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The Third Path: a New Approach to Industry-based Undergraduate Engineering and Technical Education in the United States.

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The Third Path: A New Approach to Industry-based Undergraduate Engineering and Technical Education in the United States

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Abstract

The driving forces changing how we work and the jobs that we do are impacting organizations of all sizes across all sectors. The global pandemic has accelerated the pace of change and disruption to a level not experienced before. The combination of Industry 4.0, the Fourth Industrial Revolution and COVID-19 are creating a new sense of urgency to drive collaboration between industry and education.

In 2022, academic institutions offer three paths to prospective engineering students, which students qualify for via standardized testing;

Path 1) 4-year bachelor degrees with "R1" research focus: typically following on to postgraduate degrees and careers in research or academia.

Path 2) 2-year associate degree (community college): typically leading to a career based on a technical skill or trade.

Path 3) 4-year bachelor degree with industry focus: typically leading to careers in technical-based industries

This paper presents a new approach to the "third path," the industry-based bachelor degrees. The new approach is an alternative to the traditional programs currently offered by the majority of engineering schools in the United States. The traditional academic approach is failing to fill the talent pipeline. Academic policies and practices are unable to keep pace with the exponential growth of technology, the evolving motivations of a four-generation workforce (soon to be 5 generation) and the unpredictable development of new engineering business models [1-4]. The global competitiveness of the United States is at risk, the stakes are too high to stay on the traditional course. The authors contend that paths 1 and 2, despite shortcomings of their own, are in far better shape than the third path, so they are not addressed in this paper. This paper, written more like a position paper, proposes a new model for the third path; it is based on extensive research that was discussed in prior publications by the same authors [10,11,24-26]. The Third Path model proposes revised roles for the four key stakeholders involved in undergraduate engineering and technical education. The stakeholders are: 1) Industry (United States), 2) Academic institutions, 3) Federal and State Governments, and most importantly 4) next-generation student-engineers and technicians.

Introduction

The driving forces changing how we work and the jobs that we do are impacting organizations of all sizes across all sectors. The global pandemic has accelerated the pace of change and disruption to a level not experienced before. The combination of Industry 4.0, the Fourth Industrial Revolution and COVID-19 are creating a new sense of urgency to drive collaboration between industry and education. In 2022, academic institutions offer three paths to prospective engineering students, which students qualify for via standardized testing:

Path 1) 4-year bachelor degrees with "R1" research focus: typically following on to postgraduate degrees and careers in research or academia.
Path 2) 2-year associate degree (community college): typically leading to a career based on a technical skill or trade.
Path 3) 4-year bachelor degree with industry focus: typically leading to careers in technical-based industries

This paper presents a new approach to the "third path," the industry-based bachelor degrees. The new approach is an alternative to the traditional programs currently offered by the majority of engineering schools in the United States. The traditional academic approach is failing to fill the talent pipeline. A number of publications by the current authors have highlighted the problems in detail. Academic policies and practices are unable to keep pace with the exponential growth of technology, the evolving motivations of a four-generation workforce (soon to be 5 generation) and the unpredictable development of new engineering business models.

The global competitiveness of the United States is at risk, the stakes are too high to stay on the traditional course. The authors contend that paths 1 and 2, despite shortcomings of their own, are in far better shape than the third path, so they are not addressed in this paper. The ***Third Path*** model proposes revised roles for the four key stakeholders involved in undergraduate engineering and technical education. The stakeholders are: 1) Industry (United States), 2) Academic institutions, 3) Federal and State Governments, and most importantly 4) next-generation student-engineers and technicians.

It is proposed that:

1 - Industry becomes actively involved by providing fiscal support through entry level jobs and tuition reimbursements to alleviate the financial burden and risks currently carried by students. Industry's employee tuition-reimbursement benefits would be driven down to the prospective student-engineer. Career path planning is managed by industry, not academia. Industry begins to view the new student-engineer as an employee and life-long learner.

2 - Academic institutions begin to behave as talent-pipeline suppliers to technical industries. The value of the institution's third-path program is then based on; 1) the relevance of the competencies instilled in the student-engineers, 2) the ability to provide what the students need, when they need it, at the pace they need it and 3) the integration of, and sensitivity to, the needs of industry, students, society and the economy.

