural issues still constrain realization of ICT4D goals within education systems (Paul Oduor Oyile & Alice Wechuli Nambiro, 2025). We shall discuss these challenges in the sections that follow.

2.1. Poor Infrastructure and Connectivity

One of the fundamental ICT integration issues in much of the developing world is the existence of poor infrastructure (Rana & Rana, 2020). Poverty-stricken rural communities have schools located

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in areas where electricity is nonexistent, where the power supply is erratic, and broadband internet is unavailable. Even in places where access to such basic hardware as computers or tablets is available, their utility is highly diminished by the lack of network capabilities and supporting technical infrastructure. These restrictions narrow access to web-based learning content, online classrooms, and cloud computing learning environments, effectively excluding students who can least afford online access. Thus, not only does the digital divide persist but also increase educational imbalance between rural communities and towns. From personal experience, I have online students from Mandera and Wajir in Kenya who undergo these challenges.

2.2. Teachers' Digital Illiteracy and Lack of Training

Teachers are key to effective technology integration into the teaching process. Nevertheless, it is a fact that most teachers in the Global South are not adequately digitally literate and pedagogically trained to integrate ICT into daily practice (Chama & A, 2023; Rana & Rana, 2020). Limited access to ICT tools, added to inadequate or poorly designed professional development opportunities, usually manifests itself as low self-efficacy and aversion to new technology adoption. Training, even if made available, tends to be too brief, too theoretical, or unrelated to classroom practice needs for teachers. Technology is thus not used sufficiently or inappropriately, which reinforces rather than disrupts traditional pedagogy.

2.3. Inadequate Contextually Appropriate Content

Another key hindrance to the effectiveness of ICT4D within education is the non-availability of sufficient digital content that is culturally and linguistically appropriate for local environments. The majority of free Web-based educational content is Eurocentric and potentially not sufficient for local curricula, languages, and socio-cultural environments. Employment of foreign paradigms of education has the potential to dis-alienate learners, discourage motivation, and limit the applicability of learned knowledge to local problems. Further, digital content localization encompasses content production in collaboration with content producers, lecturers, linguists, and policymakers—a process that repeatedly underfinances and under prioritizes itself.

2.4. Project Duration and Budgetary Constraints

ICT4D initiatives involve such massive expenditures of money—not necessarily for the initial hardware and software acquisition, but also for ongoing operational costs such as maintenance, training, upgrades, and internet subscription costs. Most education ministries in the developing world have limited budgets and rely too heavily on donor funds and external aid to maintain ICT programs. This dependence often arrives in the form of short pilot interventions with little or no scalability and sustainability potential. The programs fail when donor monies are removed because there are no locally funded fiscal institutions and institutional ownership (*Beyond Sustainability*, n.d.).

2.5. Insufficient Technical Support and Maintenance Infrastructure

Successful adoption of digital technologies in schools involves fast and trustworthy technical support. But in the majority of low-resource environments, there is no access to trained technicians, spare components, and logistic systems for ICT infrastructure maintenance (Mhlongo et al., 2023). If the equipment breaks down—as it must—then the equipment is out of warranty for long stretches of time, making it impossible to get anything fixed, and ICT investments become less than useless. Lack of localized, responsive maintenance services does not only discourage educators from relying on technology but also confirms the perception that ICT investments are wasteful or unsustainable.

2.6. Obstacles to Pedagogic Change and Curriculum Integration

It does not automatically mean that with the introduction of technology into classrooms, there will be enhanced learning. Its successful use in schools requires integration into the national

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curriculum and a pedagogic shift towards critical thinking, teamwork, and active learning pedagogies. Most of the education systems of developing countries are institutionally bound by examination-testing and lack sufficient room for experiment and innovation (Dron, 2023). Without explicit guidelines on how to use ICT meaningfully to exercise pedagogy and learning objectives, technology is merely a gloss or ornamentation but not an agent of transformation (Timotheou et al., 2023).

2.7. Institutional Fragmentation and Policy Incoherence

In addition, ICT4D initiatives are also principally plagued by disjointed national policies and institutional disarray. Different players—donors, government ministries, NGOs, and private sector entities—operate in glorious isolation, leading to duplication of effort, wastage of resources, and poor quality. Absence of strategic overarches weakens the potential for monitoring progress, assessing impact, and harmonizing with overall education and development strategies. Governance, inter-agency coordination, and policy harmonization are therefore key to effective scaling and institutionalization of ICT4D in education (*The Role of E-Governance in the Search for African Solutions for African Problems*, n.d.).

