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ED and INFO 2052: Oh, the places you'll go! [1,2]

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1. Introduction

Human daily life today – at work or home – would seem comfortably familiar to someone living in the United States 40 years ago, in 1972. In 2012, most adults still commute to work morning and evening, and work 5 days a week, 9 to 5. Most live in cities or suburbs[3] in nuclear families, and engage in a wide range of recreational activities, e.g., reading, playing or listening to music, watching TV or movies, playing video games, gardening, hunting, hobbies, sports and travel [24].

Still, there are also some fundamental differences in human society and the experiences of individuals and groups. Many of the most visible changes relate to technology – computers, the Internet, cell and smart phones and the World Wide Web. Facebook, Twitter and other forms of social media are the norm. The world is more networked than ever. We truly live in an instantly and continually connected global village – interdependent on each other economically, socially and culturally.

American K-20 education in 2012 is also strikingly similar to 1972, but with some notable progress. For example, in terms of literacy, the *CIA World Factbook* [5] reports that 99% of the US population can read and write. And, based on US Census Department data, there is a marked increase in high school graduation: in 2009, more than 4 out of 5 (85%) of adults aged 25 and over reported having at least a high school diploma or its equivalent. This number was just 25% in 1940, 50% in 1967 and 75% 1986 [25]. However, schools today are organized and managed much as they were in 1972 – based on a mass-production, factory model with students divided up into grade levels and classrooms of 25–40 students with one teacher, responding to bells or buzzers signaling when it is time to shuffle off to another activity. The content of education is a state-determined curriculum separated into subject areas

[1]Note from 2052: Since the purpose of this piece is to explain education and the information field today as if we were speculating from 40 years ago, we decided to immerse ourselves back in a 2012 state-of-mind by putting aside our current technologies, spaces and approaches (particularly our knowledge processors, mediatrons and virtual study rooms) and "write" a paper using a word processor. Please forgive the blandness and occasional syntax mistakes as we are still getting reacquainted with these charming but limited tools.

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[3]As of 2010, 82% of the US population lives in cities or suburbs. Central Intelligence Agency (US) [5].

articulated as grade level standards, expectations or essential learnings. Student progress is assessed primarily through formal testing. In fact, statewide, standardized testing has increased multi-fold in recent years in response to federal initiatives such as No Child Left Behind [16].

For K-12, the 2012 student experience is much the same as in 1972: a fixed, 6 or 7 hour school day, 5 days a week, 180 days a year, in self-contained classrooms with one generalist teacher in elementary schools, or a series of subject area teacher specialists at the secondary level. Most students (and teachers) follow a fixed schedule with minor variations each day.

At the district level, the logistics of managing thousands of students each day often trump preferred pedagogical or sound learning science decisions. For example, according Carskadon and colleagues [1, 3] ". . .hormone and physiological changes that come with puberty affect teenagers' sleep schedules so that they find it difficult to go to sleep early or get up early. Puberty causes shifts in teenagers' sleep cycles to favor a late night schedule, and teenagers who stay up late at night and are difficult to wake in the morning may not be 'lazy' but may simply be following their natural cycle". In a follow-up study, Carskadon et al. found that the students' brains at 8:30 in the morning were essentially still asleep [4]. These puberty-associated changes unfortunately often coincide with the transition to secondary schools that often have earlier starting times than elementary schools due to bus and after-school sports and activities schedules. Even when such research indicates that change is warranted, it has been difficult to overcome the inertia and mindset of the mass-production, factory model.

In terms of higher education, we see widespread recognition of the value of higher education with a greater percentage of young people attending and graduating than ever before. For example, the rate of college completion for the population 25 years and over grew from 11% in 1970 to 30% in 2009 [25]. However, as with K-12, the structure and approach of education in college and universities in 2012 is still very much the same as in 1972 – organized into degree programs often comprised of a series of lecture-based courses. On the undergraduate level, many of these classes occur in large lecture halls where students are essentially anonymous. A telling video created by Kansas State cultural anthropology professor Michael Wesch and 200 students highlights the frustrations of students today and the challenges they will face in their lifetimes [27].

