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Learning differences & digital equity in the classroom

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Abstract

This chapter addresses digital equity in the classroom for students with learning differences, as well as the role of technology in the provision of equitable education for the full diversity of students. The chapter discusses the evolving opportunities and challenges that information technology in the classroom presents to students with learning differences and their teachers.

To meaningfully understand this topic requires an understanding of the complex context, the forces at play, and their relation to students with learning differences. Among the forces at play are policies, regulations, the accessibility movement, technical trends, instructional design strategies, educational publishing, open educational resources, pedagogical trends, quality control approaches in education, and governance of formal education. The chapter highlights the benefits to all students of designing the classroom experience for students with learning differences.

Introduction

Todd Rose (Rose, 2015) in his book *The End of Average* amasses evidence that there is no average or typical student, that we all have learning differences. We are each a jagged, variable and evolving set of characteristics and skills. There is no one that fully conforms to the collective notion of average and individually we rarely conform to our notion of our typical selves.

Despite this insight, our formal education systems are still largely based on the industrial model of education: attempting to create standardized learners by socializing conformity, and then rating, ranking, sorting and thereby assigning the destinies of students. If our aim is to produce a standardized learner, learning differences become a problem.

This positioning of differences is counter to advanced understanding in other fields. Our formal system of education is slow to gain the insight that diversity is necessary for survival. Economists and natural scientists have long understood the importance of diversity and diversification for dynamic resiliency, and innovation. Even corporate cultures have integrated the insights of researchers such as Scott Page: that diverse perspectives make for better planning, problem solving, prediction and innovation (Page, 2007).

Students identified as having disabilities are at the extreme edges of the jagged scatterplot of difference. We assign the label of "disabled" when it is either impossible or extremely difficult to conform to standard expectations. As such these are the students that most feel the effects of educational inflexibility. Conversely, they may also be the greatest impetus for greater systemic adaptability, to the benefit of all students (Treviranus, 2016).

What is disability?

Conventional views of disability frame disability as an absolute and personally defining trait; and thereby divide the world into people with disabilities and people without disabilities. This is reinforced by services or exemptions for people with disabilities, which require certification of disability status (e.g., individual education plan, wheelchair accessible parking, funding programs for assistive technology)[1]. A definition of disability arising from the design domain contests this binary view. The definition frames disability as a mismatch between the needs of the person and the environment, product or service offered. In the realm of education this would be a mismatch between the needs of the learner and the learning experience offered. This implies that anyone can experience a disability if presented with a design that does not match their needs (Treviranus, 2014a).

Given that needs are personal and diverse, this also implies that it cannot be determined whether something is accessible until one takes into consideration the unique needs of the individual, their context and their goals. Accessibility is relative and evolving. All students potentially face barriers to learning. Like barriers faced by students with disabilities these can be seen as a product of a mismatch between the needs of the learner and the learning experience and environment. Learning needs that affect learning can include:

- sensory, motor, cognitive, emotional and social constraints,
- individual learning approaches,
- linguistic or cultural preferences,
- technical, financial or environmental constraints.

Using this framing, an accessible learning experience is a learning experience that matches the unique, diverse and evolving needs of each student.

Formal Education System and Impetus for Change

Our formal education system is a highly complex system of systems, in part constructed to buffer or resist external influences for change (Treviranus, 2016). The classroom itself is a complex system with connections and dependencies to many other nested and overlapping complex systems including the school administration, educational authorities, the digital technology industry, the publishing industry, parents, the local community, policy frameworks and sources of funding. Any fundamental change of the education system to adapt to learning differences at the edges of the jagged spectrum of student needs must take these nested and entangled systems into account.

Education as a Human Right

The formal education system has encountered many forces for change over the last fifty years. One precarious force is a nearly global commitment to education as a

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[1] https://www.ssa.gov/disability/professionals/bluebook/listing-impairments.htm

human right (e.g., the Salamanca statement with 95 nations as signatories, the Convention on the Rights of Persons with Disabilities)(Ainscow & Cesar, 2006; United Nations General Assembly, 2007). The commitment has yet to be kept. The response has been varied. One compromise has been to create segregated, separate systems of education for students with extreme differences. This has been countered with the social justice demand for integration (Dixon, 2005). The integration argument comes from the perspective of students that are excluded, but an equally cogent argument can be made from the perspective of the mainstream in that segregation denies the majority the positive influences for diversification, flexibility and adaptability. All students are different and benefit from education designed to support and nurture that difference. Society benefits when that difference can be leveraged to create more choices, provide more perspectives, find new competencies and see innovative approaches not considered before.

Digitization and Global Connectivity

Another hugely disruptive force, that has demonstrated the change-resistant nature of our formal education system, is the move to digitization and global connectivity. Beyond the buffer of our classroom walls, digital technology and connectivity have significantly changed the reality, or future, students are to be prepared for by education. Formulaic and standardized skills can be taken over by machines, computers generally have more accurate factual memories than people, and mechanistic calculation can be left to computing (National Research Council (U.S.). Committee on Defining Deeper Learning and 21st Century Skills. et al., 2012). At the same time collective, distributed production has never been easier, expertise is publicly available, and we are drowning in unfiltered information. Reduction through a popularity and affinity filter appear to be our primary means of synthesizing information and dealing with growing complexity; this has resulted in rising populism, tribalism and social fragmentation (Treviranus & Hockema, 2009).