3. ICT4D Solutions in Education Opportunities

There are opportunities that ICT4D education can tap to enhance the learning effectiveness performance, increase educational inclusion, and consolidate education systems in the developing world (Ojo & Olugbade, 2024). Implemented inclusively and strategically, ICT4D solutions offer an opportunity to break the system barriers of education disparity and enhance socio-economic development. The key opportunities are:

3.1. Broadening Access to Education

One of the strongest contributions ICT4D provides to education is to free access to education from the traditional classroom setting (Seegobin, 2024). Through online courses, and distance learning courses, ICT allows students in remote, rural, or war-torn areas to access education on reasonable terms. E-learning platforms such as Kolibri, Eneza Education, and others have demonstrated that learning can be brought to the learners regardless of geographical or infrastructural barriers in an effort to close the digital divide when coupled with the enabling infrastructure and mobilization of the community (Kadibagil et al., 2024).

3.2. Enhancing Teaching and Learning Achievements

ICT instruments facilitate the possibility of having innovative pedagogies, which enhance learner engagement, motivation, and learning. Multimedia interactives, simulations, and virtual labs accommodate diverse learning styles through self-paced and individualized learning. Furthermore, tools like learning management systems (LMS), intelligent tutoring systems, and formative assessment tools allow teachers to customize instruction to suit the needs of individual students. Information generated from these sites allows teachers to monitor in real time and respond accordingly, thereby enhancing academic performance and learner persistence (Mugizi & Nagasha, 2024).

3.3. Supporting Teacher Professional Development

Digital technology is at the forefront in facilitating CPD among educators, particularly where it is not possible to undertake face-to-face training (Alsaleh, 2023). Capacity development opportunities, best practices sharing, and access to pedagogical materials equitable in nature are obtained by teachers through online learning courses, webinars, and educator professional learning groups. MOOCs and mobile learning apps provide scalable, flexible, and inexpensive ways of

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building teacher capability, thus making quality provision of education accessible (Cvetković, 2022) (UNESCO, 2021).

3.4. Strengthening Inclusive Education

ICT4D has great potential to foster inclusive education by meeting the learning needs of disadvantaged socio-economic students and students with disabilities (Achieng & Mlitwa (Mlita), 2024). Assistive technologies such as screen readers, speech-to-text applications, and interactive learning software can provide equal opportunity for visually impaired, hearing-impaired, or mentally impaired learners to learn more on an equal basis. Moreover, online spaces can be designed to reverse gender disparities, linguistic differences, and cultural differences and thus facilitate equitable participation in learning exercises (Maguvhe et al., 2021).

3.5. Improving Education Governance and Management

ICT enhances education management and governance through the utilization of electronic data-gathering systems, Education Management Information Systems (EMIS), and real-time dashboards for evidence-informed policymaking. These systems increase accountability, optimize the use of available resources, and facilitate transparency in all the levels of administration within the education system. For instance, biometric attendance systems and mobile reporting systems eliminate absenteeism and improve supervision of rural schools by urban areas (Annapareddy, 2025).

3.6. Facilitating Lifelong Learning and Skills Development

Lifelong learning is paramount in the changing world economy. ICT-supported systems facilitate lifelong learning with possible access to vocational skills, digital literacy, and micro-credentialing. These facilitate young people and adults to acquire relevant 21st-century competencies such as coding, entrepreneurship, and critical thinking—competencies to interact with the digital economy as well as enhance employability in the formal and informal economies (Poquet & de Laat, 2021).

3.7. Facilitating Resilient Education Systems

The global pandemic of COVID-19 helped to bring to the forefront the need for digital resilience in education. Those countries that had ICT-based education infrastructure did better in balancing disruption by using e-learning models. ICT4D applications are therefore a crisis-buffering application against shock—pandemics, natural hazards, or political instability—to achieve educational continuity and system responsiveness. Digital preparedness has thus become the leading support pillar of resilient and future-resilient schooling systems (Motz et al., 2023; Tarricone et al., 2021).

4. Case Studies (Lessons Learned)

4.1. Case Study 1: One Laptop Per Child (OLPC)

OLPC has been the most highly publicized and ambitious effort to date to bring ICT to the developing world's elementary school network. The project was created in 2005 by MIT Media Lab with the aim of transforming learning by giving each learner a low-cost, rugged, internet-enabled laptop—i.e., the XO laptop—to last through rough handling. The ideals were visionary in aiming to shrink or eliminate the digital divide and empower technology-facilitated constructivist, self-directed learning (Cueto et al., 2024; El- Halwani & Hallal, 2023).