But, the winds of change are strong – fueled by the advances in information technologies. Our daily lives are infused with digital tools and devices – personal computers, mobile and smart phones, game consoles and social networks. These technologies boost our capacity to process, store, retrieve and communicate information and have fundamentally changed the way we engage in work and recreation.

One would expect similar profound changes in education; however, schools, particularly K-12, have lagged behind in terms of ubiquitous use or integration of technologies in learning and teaching. While the ratio of K-12 students to instructional computers with Internet access has dropped significantly in the US (6.6 to 1 in 2000, 3.8 to 1 in 2005 and 3.1 to 1 in 2008 according to [22]), many students still do not have continuous or regular access to a computer or digital device for individual use in school. It is still the norm for K-12 students to share limited numbers of machines in classrooms or be scheduled every few days for a period of time in computer labs.

Availability and access to technology is much different in higher education. According to the 2011 EDUCAUSE annual study (ECAR) of 3000 students at 1179 colleges and universities, most students own multiple digital devices including a laptop (87%), a USB thumb drive (70%), an iPod (62%), a smartphone (55%), a digital camera (55%), a webcam (55%) and a desktop computer (53%) [7]. "Their clear preference is for small, mobile devices that fit in a pocket or backpack and go with them everywhere" (p. 7). However, few students report that their instructors use technology effectively (19%) or frequently enough (20%).

College and university students are heavy personal users of technology for access to resources, productivity and connecting to people and information. And, most students recognize the promise of technology for making learning a more immersive, engaging and relevant experience [7]. Many faculty are also regular users of technology for personal productivity, information and communication. However, from a structural perspective, higher education has not undergone the same transformative technological changes as other sectors.

We expect that by 2052 education on all levels will be radically different from today with a far-reaching shift from education factories aimed at the masses to individual education aimed at meeting the goals and aspirations of individuals. Christensen, Horn and Johnson argued that if schools cannot incorporate technological innovations to personalize learning, then students will pursue education *outside of* traditional schools instead of *within* them. If schools do not adapt, they will meet the same fate as businesses such as Digital Equipment Corporation, which dominated the business computer market in the 1960s and 1970s but went out of business when it failed to respond in time to the growing personal computer market [6].

We agree with this assessment of the immediate challenges that schools face, but we go even further: we assert that disruptive change in the locus and control of education is inevitable and desirable. Just as technology has allowed consumers to find media beyond just that from traditional publishers, newspapers, record companies, television networks, movie theaters, bricks-and-mortar retailers and others, so too students will be able to access more learning opportunities beyond the narrow and monopolistic control of schools, colleges and universities. Colleges and universities should still provide students rigorous and clearly defined programs of study and high quality educational opportunities, but the emphasis will be on customized learning for individual students with multiple paths to show achievement.

In 2012, we already see developments driven by technology that herald a shift from a mass production education model focused on instruction to a customized, individualized model focused on learning:

- The "flipped" classroom with an inverted teaching structure where the content is delivered outside class (usually online), and engagement with the content (discussion, exercises, skill development and practice) is done in class, guided by the instructor and in collaboration with peers [23].
- Online lessons ranging from the Khan Academy's homespun math videos free on YouTube to Apex Learning's for-profit online Advanced Placement (AP) courses (www.khanacademy.org, http://apexlearning.com) [26].
- Massively open-online courses (MOOCs): free or low cost online courses offered by top schools, e.g., the joint MIT/Harvard edX partnership [2,10].

This demassification and individualization will be possible due to expanding technological capabilities for managing huge amounts of data and information about learners, new forms of programs of study and educational experiences, new processing, access and communication tools, and a sophisticated multimodal information infrastructure supported by skilled information professionals. The nature, characteristics and scope of these areas are explored in more detail below.