Currently, there is a dawning understanding that as a society we need collaborators, critical thinkers and the skills and characteristics that machines do not address. One of these characteristics is the fostering of divergent skills, combined, and thereby multiplied, to address the complexity of our current global reality (Weigel, 2002). Our formal education systems appear to be structurally biased against answering this challenge. A positive transfer effect, of the demand to accommodate students with learning differences, may be to disrupt this structural bias and stretch our education systems to support and even foster diversity. Redesigning education to address the needs of students with learning differences logically benefits all students and society as a whole. Disability, often occupying the outer edges of difference, crosses all cultural, geographic, political, economic and age divides and touches all lives. Accessibility for students with disabilities is in everyone's interest.

The Opportunities and Challenges of Digitization and Global Connectivity

For students with learning differences digital systems and computer-mediated learning provide both an opportunity and a risk. If designed correctly these systems can unlock previously inaccessible learning experiences and overcome many barriers to access. However, if not designed inclusively these systems amplify and speed disparities between students that have digital equity and those who don't. These systems then not only feed into vicious cycles of exclusion but also exponentially amplify their effects.

Opportunities

When computers are configured to enable alternative means of presentation and alternative means of control, they act as powerful translation devices for students and teachers who cannot use the standard means of accomplishing academic tasks. Visual information and text can be translated into speech, sounds or tactile signals: through screen readers, refreshable Braille displays, or haptic interfaces, for example. A variety of voluntary actions can be translated into the equivalent of keyboard and mouse/trackpad input. These voluntary actions might include speech, pointing with your head or foot, or activation of switches through discreet movements of any body part, including blowing or sipping, contracting muscles or even through repeatable patterns of brain activity read by an electroencephalogram (EEG) device. For students who face barriers to traditional modes of engaging in academic activities, computers thereby act as a path to speaking, writing, reading, experimenting, manipulating learning materials and researching (Alper & Raharinirina, 2006).

Digital content is far more flexible and mutable than print. Many students experience what has been termed a "print impairment" that makes access to traditional printed curriculum difficult or impossible, including students who:

- cannot see print,
- have difficulty seeing print because of the size and contrast of standard print materials,
- have difficulty decoding text, and
- cannot hold and manipulate a physical book or page.

Digital learning materials, if designed correctly, offer many advantages (Thomson, Fichten, Havel, Budd, & Asuncion, 2015):

- text can be translated to speech for students that cannot see or decode text (e.g., students that are blind or have dyslexia),
- content can be magnified, spaced and presented in higher contrast for students that have difficulty seeing,
- distracting materials or complexity can be reduced or hidden for students that have difficulty with focus, and
- manipulation and navigation of content can be controlled through available alternative voluntary actions (e.g., head movements, vocal command, puff or sip, for students with paralysis or reduced dexterity).

Networks and global connectivity can connect students, teachers and parents, who have minority or outlying needs, with connections to others that share these needs. Global connectivity can also reduce redundant production of learning material variants (e.g., a text description of a visual graph or a text caption of a video). Global networks have been used to crowd-source and cooperatively create alternative formats such as captions of audio in videos for students that have difficulty hearing[2].

Rapid prototyping tools allow the rapid customization of physical materials and tools. These include holders, handles, stabilizers, switches, buttons, and device casings to make controls easier to hold and manipulate (Buehler, Hurst, & Hofmann, 2014). Internet of things sensors, monitors and actuators enable the creation of smart environments that can be responsive to diverse personal needs (e.g., controlling light, heat and security) (Domingo, 2012).

The major caveat to all these disruptive opportunities is: *if* designed correctly. The systems and their associated practices must be designed to support human diversity. To accomplish any of these potentially liberating functions, digital systems must support the flexible transformation, augmentation and replacement of both presentation (e.g., visual, through speech and sound, or tactile), and means of control, as well as the integration of scaffolds and supports. The design must acknowledge that humans are diverse, not typical or average.

Risks and Challenges

Since the emergence of personalized computers and the ubiquitous proliferation of network connectivity there have been numerous trends that have both threatened and promoted support for human diversity in the socio-technical ecosystem.

Some of the most change-resistant systemic threats are associated with traditional market models. A competitive market compels a producer to strive to address the largest customer base and to protect their hold on their market-share through proprietary practices. This is both antithetical to interoperability and excludes anyone who does not fit into the constrained boundary of the customer majority.

Supporting human diversity requires interoperability between the various components or parts in the socio-technical ecosystem (Treviranus, 2014a). The range and extent of diverse human requirements demands a plurality of developers and suppliers. The original designer, developer and producer cannot be expected or relied upon to anticipate or address all of the diverse human requirements. In as far as digital systems are modular and “mashable”, new, unanticipated, alternative interfaces or user experiences can be added or the existing ones can be adjusted or augmented. This requires open, transparent, commonly agreed upon protocols or open interoperability standards for software and hardware and open data formats. These provide the common meeting place from which the human interface can diverge.