The OLPC initiative was introduced in many countries with large-scale deployments in countries such as Peru, Rwanda, Uruguay, and Ethiopia. Peru's government distributed over 800,000 XO laptops to impoverished rural school children with minimal teacher training and little facilitating infrastructure. The deployment strategy was simple hardware delivery to the students, based on the assumption that exposure to the laptops would transform education itself.

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Regardless, OLPC outcomes were still uncertain and, in a few cases, disappointing. Certain elementary implementation issues were encountered. To begin with, infrastructural limitations—unreliable power supply, connectivity, and inadequate classroom infrastructure—discouraged serious laptop use by quite a considerable margin. Next, pedagogical competency and even technical proficiency among the majority of teachers were still inadequate to make use of the laptops for pedagogical ends. Hence, the laptops were bound to remain idle or be utilized for basic use rather than leveraging them in the spirit of enabling additional learning.

Further, the scholarly content preloaded on the computers never became synchronized with local syllabuses and languages and therefore, became less useful and effective. Studies such as Arns et al. (2012) indicated that the purchase of hardware was given top priority in most OLPC deployments, while the rest of the essentials, such as planning the curriculum, training teachers, and engaging the public, were left behind. Sustainability was also lacking with maintenance costs, replacement hardware, and program sustenance for the long term not even thought about for most countries.

OLPC provides a range of ICT4D lessons in education. First and foremost is the acknowledgment that technology alone will not improve learning outcomes. ICTs must be situated in an enabling environment such as adequate infrastructure, teacher training, culture-and-language-congruent content, and active engagement of local stakeholders and schools' communities. The OLPC experience teaches us that there must be a systemic, systems-level process followed in putting ICT solutions within the education system (Ezumah, 2020).

4.2. Case Study 2: Kenya's Digital Learning Program (DLP)

The Digital Learning Program (DLP) of Kenya, instituted in 2016, is a national flagship program aimed at realizing the national vision for the mainstreaming of Information and Communication Technology (ICT) in the country's public primary schools. The project was embedded in the broader Vision 2030 government development policy and had to transform teaching and learning by offering digital resources for students and teachers that enable competency-based learning. Unlike some other earlier foreign projects such as OLPC, Kenya's DLP was a proposal that was prepared as a multi-stakeholder public policy initiative involving infrastructure, digitization of content, building capacity in teachers, and institution building (Wairumbi, 2021).

The ultimate goal of the DLP was to put a learner digital device (LDD) in the hand of every public school student at the Standard One level—a computer tablet with digital learning content adapted to the national curriculum. The teacher digital devices (TDDs) were provided to the teachers, while the schools were given digital content servers, projectors, and power backup centers. It was rolled out under the leadership of the IT Authority following consultations with the Ministry of Education, Ministry of ICT, and other private stakeholders like local producers (Kyalo, 2021).

During the pilot phase, the DLP was extended to more than 22,000 primary schools and covered more than 1.2 million digital devices. The Kenya Institute of Curriculum Development (KICD) also developed digital content in Kiswahili and English languages and was intended to complement the new competency-based curriculum. Teacher training for professional growth was also part of the rollout plan and entailed thousands of teachers being certified in minimum ICT skills to facilitate digital pedagogy (Kiugu, 2020).

But the DLP faced some situational and practical constraints. First, there was hardly any ICT infrastructure in the majority of the rural schools due to the fact that it had a poor connection to electricity, inferior internet, and security issues. These limitations affected the equipment's usability and supportability. Second, when initial teacher education was provided, it was normally specialized and fragmented to promote deep pedagogical integration of ICT to learn in class. Moreover, teachers utilized the traditional means of teaching since they were not at ease or were not confident enough to employ computer-based tools (Kiarii, 2023; Kinoti, 2024).

Third, the sustainability of the DLP has also been questioned. Device failure, technical support unavailability, and lack of adequate plans for the retirement of older devices have been some of the

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challenges. Low device usage by some of the schools as a result of lack of follow-up training or regular mentorship of the teachers was observed. Budgetary and infrastructural constraints also impacted the program, hindering its full roll-out to all the target schools.

Despite such issues, Kenya's DLP has been an enormous success and has yielded some significant lessons. It determined that integration of ICTs needs to be contextualized as part of national educational goals and local environments. Local developed curriculum-based digital materials in indigenous languages was one of the major strengths that enabled contextualization. Secondly, stakeholder engagement by a cascade of stakeholders from local producers to schools allowed national ownership and capacity development.