2. The demassification of education

The most profound and far-reaching change in education over the next 40 years will be the move from a mass production model focused on teaching to a customized, individualized model focused on learning. As noted above, in 2012 education K-20 predominantly follows a factory approach – organized

around the inputs of instruction (classes, schedules and curriculum) for students enrolled in institutions and programs of study. By 2052, the focal point should be the individual student and what she or he needs to learn in order to achieve certain goals. Education is decentralized. In 2052, there are clearly defined learning goals and objectives for various degrees, certificates or other programs of study, but students are able to attain and demonstrate requisite knowledge and skills via many different paths and earn credit for involvement in research and student-driven investigation that might diverge from conventional pathways of learning.

This requires a shift in the roles of the academy – transforming from sole source control of the means and ends of instruction to an open approach that facilitates learning from multiple, alternative paths. In 2052, colleges and universities will no longer be fully responsible for the delivery of instruction. Rather, beyond offering unique, high quality learning opportunities (e.g., the best scholar, teacher, mediaprod and/or lecture), the institution is engaged as the aggregator and validator of learning and achievement. Brands are differentiated in three ways: (1) the quality, uniqueness and quantity of learning experiences offered, (2) the ability and reputation of the institution as advisor, mentor and guide to individual students in various disciplines and professions, and (3) the reputation and credibility of the institution as assessor and validator of student achievement. A "degree" from a top school will represent the validation by that institution that a student has attained the level of knowledge and skills deemed essential and appropriate for a program of study, not that a student has enrolled and completed a certain number of courses.

This demassification and change in emphasis from instruction to learning requires sophisticated, effective and efficient information management systems. Customized learning requires detailed and specific data and information about the following:

- Students: personal attributes including cognition, goals and objectives, interests, experiences, activities, products and performance.
- Learning experiences: formal and informal experiences in terms of validity and reliability of the institution and/or teacher(s), content (information, knowledge and skills), logistical attributes (locus, method, time frame, etc.) and applicability to various programs of study.

In 2052, the infrastructure of the academy – personnel, resources, facilities, systems – is primarily focused on fulfilling the aggregator/validator role rather than the 2012 focus on direct delivery of instruction. And, the linchpin that makes all this possible is the "personal education record" – the PER – backed by carefully established standards, protocols and governance of data and metadata.

The 2052 personal education record (PER) bears little resemblance to the traditional academic transcript. The traditional transcript is severely limited – providing information about courses taken and grades for each course indicating a student's overall performance. The transcript is organized one way – chronologically and offers little in the way of context or specifics. Readers of the transcript might be able to infer more detail about what the student knows and is able to do if they had background knowledge about such things as the course content, examples of the student's work, the nature and abilities of other students, assessments used, and the instructor's grading approach and philosophy.[4]

The mid-21st century Personal Education Record is a completely different form of documentation. It is a dynamic, holistic knowledge system that seeks to capture all *learning* experiences – regardless of how or where the student experienced them – physical or virtual, formal or informal, purposeful or serendipitous. By identifying and tagging diverse learning experiences, the PER stores "big data" about

[4]See Bill Graves's paper in this volume for his description of an Educational Positioning System which can both help students navigate through various opportunities to learn and maintain a private but sharable record of their educational data [13].

an individual student's experiences and goals. In some ways the PER is like a portfolio, but its large-scale processing/crunching to organize and parse this data also makes it relatively easy for those who need to see a summary of evidence of a student's abilities in particular areas to do so. The PER's system of validation of learning achievements by the student's mentors and advisors also allows prospective employers or academic admissions personnel to be confident in the validity of documented accomplishments.

The PER provides a well-organized information system to connect students' goals and schools' programs of study to relevant learning experiences. Students use the system to set goals for their education, be offered suggestions for experiences to learn to apply new ideas, add records of those experiences to the PER, and have those records validated by faculty and/or other mentors.