Entities at the margins of a domain are the first to feel the effects of problems within a domain. Such is the case for the alternative computer access system (or assistive

2 http://amara.org/en/

technology) producers at the edge of the digital market. Most mainstream applications and devices are designed to address the needs of the typical customer. Assistive technology is relied upon to bridge the divide between the needs served by the standard product and the needs of people with disabilities. For students who can't use a standard computing device, they must acquire both the standard device and an assistive technology that more closely fits their unique needs.

The producers of these assistive technologies face two major challenges. Because they are serving a customer base that is more diverse than any other (the only common characteristic of disability is difference), if they do their job well they will have a relatively small customer base for any one design. At the same time they need to ensure that their product will interoperate with all of the applications, browsers, operating system utilities, and peripherals on the computing device their customers use. This means interoperating with a huge variety of frequently updated applications that may be mashups of many components, with difficult to determine provenance. To make matters worse most of the developers of these mainstream applications are reluctant to share information about how to interoperate with them. As a result the alternative access system industry is struggling, causing a limited supply in even the most well resourced countries. Because of limited supply, and public funding rules that restrict funding to only qualified vendors and products, alternative access systems available to students with disabilities are relatively expensive. The systems frequently suffer from interoperability problems meaning that many functions or applications are not available to students that rely on alternative access systems. Because of the technically and economically difficult market, there is a decrease in the alternatives available to students with needs at the edges of this already marginalized group, such as students that have severe motor limitations. As a result, it may cost more than 10 times as much for students with disabilities to get online (Khetarpal, 2014). Digital access is getting less expensive, faster, more reliable, more multi-function and more ubiquitously available for students that can use mainstream products. The opposite is often true if you have a disability and cannot use a standard access system. This produces a broadening technology gap that compounds the disparity these students already encounter.

Promising Trends

One promising trend that circumvents some of these limitations is when the manufacturers of the standard products include and integrate assistive technology features directly into their products. Examples of this include: the availability of screen reading functions in touch screen devices, voice recognition as a standard feature, and word prediction or character disambiguation in on-screen keyboards (Brunet & Ramachandran, 2016). Another promising trend is the availability of open source assistive technologies. This is especially beneficial to students in the many countries that do not have an assistive technology industry (Ptolomey, 2011).

Another very promising trend is the adoption of inclusive design as a corporate-wide design strategy, as has been exemplified by Microsoft Design[3]. Microsoft is leveraging the insights and innovations inherent in designing for and with people with disabilities to improve their products overall. The design team has adopted and advanced the inclusive design toolkit of the Inclusive Design Research Centre as an enterprise-wide strategy (Kuang, 2016). The trade press has suggested that this has helped to make Microsoft "cool again" (Anderson, 2016).

The ease of copying, that digital systems afford, has acted as a disruptive counter-force to proprietary systems that cater only to the typical consumer. This has created "zero marginal cost" markets for many commodities, including books and music; or replication and mass production with negligible cost after the first instance of a product (Rifkin, 2014). New market models, that leverage the diversity and innovation that comes from openness and interoperability, have emerged in the form of platforms that leave the creation of variants to the world at large (e.g., IOS apps, Android, YouTube, etc.). These provide ecosystems that enable diversification of designs, but also means of finding variants that fit unique needs.

The Promise and Challenges of Open Education Resources

This market tug-of-war has played out in the education domain in the form of competition between established educational publishers and nascent openly-licensed education resources or OER (Open Education Resources). OER provide greater equity for disadvantaged regions globally and students that are economically disadvantaged. OER are openly licensed to support what are referred to as the "5R Permissions of OER," the right to:

1. retain and make your own copies,
2. reuse in a wide range of ways
3. revise, adapt, modify and improve
4. remix by combining two or more, and
5. redistribute to share your contributions with others (Lumen Learning, 2014).

OER thereby offer the potential to create many variants and choices to match the variability and diversity of student needs. This same latitude and variety is not available to mass-produced, copyrights-protected traditional publishing.

Students who require alternative formats (and their parents and support services) report spending inordinate amounts of time and energy addressing digital rights management (DRM) restrictions that prevent the creation of variants and lock out the opportunity to translate from one modality to another (Whitehouse, 2008). While hard-won exemptions to DRM restrictions for students with print disabilities have been granted in certain markets (e.g., the Marrakesh Treaty) (Fitzpatrick, 2014), the burden to prove that a student has a disability and the parallel supply chain that is required to acquire an alternative format textbook result in an onerous process for an already taxed student and their support system. The open licenses of

3 https://www.microsoft.com/en-us/design/inclusive

OER would circumvent this complex and difficult means of acquiring accessible learning material.

The most acrimonious battlefield has been in the United States where educational publishing has been an extremely lucrative and well-entrenched market. In the primary and secondary grade market, large textbook publishers are aided by a highly competitive "textbook adoption" framework that structures competition for public funding in such a way that large profits are guaranteed to the winning textbooks and other choices are left with little support (Petrides, Jimes, Middleton - Detzner, Walling, & Weiss, 2011). Textbook adoption was enacted to promote, protect and curate the quality of textbooks that receive public funding. The design of the curriculum and textbook ecosystem then further entrenches this competitive advantage by granting management of textbook clearinghouses to these same winners in the adoption contest, thereby granting further advantage to the dominant publishers. Students with disabilities have been used as a "pawn" of sorts in this battle. To understand the complex role that students with disabilities have played in this struggle requires an understanding of regulatory frameworks that support accessibility.