The DLP states that successful ICT4D education initiatives should be addressed holistically, coupling hardware installation with large-scale teacher training, curriculum integration, infrastructure backup, and long-term financing agreements. Once all these are put together, computer-based learning strategies can become mighty tools of educational transformation, particularly in settings of resource limitations.

A comparative study between Kenya's Digital Learning Program (DLP) and One Laptop Per Child (OLPC) program documents universal patterns and system drivers for ICT4D program uptake in education. Regardless of geography, politics, or economies, both studies document verification of the need for a contextual and integrated framework to digital transformation in different learning environments.

Strongest of the keys to success is the availability of top-quality digital infrastructure. It is not simply a matter of getting access to electricity and reliability of internet service but using good-quality hardware and setting up the systems for frequent technical support and maintenance. Shortages of infrastructure—most acutely in rural and off-grid areas—narrowly limited the successful deployment of digital technology for OLPC and DLP. Without inclusive infrastructure, even the most effective ICT tools cannot have their desired impact.

Also high on the agenda is the delivery of interactive and in-depth teacher education. Teachers are the prime agents of pedagogic innovation, and they are the success or failure of technology-supported learning programs. Glimmerings of short-term length one-shot training like were observed in both case studies are insufficient. Otherwise, trainings must incorporate continuous professional improvement, mentoring, and peer learning mechanisms which will equip the teachers to focus on technical as well as pedagogic issues of the ICT adoption.

The second most important aspect is the development of contextually appropriate, curriculum-influenced digital content. In order to enable the value addition to learning achievement, the technology should be accompanied by content suited to learners' linguistic, cultural, and curriculum context. DLP was excellent in this regard through the development of content in English and Kiswahili at the Kenya Competency-Based Curriculum level, while OLPC project struggled with content suitability in implementation environments.

Second, there has also been an ongoing issue of sustainability of funds. ICT4D projects are usually launched with enormous initial capital costs but lack separate plans for long-term financial sustainability, for example, device replacement, software updating, and technical support funding. Similar to OLPC, the absence of planning for recurrent costs can undermine the scalability and sustainability of e-learning initiatives.

Finally, political will and ownership of people constitute the pillars of ICT4D effectiveness in education. Political will from the government guarantees policy persistence and resource mobilization, while institutionalization of people via conduciveness and ownership at the local level drives conduciveness up. DLP in Kenya was supported with unshakable political will by the Vision 2030 master plan that facilitated ICT institutionalization in the education policy. But each proposal is assuming that stakeholder engagement has to leap out of establishment and become married up with the monitoring, feedback, and governance processes.

Typically, the studies show that ICT4D initiatives must embrace adaptive, locally designed models of iterative learning, stakeholder interaction, and systemic integration. Initiatives without

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such interconnected variables will be transitive and disjointed, yielding little value in education at high cost. Ecosystem-oriented approaches are therefore required in shifting from technology-centered to shifting in making effective and sustainable contributions to education reform with ICT support.

5. Discussion

The cross-comparison between the One Laptop Per Child (OLPC) and Kenya's Digital Learning Program (DLP) offers penetrating insights into the dynamics of Information and Communication Technologies for Development (ICT4D) in education in the Global South. While both initiatives attempted to harness technology for educational transformation, their partial success and remaining challenges converge in a series of overarching, interconnected themes: robust infrastructure, large-scale teacher professional development, locally relevant digital content, viable funding models, and solid political will underpinned by enabling community support. These lessons from the case studies unequivocally suggest moving away from the technology-focused concept to the more encompassing, ecosystemic theory of digital education reform.

5.1. Interconnectedness of Root Cause Factors

The findings emphatically argue that the efficacy of ICT4D programs lies not in piecemeal interventions but in the synergy of these root cause factors. As abundantly demonstrated by both OLPC and DLP, weak infrastructure (i.e., erratic power supply, poor connectivity, and lack of technical support) is a deadly bottleneck. The most advanced digital technology becomes so much useless gadgetry if there is no solid infrastructure for its operation and maintenance. The "digital divide," traditionally defined as a lack of access to hardware, is compounded by this infrastructural lack, persisting inequalities in education, particularly in poor and rural areas.

Moreover, the success of even an opulently resourced technological initiative is essentially thwarted by a lack of teacher training and technical support. Both case studies confirmed that initial, often superficial, training sessions were insufficient to prepare teachers to use ICT effectively in teaching. Teachers, as frontline practitioners, require ongoing, practice-based professional development beyond the level of basic technical competence towards pedagogical innovation. Otherwise, technology becomes a cosmetic add-on rather than an engine for innovative teaching and improved learning. This is in line with the theme of the Global Education Monitoring Report (2023), which firmly positions teacher capacity at the forefront of effective technology use.