To provide a structure for the PER, universities, colleges and vocational schools partner with employers and other stakeholders to map the curriculum in old and new fields of study. Information professions help to create, manage and organize these as a clear outline of certain foundational topics of which students should be able to show understanding when they study in a particular field. The system also maps related or tangential topics that students may want to investigate to deepen understanding as well as certain open questions in need of original research. This map provides a framework on which students can attach evidence of learning. Learning experiences have associated metadata to prompt students to connect a memory of the experience (much like a short video) to the learning map in their PER. These organized records of memories can serve as evidence of learning and as opportunities for the student to reflect on their experiences and make connections to other concepts learned.

3. The changing roles of the academy

Universities serve a range of distinct educational roles:

(1) Research: Extending knowledge through questioning and investigation.
(2) Curriculum: Deciding what should be learned.
(3) Teaching and learning: Providing opportunities for students to engage with topics of study.
(4) Assessment: Checking students' understanding of specific material studied.
(5) Validation: Affirming, through conferring degrees or other credentials, that a student has completed a program of study with requisite knowledge and skills.

Universities and other higher education institutions have carried out these roles since at least the time of Abelard. The nature and scope of content to be learned, however, is now affected by the accelerated pace of research leading up to 2012. If educators still think of the curriculum as a fixed body of knowledge in 2012, we will need to become more flexible in that thinking not just for our doctoral students, but in the work of teaching master's students, undergraduates and vocational and technical students as well. Information and communication technologies (ICTs) are also changing so quickly that all programs of study must adapt to new ways of harnessing students' ubiquitous access to information. Current ways for structuring the curriculum and teaching courses will not be adequate for connecting students with a multiplicity of ways to learn – not just on the campus, but also in nature, workplaces, cultural institutions and virtual worlds. If students can learn off-campus and document these diverse experiences as evidence of understanding and competence, then – to remain relevant – universities need to consider new ways to assess and validate the knowledge and skills that these students demonstrate. In this section, we examine each of these five roles of the university and consider how the vision for each role may be changing.

3.1. Research

Extending knowledge through original research continues to be a key role for universities. Faculty and students strive to advance knowledge by exploring unanswered questions. Professors and advanced graduate students, however, will not be the only ones doing original research. All persons need higher levels of thinking to cope with changing information and technology in 2052. Research cannot be isolated in the ivory tower. University researchers continue to guide research agendas, but they also continue and deepen collaboration with practitioners and with students. Such collaborations, when done well, provide benefits to university students and faculty and to industry by providing opportunities to connect students with rigorous and relevant learning opportunities. Such partnerships allow students to learn from and earn credit for contributing to research and innovation.

In 2012, research is too often considered as being distinct from teaching. Instructors and others also conflate the remaining functions on the above list (particularly curricula, teaching and learning, and assessment) under the umbrella of "teaching". Such conflation often prevents us from attending to each of those functions in ways that might better support students' learning. All five of the universities' functions deserve distinct attention, but may need to be more integrated in practice.

3.2. Curriculum – The ends of learning

The Academy in 2052 plays a major role prioritizing what students learn – the ends – but has a smaller role in determining how students learn these things – the means. By charting the learning map used in most students' PER, the university defines curricula and helps students set clear goals. When students are considering education and career options, they can meet with a mentor and look at the related learning maps to help them set goals. The student can try out some learning experiences or meet people identified as having relevant interest and/or expertise. Using this information, students can select programs of study and immediately begin learning and recording experiences in the PER.