Accessibility Regulations and Laws

Accessibility, or design that works for people with disabilities, is a precarious value: most people agree that it is important, but it is one of the first things to be compromised when other pressures arise, such as time and budget constraints. To protect this precarious value, progressive public institutions and governments have been compelled to create laws, regulations and policies that oblige accessibility. However, laws, regulations and policies are very blunt instruments. They are most effective in changing behavior when compliance can be easily tested using consistent, objective measures. Creating clear, concise, objectively testable criteria inevitably requires reduction and compromise. It does not lend itself to enumerating the broad, complex spectrum of diverse needs. Thus certain needs are inevitably left out or compromised.

The Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C) is the primary manifestation of the movement for digital equity for people with disabilities [4]. The Web Content Accessibility Guidelines (WCAG), one of three foundational sets of WAI guidelines, are embedded in laws, regulations and policies in many jurisdictions around the world. The WAI has produced and maintained three sets of guidelines:

1. **Web Content Accessibility Guidelines or WCAG 2.0** (Caldwell, Cooper, Guarino, & Vanderheiden, 2008), define how to make Web content more accessible to people with disabilities. The guidelines are divided into four overarching principles:

4 https://www.w3.org/WAI/

- **Perceivable** - Information and user interface components must be presentable to users in ways they can perceive. This means that users must be able to perceive the information being presented (it can't be invisible to all of their senses).
- **Operable** - User interface components and navigation must be operable. This means that users must be able to operate the interface (the interface cannot require interaction that a user cannot perform).
- **Understandable** - Information and the operation of user interface must be understandable. This means that users must be able to understand the information as well as the operation of the user interface (the content or operation cannot be beyond their understanding).
- **Robust** - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. This means that users must be able to access the content as technologies advance (as technologies and user agents evolve, the content should remain accessible).

Although the WCAG guidelines address barriers to accessibility in web content, they can be applied to all digital content. WCAG also includes useful techniques documents that demonstrate how to develop accessible multimedia content. Following these guidelines removes barriers to content and user interface transformation, making it possible to personalize Web delivered learning resources.

2. **The User Agent Accessibility Guidelines (UAAG) 1.0** (Jacobs, Gunderson & Hanson, 2002) and 2.0 in draft (Allan, Lowney, Patch, & Spellman, 2015) guide "developers in designing user agents that make the web more accessible to people with disabilities. User agents include browsers, browser extensions, media players, readers and other applications that render web content. A user agent that follows UAAG 2.0 will improve accessibility through its own user interface and its ability to communicate with other technologies, including assistive technologies."
3. **The Authoring Tool Accessibility Guidelines (ATAG) 2.0** (Richards, Spellman & Treviranus, 2015) provide information to web authoring tool developers about how to design tools that will produce accessible web sites as well as how to design authoring tools that have accessible interfaces. The purpose of these guidelines is to make it easier for web developers to produce accessible content even when they are not aware of or motivated to follow accessibility guidelines and to enable individuals with disabilities to participate in the construction of web content. Authoring tools that comply with the seven guidelines of the ATAG document can support accessible web authoring through prompts, alerts, checking and repair functions, help files and automated tools. Additionally, the authoring tool will be accessible to authors with disabilities. The goal of ATAG is to encourage development of accessible web content that reaches a broader, more diverse audience as well as enable individuals with disabilities to participate fully in web culture as active creators of content.

The Challenge of Enforceable Regulations

The simplest, most easily enforced, interpretation of accessibility is an absolute definition. Any relative framing leaves room for subjective interpretation and compromises compliance testing and enforcement. This creates a dilemma in the global community that supports digital inclusion for people with disabilities. Absolute criteria inevitably compromise or negate accessibility for individuals at the edges of the jagged spectrum of human needs, or individuals that don't fit established categories of needs (e.g., individuals with multiple disabilities, individuals with disabilities that don't as yet have an associated advocacy group). These individuals are therefore, also, most vulnerable to exclusion. On the other hand, relative criteria are largely impervious to enforcement. One approach to addressing this dilemma is to require interoperability, open standards and open formats and thereby protect the opportunity for diversification and enable the creation of variants. However, for companies that view accessibility as merely a legal risk and rely on closed, proprietary business practices, this demand for openness is seen as something to lobby against. The struggle for greater accessibility through regulations then becomes a battle of influence between established industry and advocates for excluded consumers.

Laws, regulations and policies are also slow to change. Therein lies a further dilemma for legally enforced digital inclusion. The pace of change in the digital domain is unprecedented. Survival within the digital market requires constant innovation and responsiveness to this change. Laws that constrain freedom of movement within this environment are seen as hostile to innovation and corporate survival. Many strategically wily corporations have walked the fine line of obstructing regulations without the public appearance of hostility to accessibility, and the associated public relations mistake of showing lack of concern for people with disabilities (Stienstra, Watzke, & Birch, 2007).

Diversity-Supportive Regulatory Design

Ironically therefore, movements to legally enforce digital inclusion have been pushed to support inflexibility and to oppose innovation. To support diverse learners requires flexibility. To address unmet needs requires innovation. Several promising alternative regulatory designs have emerged but these have not received the popular support that prescriptive accessibility checklists have received. One reason may be that popular support favors simple, literally graspable concepts rather than nuanced and indirect strategies.