Contextually relevant digital content was a tall order. OLPC's content irrelevance was in sharp contrast with the more focused efforts of DLP to align digital content with the national curriculum and local languages. The juxtaposition brings out the fact that content created for use in Western contexts is not necessarily transferable to the unique socio-cultural balance and learning requirements of developing nations. Effective ICT4D involves significant investment in creating local content, done in liaison with subject experts, pedagogues, and cultural experts so that it is not only pedagogically appropriate but also culturally applicable (KICD, 2018).

5.2. The Need for Sustainability and Governance

Beyond day-to-day operational challenges, long-term sustainability in the funding models is necessary. Neither OLPC nor DLP managed to bridge the divide between the initial donor- or government-funded investment phase and self-funding models of maintenance, upgrades, and longer-term support. The syndrome of "pilotitis," whereby projects surf external funding for some time but fold when this runs out, is a reminder to everyone that longer-term costs and replacement cycles have to be built into programs at the outset. This requires several sources of funding and greater local ownership of ICT projects.

Finally, and not least, political will and civic engagement cannot be overstated. Kenya DLP was served well by the fact that it was aligned with the nation's Vision 2030, a great government support.

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The highest level of political will is most essential in the development of coherent national policies, enhancing inter-agency coordination, and guaranteeing needed resources. Yet, both cases also highlight the importance of grassroots-level involvement. community buy-in and participation are essential in order to obtain ownership, guarantee device safety, and ensure effective use beyond school hours. Without such commitment, good policy will stumble on failed implementation and a lack of local buy-in.

5.3. Towards Adaptive and Learner-Centered Models

Based on these observations, the argument is heavily in support of effective ICT4D programs embracing adaptive, locally relevant models. This means abandoning "one-size-fits-all" technological implementations and adopting adaptive models with the flexibility to flex to meet local and regional requirements. Such models must have a robust emphasis on iterative learning in order to allow programs to evolve dynamically in response to continuous monitoring, assessment, and stakeholder input. This is a strategy that goes beyond the simple "installation" of technology and the embracing of a culture of innovation and continuous betterment in education.

Finally, the goal of ICT4D in education cannot be merely deploying technology, but changing learning environments to be more inclusive, more interactive, and more relevant. This must be a student-led process where technology is an enabler of greater learning, critical thinking, and attaining 21st-century skills and not a goal in itself. Even as the ed-tech community evolves, the lessons of projects like OLPC and DLP are enough to push policymakers and practitioners to keep striving relentlessly towards developing strong, sustainable, and human-centered digital learning ecosystems in the Global South.

6. Conclusions and Recommendation

Using Information and Communication Technologies for Development (ICT4D) in education is a revolutionary approach to curbing the centuries-long gaps in education and improving the learning outcomes, particularly in the developing world. However, as has been experienced from case studies of the One Laptop Per Child (OLPC) project and the Digital Learning Program (DLP) in Kenya, the effectiveness of ICT4D interventions is not so much a matter of the availability of digital hardware or software, but a well-balanced model of infrastructure, human capacity, local content, governance, and planning for sustainability.

The OLPC project proved the hardware-centric approach to be limiting. Despite better intentions and mass coverage with hardware, the absence of teacher training, appropriate content, and good infrastructure adversely affected its long-term impact considerably. Kenya's DLP, even when it was more national curriculum objective-oriented and had more institutional support, was plagued by implementation issues in terms of a dearth of support infrastructure and sustainability. These instances highlight that technology will not address deep-rooted problems in education on its own without simultaneous investment in the whole education system.

It is therefore critical that developing countries implement adaptive and holistic ICT4D policies driven by continuous feedback and learning and based on local realities. ICT4D initiatives must put long-term sustainability at the forefront of the agenda, with successive investment in infrastructure upgrades, content updates, and teacher training. Furthermore, strategies should be inclusive, closing the digital divide across geography, socio-economic status, and gender so that no child remains behind in the digital age.

Policymakers, development partners, and institutions of education must be charged with the mandate of co-developing ICT4D systems that are not only technically feasible but also socially and pedagogically palatable. Political will, stakeholder engagement, and cross-sector partnership are critical in building a culture of digital literacy and innovation.

If inclusively and critically applied, ICT4D can influence 21st-century learning. ICT4D may be applied to increase equity, relevance, and the capacity of education systems to survive emerging

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global challenges. The future of learning in developing environments lies not in technology, but in our ability to apply that technology in a system that is inclusive, equitable, and learner-centered.

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