The structure of the programs of study in the PER define the concepts and skills that a school believes students should master as they work toward a degree or credential. Each program of study has standards that are consistent, clear on granularity and measurable. A program of study provides a framework for connecting students with learning opportunities that are consistent with student goals and requirements of the university.[5] The frameworks used in the PER prioritize foundational concepts and procedures that all students in a particular program of study are expected to master, but they also identify extended or tangential areas that students can explore to extend their understanding, develop expertise or distinguish themselves as having gone above and beyond the basics. Many students express interest in exploring uncharted territory. For these students, the map and frameworks provide guidelines for related foundational ideas they can study as well as open questions to explore with a mentor's guidance.[6]

3.3. Connecting students with educational opportunities – The means of learning

In 2012, higher education still views a program of study as a series of courses with particular topics on the syllabi, all of which must be taken by a student to earn a particular credential regardless of the

[5]Graves also describes an Educational Leadership Commons based on the Internet Society which could guide policies for competency-based learning and evaluation [13].

[6]In this volume, Liz Liddy explains the need for schools to be flexible in providing opportunities for students to explore innovative ideas, and she presents the iSchool at Syracuse's Certificate of Advanced Study in Information Innovation: _____ as a model of agile credentialing [19].

different backgrounds and experiences students have prior to entering their programs of study. Schools will change, however, from a focus on course-based teaching to one of competency-based learning. In 2052, a university's learning spaces look very different. Lecture halls seem like quaint relics, used for special presentations and events. Learning is not organized around courses in the traditional sense, but around menus of potential experiences that could be associated with programs of study. Students and their mentors consider various opportunities for the student to engage with simulations, interactive study rooms, other people and real world experiences related to the goals in their learning plan.

Universities remain communities where students can engage with other people in conversations in which they encounter new ideas, confront misconceptions, deepen their understanding of concepts and hone skills. Colleges and universities, however, no longer have exclusive control over the means of education. Based on the complete and holistic PER, students have a range of options, which besides talks and colloquia within the school's community, also include opportunities to connect with people, workplaces and media from all corners of the physical and virtual worlds.

In 2052, for example, a person interested in becoming a library and information science professional is able to request a preliminary degree audit that compares their learning accomplishments with the baseline of defined learning goals (knowledge and skills) for the profession created and validated by professional and accrediting organizations working in cooperation with the schools and employers. Based on the applicant's PER, the audit authenticates relevant attained knowledge and skills and gaps to be addressed in a program of study. Various accredited, degree-granting institutions can then offer program of study "quotes" – the learning goals and objectives that must be attained as part of the program and the various paths open to the student to attain them. Schools and programs vary greatly in terms of unique learning goals beyond the common baseline, special areas of expertise, emphasis or focus, reputation of core faculty, and preferred learning experiences and options. Innovation and alternatives are encouraged, and applicants could choose the school, program and options that best meet their needs. This is all made possible by a massive data and metadata infrastructure that fully integrates with individual learners' PER.

3.4. Assessment of students' understanding of concepts, skills and topics studied

Already, in 2012, we are beginning to see how people and systems can work together to give students prompt feedback on their understanding of the content they are studying. The Coursera project (Stanford, Princeton and others) and EDx (MIT and Harvard) are already building inter-institutional systems in which machines and crowd-sourcing help professors grade and give immediate feedback on students' formative work in massively open online courses (MOOCs) [10,17,18,20]. Cathy Davidson of Duke created a stir in 2009 with a blog post titled "How to Crowdsource Grading" in which she announced that instead of giving all the grades in one of her classes, she would have students do peer-grading so that they "learn how to be responsible judges of quality and. . . learn to be responsive to feedback as well" [8]. The story went viral, with many people criticizing Davidson for abdicating her responsibility as professor of the class, but she later wrote about how she was able to see the quality of student work improve when they felt they were writing for a genuine audience of in-class peers and external online readers. Stepping back from micro-assessment allowed Davidson to see the bigger picture of each student's contribution not only in his or her own assignments but also in their responses to the work of others. Crowdsourcing the micro-assessment facilitated Davidson's macro-assessment of each student's engagement with the topics covered in the course [9].