Legislative strategies that are more diversity and innovation supportive include:

1. Providing a process to validate new strategies that achieve equivalent accessibility as the criteria in a regulation. This would facilitate innovative advances and would also provide a mechanism for updating the regulations.
2. Giving priority to strategic pivot points, or common meeting places that enable divergence and diversification, such as requiring open interoperability standards that allow alternative access systems to more

easily connect, and open formats that can be played on a variety of browsers and players.

3. Regulating a process that results in inclusive design rather than requiring a specific outcome. This would encompass prioritizing regulations that require that the tools used to create digital content and interfaces support designing for diversity. This approach would have the advantage of requiring compliance and understanding from a much smaller group of legally obligated entities, namely the developers of authoring tools rather than the myriad of Web content authors. An example of this strategy would be to give priority within the global Web Accessibility movement to authoring tool guidelines that represent the process, in contrast to Web content guidelines that represent the outcome or product.

Compounding the phenomenon that popular support favors simple and direct ideas, is the tendency to also favor immediate or short-term rewards. This combination may cause the bias against systemic interventions. System-wide interventions are more diffuse but afford far greater and more lasting impact. These interventions include:

- requiring education and training of future producers and suppliers to include an understanding and competency in designing for diversity,
- ensuring that currently excluded individuals can participate not only in the consumption but also in the production of knowledge and products, and
- requiring the participation of diverse perspectives in decision-making bodies that influence socio-technical directions.

Aligning Open Education Resources with Accessibility

The legislative compromises that the accessibility field has had to make, to create regulations that can be broadly understood and enforced, has meant that the accessibility movement has become misaligned with the OER movement. OER are a potentially powerful ally that favors diversity and the innovation that is birthed by variability in education. The OER ecosystem boosts flexibility and the more long-term systemic growth that supports the emergence of designs that span the spectra of human diversity. As far as OER provide a means to create a rich array of choices, and a process for finding satisfying choices for the full diversity of students, the OER ecosystem will offer more inclusive and long-term digital equity in education. The largely unregulated, organically organized, opportunistic OER production effort, however, does not naturally lend itself to absolute criteria. Publishers that see OER as a threat have used this to their advantage and have claimed that the adoption of OER in formal education systems should be disallowed because they do not adhere to accessibility laws. A simple response, that has yet to be formally articulated by the adjudicators of this struggle, is that compliance with accessibility requirements should be judged at the system level rather than the individual resource level. Thus if the pool of resources offers options for the full diversity of learners it is compliant with the accessibility requirements, and each resource does not need to meet all the fixed criteria. This would reduce the compromise that students, that don't fit defined categories or criteria, need to make. It would also support the innovation that comes from diversification.

This however requires a system that matches the diverse individual requirements of students with a satisfying resource or learning experience. Resourceful parents, educational assistants and teachers have been attempting to perform this function. OER portals such as OER Commons[5] and GOORU[6] have begun to integrate search features that stretch to the edge requirements of students with disabilities.

The FLOE Project[7] is helping to provision the OER ecosystem with an infrastructure or platform to deliver a learning experience that matches the needs of students with learning differences. FLOE aims to use the platform model to pool and share reusable resources and supportive tools that enable a growing, diverse global community to create a rich pool of learning experience variants. To achieve this ambitious goal requires OER resources that are amenable to reuse and a large, diverse pool of OERs. If the default OER is inaccessible to a specific student the inclusively designed system would either:

a) transform the resource (e.g., through styling mechanisms),
b) augment the resource (e.g., by adding captioning to video), or
c) replace the resource with another resource that addresses the same learning goals but matches the learner's specific access needs.

To achieve this functionality requires:

- utilities that help learners discover, explore, refine and declare their learner preferences (thereby also supporting learning-to-learn and metacognition)
- markup, metadata or algorithmic means of locating resources that match specific learner needs or preferences
- a private and secure means of storing and transporting personal learner preference files from one learning experience to the next
- a matching service that can reconfigure, augment or search and find a resource that matches a learner's preference specifications
- supports to help OER producers to create reconfigurable resources and provide helpful metadata regarding the learner preferences the resource can match. Ideally these supports should be embedded in the tools used to create OER.

The FLOE project has created the necessary pluggable building blocks that are being integrated into projects that deliver OER. Fortuitously these steps are not foreign to the OER effort but can be seen as impetus to advance the OER agenda as a whole. However this approach is helped by conceptual and practical adjustments in both

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5 https://www.oercommons.org

6 https://www.gooru.org/welcome/

7 http://floeproject.org

the OER and Accessibility communities. The approach requires that the OER community:

- fully adopt and support the principles of cumulative authoring, derivative works, reuse and repurposing that is already a part of the OER mantra,
- improve learner-focused resource discovery and the prerequisite labeling,
- promote an authoring attitude that lets go of the tight control on a fixed presentation or rendering,
- invest further in a learner-centric approach to resource design,
- commit to support open interoperability standards for both file formats and programming/scripting environments,
- support open source tools with open communication protocols to enable interoperability with assistive technologies, and
- improve portability or device independence of resources.