In 2052, students engage in many different activities that provide ongoing evidence of learning the specific objectives associated with their learning plan. When students have gaps in their understanding or

do not demonstrate learning on a first attempt, they have repeated real and virtual opportunities to review the material and/or meet with tutors. Assessment of learning includes digital evidence of students' work and experiences as well as annotations by faculty, mentors, workplace supervisors and others who attest to specific knowledge and skills that the student has demonstrated.

Standardized testing, teacher quizzes and tests, performance observation and other methods have long been used to check if students can demonstrate a particular understanding or skill. Before 2012, however, there was no practical way available for students and teachers to store all this data within a framework that helps show the larger picture of a student's knowledge and skill. A traditional transcript may be intended to provide this bigger picture, but the transcript does not provide the option to go back and see which standards were actually assessed in a course – and which of those standards the student mastered. The PER system, by contrast, gives the viewer the ability to zoom in to show the specific standards students have achieved and to view some of the evidence that was the basis for the assessment of the student's competencies and achievements.

3.5. Validation

One significant role that universities play to is to grant degrees and other credentials which confirm to employers and other stakeholders that a student has met or exceeded requirements to show proficiency in a given field of study. This role is even more important in 2052 as students bring together learning experiences from a wide variety of contexts.

To determine whether a student has fulfilled the goals on his or her program of study and met the requirements to earn a degree, faculty members who have worked with the student review the evidence in the PER and discuss it with the student and with one another. Mentors affirm achievement and highlight learning experiences that have distinguished a student's personal achievement in their program of study. Faculty working with the student also look at the big picture to confirm when the student has shown all of the essential knowledge and skills that a credential certifies. Such review assures the rigor that the institution expects of its graduates and helps assure future employers that a graduate has the knowledge and skills that the degree represents.

4. Technology – Tools and environments

Before projecting forty years into the future, it is revealing to reflect on the extraordinary developments over the past 40 years. For example, Intel introduced its first 8-bit microprocessor in 1972 (the 8008 chip) which IBM used it in its first personal computer in 1981. In the late 1970s and early 1980s, Atari video game systems and cartridges became common in many homes. In 1982, TCP/IP (the Internet protocol) was standardized and a world-wide network (the Internet) was introduced [15]. The 1990s saw the emergence of the World Wide Web, Wi-Fi and Google followed in the first decade of the 21st century by such innovations as the iPod, Facebook, YouTube, Twitter, the iPhone, iPad and Kinect. These and related technologies have profoundly affected the nature of human interaction, productivity, commerce, creativity and recreation.

We have not yet seen the same level of impact of technology on education as in other sectors. In 2012, there are still concerns about technology access, availability, and infusion into instruction (K-20). With the exception of PowerPoint and the recent increase in availability of online classes, the adoption of technology for teaching has been modest. However, as noted, college and university students have embraced technology for productivity, access to resources, and connecting to people and information.

Word processing, e-mail, the Web and search are indispensable tools for students and faculty in 2012, and their impact on writing, information seeking and use, and communication cannot be overestimated [7].

Fully aware of the awe-inspiring explosion in technological innovation and creativity over the past 40 years, we expect even more world-changing developments in the next 40 years. Examples include:

- For productivity, from processing words to processing knowledge via a personal digital guide (PDG) in the form of an avatar or hologram that supports, guides and facilitates creating and communicating knowledge. Beyond the use, processing, and presentation of information in all possible forms, the key capability of the PDG knowledge processor is the collaborative, continually evolving relationship between the PDG and the user to improve framing tasks or problems, information gathering and use, and synthesis and presentation of knowledge.
- For information, search tools that are aware of context and user needs make highly relevant and credible information and data of almost any kind instantly available and customized in style, language and format (including massive data sets displayed as virtual or physical 3D objects) to the needs and preferences of the person.
- For communication, wearable or implanted nano-devices respond to thoughts and transfer data, information or ideas effortlessly as well as manage, process and store incoming messages according to personal preferences.

In 2012, we already live in an increasingly intelligent environment with a parallel information universe that monitors, interacts and provides feedback to humans. This continuous connectivity will expand many-fold over the next 40 years as more and more physical objects (such as walls, windows, desks, tables and even chairs) become digital and "intelligent" in terms of capable of carrying out processing and being addressed (i/o). In 2052, we routinely use digital paper and books that look and feel like physical paper and books, and nano-devices are embedded in our possessions for access and use that are directly brain-controlled and manipulated. We even have digital paint (digipaint) that can coat any surface to make it connected, addressable, and smart.

One development has particular relevance and impact for the information field and education: the virtual study room. The virtual study room is a flexible and customizable space in a virtual environment that facilitates individual (or group) information problem-solving. Similar in purpose to the small, private, isolated and highly popular study rooms found in some university and libraries in the physical world, the virtual study room offers the same advantages of the physical study rooms. It is a place for focused study and thought, to store and organize gathered resources and materials, and to be able to leave and return to find your materials and work exactly as you left them.

At the same time, the virtual study room overcomes the constraints of restricted numbers of physical study rooms, the small size and limited furniture and contents, and the need to eventually put away your materials and give up the study room so others can use it. In a virtual world, users can even have a different study room for every major topic, project, or question they wish to investigate. Virtual study rooms help to immerse users in their work – easily remembering where they left off, surrounded by content, self-organized for their own work styles, and conditioned to focus, think, and create while in the room [12].

By the mid-21st century, virtual study rooms are a common feature in academic libraries. Many faculty and students even choose to present their room (or part of their room) as a public space for sharing their thoughts, knowledge and ideas. These public virtual areas can be temporary or the creator can petition the librarians to consider the room as a permanent part of the library collection. In this way, the academic

library becomes directly involved with local knowledge creation and sharing, contributing to the global knowledge network.

5. Implications for the information field and information education

The culminating conclusion from all the preceding points, speculations, and arguments is that education in 2052 will be fundamentally and radically different than in 2012. The change in overall structure and organization and many of the specific differences in education requires a sophisticated information and technology infrastructure and numerous systems, devices, resources and tools. Therefore, the information field and information schools can and should play a leading role in the transformation of education.

Content-wise, information and information technology are the underpinnings for transformation of education. The information field *has* gone through a revolution, and the scope and content of the field is profoundly different today than it was in 1972 before personal computers, the Internet and the Web. The change is more than just the move from large mainframe computers, proprietary dial-up databases and services, with limited and restricted access to 2012s powerful, hand-held digital devices, the WWW and thousands of online databases with fast, direct and easy access.

One of the biggest and most fundamental differences is the change from scarcity to abundance to overload. The challenge today is not one of finding or locating information; it is sifting through all the sources and information to determine what is the most relevant and credible. In Project Information Literacy, Head and Eisenberg found that students are comfortable and able to search out information. They report difficulties, however, with clearly defining their task or problem, filtering through all the irrelevant results, and applying quality information to their tasks [14].

This points to a very different role and emphasis for libraries and librarians – from traditional collection development, management, and access to customized, individualized and targeted information services and instruction. It also reflects important new areas of professional engagement as well as research and development opportunities for information professionals and scholars across the broader information field. For example, as described earlier, the transformation of education from factory to individual requires an elaborate, powerful data and information infrastructure. From an information perspective, there is major work to be done in terms of fully understanding: the needs and behaviors of learners, teachers and other players; information and knowledge organization; large- and small-scale systems design; developing policies and standards; institutional coordination and management at all levels; and envisioning and planning new forms of information and learning services.[7]

By 2012, many information schools have earned positive reputations within their institutions as innovators in implementing online learning programs, integrating technology into the classroom and cross-disciplinary collaboration. Information schools also work well together, for example, through the iCaucus (www.ischools.org) and cooperative efforts such as the WISE consortium for shared distance education opportunities (www.wiseeducation.org).