The Accessibility community must:

- adjust the interpretation and implementation of accessibility legislation and policy to judge accessibility by the ability of the system (rather than each resource) to address the individual needs of each student; notably this does not require that the letter or spirit of existing legislation be changed only the interpretation and implementation,
- recognize that OER are a viable alternative to the complex, confounding and deeply entrenched Digital Rights Management conundrum that is consuming so much accessibility effort and passion,
- let go of the focus on equivalent content and focus on equivalent learning, and
- recognize that in the digital realm it is possible and effective to shift from a one-size-fits-all to a one-size-fits-one approach to providing universal access.

A growing community of interest in OER accessibility, including the FLOE Project partners, supports this shift in both communities through practical tools, advocacy and education.

The following diagram provides an overview of the FLOE process and infrastructure:

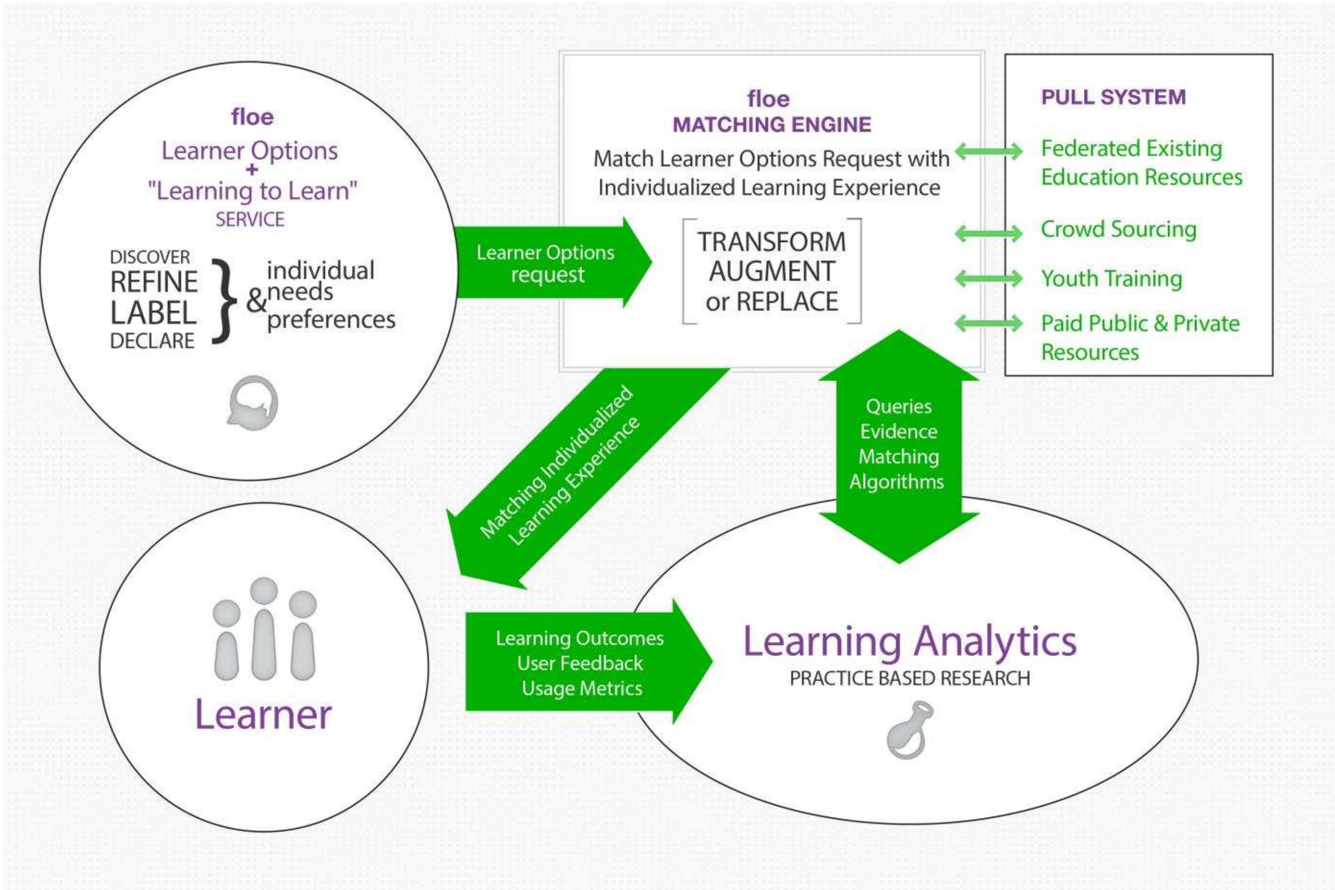

Figure 1: *The FLOE ecosystem enables the learner to refine their understanding of their needs and preferences, request a matching resource, and provide feedback regarding the match provided. This feedback provides important evidence regarding what works for learners who are outliers.*

FLOE leverages an international interoperability standard called AccessForAll. This is expressed both as an International Organization for Standardization (ISO) standard, (ISO/IEC 24751)[8] and an IMS specification (IMS AccessForAll) (Jackl, Treviranus, & Roberts, 2004). AccessForAll supports a common language for describing personal needs and preferences (or student accessibility requirements) and a common language for describing resources that might match the needs and preferences.

Diversity Supportive Pedagogy

Several pedagogical movements assist in the changes required by the individualized AccessForAll approach to learning design. AccessForAll and FLOE are well aligned with pedagogical models that support accessibility and equity such as Universal Design for Learning (UDL) (D. Rose, 2000) and Differentiated Learning. UDL promotes three principles:

[8] http://www.iso.org/iso/catalogue_detail?csnumber=41521

- Principle I: Provide Multiple Means of Representation (the "what" of learning). This addresses perception, language, expressions and symbols and comprehension.
- Principle II: Provide Multiple Means of Action and Expression (the "how" of learning). This addresses physical action, expression and communication, and executive function.
- Principle III: Provide Multiple Means of Engagement (the "why" of learning). This addresses recruiting interest, sustaining effort and persistence and self-regulation.

FLOE can be said to be the network-enabled instantiation of these pedagogical frameworks.

Personalization

Projects such as FLOE, that implement AccessForAll, are also aligned with diversity-supportive e-learning trends toward personalization. Both are promoting one-size-fits-one education rather than one-size-fits-all education and the rejection of mass, "cookie-cutter" education. The trend to personalization is in part motivated by evidence that better learning outcomes are associated with personalized learning (Beetham & Sharpe, 2007).

The label of personalization has been used to cover a broad range of very different initiatives. These initiatives differ in the following ways:

1. What is personalized, including the:
   - path or sequence of steps to achieving a learning outcome, including repetition of specific items
   - pace or how much time is devoted to each part,
   - personalization of the content used, including using local information, a favorite topic (e.g., teaching math using dinosaurs), using first and second languages at the same time, etc.,
   - presentation of the content including the style of text, magnification, color contrast, spacing and layout, density of content etc.
   - modality of delivery including video, audio, text, images, immersive content, etc.
   - degree and type of interactivity, including games, quizzes, collaborative exercises, etc.
   - form of pedagogy used, including constructivist, didactic, experiential, project based, problem based, collaborative, competitive, etc.
   - form of motivation, including external feedback, internal feedback, affinity topics (e.g., trains, panda bears, or currently popular personalities), peer support (e.g., buddy system)
   - form of social support, including peers or instructor
   - scaffolds provided, including prompting, calculators, dictionaries, thesaurus, etc.

2. What kind of learning trajectory or plan is supported? This could include the following forms of planning:

- predetermined by education authority or instructor
- self-guided by students themselves
- a formal and constrained trajectory
- a responsive and opportunistic learning plan
- a life-long learning plan that has no terminus

3. Who decides what and how things are personalized? This could include the following strategies:
    - machine intelligence makes the decisions based on fixed algorithms or adaptive algorithms (and either informs the learner or does not inform the learner)
    - educators or teachers control the factors to be personalized
    - the learner is informed about the choices and what has worked for them and decides what is personalized and how it is personalized.

4. What data is used to guide personalization? This includes:
    - personal data for each student,
    - representative data from previous students or a pool of students, or
    - a combination of representative data and personal data

5. Who the data is presented to? This includes:
    - The machine intelligence engine and company creating it,
    - The students and learners themselves through dashboards and visualization tools, and/or
    - The teachers and educators.

Metacognition, Smarter Machines and Smarter Students

Projects such as FLOE differ from mainstream personalization initiatives in one important respect. Personalization initiatives are often used as a raison d'être for applying artificial intelligence to education. Adaptive education systems make data-backed decisions regarding the learning design that will bring optimal results for a student (Schunk & Zimmerman, 2008). The FLOE project is guided by the ethos that students should become experts in their own learning; that students should be able to experiment and draw conclusions about what works best for them. The FLOE project asserts that machine learning should not supplant student metacognition, self-regulation and self-determination but assist students in making informed decisions about their own learning requirements. FLOE and similar projects also support students in developing their own learning plan.

Becoming an expert in your own learning requirements rather than leaving this up to a data-driven inference engine is better suited for students who are outliers (Treviranus, 2014b). Research, including big data and learning analytics, aspires to draw generalizable conclusions that can be applied to the majority, or a large prescribed group, with predictable results. The veracity of the conclusions depends upon an accurately representative group of "subjects", and the accuracy of predictions depends upon statistical power through numbers. By definition these generalizations do not hold true for learners who are outliers. This is in large part due to the fact that there are no representatives that meaningfully reflect the unique interconnected complexity of requirements to be represented, let alone a large enough group of representatives to garner conclusive results. The only viable alternative is to represent yourself and to iteratively discover and refine your understanding of your own learning requirements with the help of supportive facilitators or tools. Tools can support this discovery by measuring and presenting "small" (personal) and "thick" (contextualized) data about the conditions under which you learn best for a given context or learning goal, allowing you to refine these conditions and monitor the results (Welles, 2014). Taking from models in sports and gaming, students can hone their learning performance.

Quality Control

Prescriptive quality standards, especially centrally controlled determination of quality, is often an impediment to more diversity-supportive inclusive design of formal education. Ironically, safeguarding equal access is frequently used as the motivation for centrally imposed quality standards (Goldberg & Cole, 2002). Unfortunately this removes self-determination from teachers and students and restricts leeway for diversification and thereby customization and personalization, or designing for diversity. However, common education standards such as the US Common Core can be used to provide useful descriptive metadata regarding the learning goals met by a learning resource (Achieve, n.d.). When this is combined with accessibility metadata or metadata regarding the accessibility requirements met by the resource, this Common Core metadata can be used to find learning resources that address personal needs and also achieve an equivalent learning goal.