Because the essential elements for radical innovation in higher education articulated in this paper are core academic and professional concerns of the information field, information schools can lead the way

[7]Moran and Marchionini list six core values which iSchools draw from the tradition of librarianship: organization of information, universal access to knowledge, collaboration to share knowledge, intellectual freedom and diversity of thought, self-directed learning and stewardship and preservation of knowledge. To successfully transition to the flexible and individualized model of education we describe here, these six core values may need to drive not just iSchools but whole institutions and collaborative networks of organizations with a stake in higher education [21].

in terms of studying, designing and implementing new approaches, structures and systems. In addition, information schools encompass both the professional and the academic. While this has been a point of contention at times in the past, this should be a strength moving forward. Information schools can lead the way in terms of celebrating the professional and the academic, for example, infusing R&D into learning at all levels.

Work and life in the 21st century requires both the theoretical and the practical, and information schools can serve as a model for the integration of professional and academic content, skills, issues and concerns. This includes new relationships with business and industry – going far beyond internships or placement of graduates. The private and public sectors work together to provide students opportunities for learning from direct involvement with real-world activities and to give employees recognition for workplace learning.

There is a tremendous amount of work to be done to make individualized education the norm. Most of this work intersects with the scope and interests of the information field and information schools. Cutting-edge topics such as big data, social media, privacy, security are directly relevant, but the information field and schools also need to articulate and champion the broad vision, actively seek out partners on campus, and get buy-in from those engaged in top-level decision-making and strategic planning. Now is the time to take the initiative.

6. Discussion: Warnings and limitations

The idea of individualizing instruction through the PER is not without problems. These potential difficulties, however, are ones that information professionals are well poised to help colleges and universities address successfully. One such problem is balancing information abundance and information quality. In designing the PER, learning experiences will need to be catalogued or tagged in such a way that high-quality, relevant options float to the top of a student's menu of choices. Information professionals' expertise in evaluation and use and knowledge organization will be key to effective design and implementation of the PER.

Another potential difficultly is the Big Brother problem. The ubiquitous nature of the systems discussed could make it difficult for students to access content and record evidence of learning while still maintaining personal privacy. Again, library and information professionals have a long tradition of providing users with open access to information while maintaining confidentiality of patron records – expertise that will be important if schools are to successfully deploy such systems. Unfortunately, individualization of education with a PER system could potentially reify existing social inequities if it is easier for socially-connected, upper class youth to find mentors to attest to their learning than it would be for youth from poverty to get equivalent recommendations. While inequity is not an easy problem to solve, information professionals have a long history of extending information services to impoverished communities – experience salient to helping address this problem. Giving students more control in selecting media and experiences from which to learn will make it ever more important to ensure that students are effective users of ideas and information. The information field's commitment to information literacy can also help students to be better prepared with the research and critical thinking skills essential to be successful in these new learning environments.

Personal education records should be used for individualization of education, but if done badly, the PER has the potential to promote conformity. This is yet another area where information professionals' commitment to intellectual freedom and our history of building and providing open access to resource

collections that represent diverse viewpoints will be important to helping colleges and universities successfully design and implement systems to effectively support the future of learning.

7. Conclusion

While it is impossible to predict the specifics of technological change 40 years in the future, we have identified some key trends, scenarios, and desired outcomes. We have tried to provide a glimpse of potential for radical transformation for education in 2052, but the reality is likely to include more profound innovations than we can possibly imagine today.

We believe that education in 40 years will be radically altered, disrupted, and different in both structure and delivery. While technology is a major force driving these changes, they are not primarily about systems or devices. Connectivity, machine learning and interactivity will be marshaled to individualize highly motivating learning and facilitate communities of practice. The PER should not replace human contact and interaction; it should facilitate mentorship, discussion and social learning. This revolution is about replacing a system that treats students as mass-produced widgets rolling off an education assembly line with one that supports a network of mentors who recognize each student as an individual and who are empowered to treat them as such.

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