New Challenges for Inclusive Design

The tension between a one-size-fits-one and a one-size-fits-all "checklist" approach to accessibility and inclusion becomes even more complicated as learning resources become more interactive, multi-modal, immersive and collaborative. This is especially the case for learning experiences that do not translate easily from one sensory modality to another. It can often be argued that a legally accessible learning resource is not an equitable learning resource.

For example, a text description of an interactive science simulation is not an equivalent learning experience and is not likely to achieve the same learning outcome. A real-time sonification of the simulation that matches the student's personal mental models and codification of sounds would be far more equitable. A partnership between the University of Colorado's PhET project and the Inclusive Design Research Centre is developing a framework for sensory translation from vision to sound (real-world audio combined with speech) that enhances the experiences of the simulations for all students[9]. The IDRC is also developing a means to express charts and graphs through sounds. Students can choose a sound

9 https://phet.colorado.edu

codification system that makes the most sense to them (e.g., a long tone for tens, followed by short sounds for single digits to indicate the size of a pie slice)[10]. Both the DIAGRAM Center in the US and the Inclusive Design Research Centre in Canada are exploring the use of 3D printing to create tactile models for individuals that cannot see images[11]. Both initiatives are also exploring the combination of audio and touch, whether it is tactile graphics and audio in the case of the DIAGRAM Center; or haptic artifacts and effects (e.g., flow of river, extrusion of province or state to feel the boundaries better, effect of elastics to indicate latitude and longitude) combined with audio for maps and geographic information in the case of the IDRC (Treviranus, 2000).

A text caption of an evocative piece of music is not as instructive as the original. A visualization of the music accompanied by vibration, such as provided by the "Emotichair" developed at Ryerson University is much more equivalent for someone that is Deaf (Karam et al., 2010). The Emotichair project translates sound to vibration and provides a means of composing vibro-tactile music, thereby enhancing the experience for both Deaf and hearing students.

A text description of an immersive environment is not equivalent to exploring the space. A responsive 3D soundscape that can be explored, with speech labels that can be selected according to the student's interests would be far more equitable. These are experiences that are being explored by a number of museums including the Virtual Museum in Canada[12].

One currently unsolved challenge is interactive collaborative experiences in which the collaborators each have different preferences or requirements. This can be resolved if the collaborators are remote as they can each have a personalized view of the interaction, but becomes more difficult if collaborators are sharing an interface. The Canadian Museum for Human Rights[13] has implemented multi-touch tables in which each zone can adapt to the needs of the user but the overall experience continues to be collaborative. Another very promising practice is to enlist peers to provide and refine translation. This works best if it is supported in the collaborative interface.

Inclusive Life-long Learning

Socio-technical trends and the inevitable transformation of work require a re-thinking of education. Education suited to emerging realities inevitably includes radical diversification and continuous refreshing of competencies only achievable

10 http://floeproject.org

11 http://diagramcenter.org

12 http://www.virtualmuseum.ca

13 https://humanrights.ca

through life-long learning. To supply this diversified and perpetual education requires self-guided learners. However, the structural barriers to an approach that supports students in fully taking control of their own learning are many. Education itself has a history of paternalism and the belief that students do not know what is best for them. Students who have disabilities or students who are at risk often face a strange duality of infantilization or demonization. Either there is an added layer of protection or assumed vulnerability and incapacity; or the students are blamed for failure and distrusted (especially students who face mental health issues or invisible disabilities, or who don't "respond to treatment") (Epp, 2003). Any understanding of the students "condition" is usually hidden from them.

Our systems of education must also recognize the beneficial role of mistakes and failure. Using failure and error as a tool for learning is rare. Learners with disabilities are often protected from failure. Failure in education is seen as and set up to be deterministic, it is used to predict all future performance, putting students further at risk.

Standardization, establishing norms and corralling and guiding performance through measurement (e.g., bell curve) or statistical evidence are inextricably fused with the values and aspirations of formal education. Individualization would lead to divergence and would reduce control. The individually chosen approach would not conform to the target metrics set up for formal education systems, causing systemic disruption to established reward systems (e.g., students awards, educator promotion and institutional ranking). It is uncertain at what point formal education systems would be willing to risk devolving quality control to the student and supporting each student in refining their own learning performance.

However, an established phenomenon in inclusive design is that designing for the margins benefits the majority (Jacobs, 2002). A mass approach to education has many casualties. All learners are multi-faceted and unique. The systemic advantages of diversity are well documented. Like all relatively free-form discovery, the necessary diversification of education and divesting of control to students is an evolving, messy, risky process requiring trial and error, play, mistakes, failure and patience. Students at the periphery are practiced in navigating this type of terrain.

Conclusion

Evidence and exemplary models are mounting that resoundingly support the principle that designing for students with learning differences and stretching to make room for a diversity of perspectives in our formal education system benefits all students and society as a whole. To successfully serve the purpose of preparing all students to meet their full potential and become prosperous, self-guided contributors to our global community, formal education systems must undergo a significant culture shift. Students with learning differences may be the impetus that pushes our complex system of education to make room for diversity to the benefit of all.

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