3 - State and Federal Governments begin to sponsor and participate in collaborative organizations where the needs of industry, the state, professional organizations, the academy and the student-engineers are brought together and assessed. Accreditation standards and technical classifications are developed through consensus and are administered to build the engineering professions as well as the industry. The levels of achievement required to be conferred as a "bachelor's degree" are set by this accrediting body using a system similar to skilled-trade certifications and professional engineer licensing.

4 - Student-engineers get relief from the burden of crushing debt. Instead, they earn tuition reimbursement as they work through the program. Degree-earning programs are developed based on the situation of the individual student-engineer. The student-engineer becomes a life-long learner immediately following high school graduation. Student-engineers have the opportunity to opt-into the program at an entry point aligned with their academic status, whatever that may be.

Student-engineers must make "reasonable" progress to remain in the program. They progress at a pace suitable to the learning style of the individual student. The arbitrarily imposed 4-year timeline is removed. Students achieve degrees via a combination of traditional classes, combined with badging, credentialing, competency testing, and experiential credit as determined by the governing accreditation boards (similar to the European model, but the student is granted the autonomy and authority to opt-in / out).

A new model of the third path, the path to applied engineering in industry, is critical to the global competitiveness of engineering in the United States and will be set forth in this paper. This paper is not a research paper, but rather a position paper where some bold ideas are proposed to address the pressing needs in engineering education in the age of Industry 4.0. While this is not a typical research paper, the work is based on extensive research. In prior publications from ASEE 2020 and 2021 the authors summarized the research and key publications are included in the References section.

Landscape Snapshot

The socio-technical landscape is one of disruption and rapid change unlike anytime in modern history. Four central forces are transforming how we live, work, and compete in these dynamic times. First are the technical forces associated with the Fourth Industrial Revolution, Industry 4.0, are unprecedented. The term "Industry 4.0" is now commonly used in reference to this revolution. Industry 4.0 is a result of the convergence of digital, biological, and physical technologies.

The second force shaping the landscape Is found in what the global COVID-19 has invoked on society. Millions of dead, work, family life, education all disrupted in ways up until then unimaginable. The stress on our health care system, especially the stress on the workforce is unparalleled in modern times. Food supplies and distribution systems are being taxed in new and challenging ways as governments pump in billions of U.S. dollars to prop up demand.

The dynamics, opportunities and challenges associated with navigating a four, soon to be five generation workforces represent the third central force. This includes elements such as leadership succession as Generation X and Millennials ascend while Baby Boomers leave the workforce. One thing that is often overlooked is that these 5 unique and distinct generations bring valuable talents and perspectives that represent important opportunities to advance diversity, equity, and inclusion throughout our culture.

Table 1 - Four Central Transforming Forces Shaping the Landscape

Technical Forces	Societal Forces	Cultural Forces	Economical Forces
Fourth Industrial Revolution Convergence of digital, biological, and physical technologies and systems in new ways that create socio-technical value.	Global COVID-19 Pandemic Dramatic loss of life combined with unprecedented challenges to public health, food systems and the world of work.	Five Generation Workforce Generational transition and leadership succession involving five diverse groups with unique socio-cultural characteristics.	Changing Economic Environment Challenges associated with digital integration, technical workforce development, and supply chains on business operations.

Sources: Pistrui, Kleinke, Das, and Mick, 2021; World Health Organization, 2020; Pistrui, Kleinke, Bonnstetter, and Gehrig, 2018; Schwab, 2016.

The changing economic environment is the fourth central force dramatically shaping and re-shaping business models, technical innovation, industrial systems integration, manufacturing techniques, not to mention customer relationships. The integration of digital tools and techniques with legacy operations pose new challenges and opportunities that have widespread implications on business performance. The shortage of qualified technical talent is a significant challenge across all industrial sectors.

When these factors are put into perspective with the current state of engineering and technical education with workforce development in the U.S. it is necessary to conceive, develop, and scale new models to meet the needs of industry, enhance socio-economic well-being and sustain our leadership role in the global economy. There is no longer time to ponder; it is a time for vision, leadership, and action to form new collaborative models that will require some new and different roles for key stakeholders, principally industry.

Disruption and Revolutions

As a result of these central transforming forces some professions and jobs have disappeared. Currently, due to the development of digitalization and robotics, we are facing a similar era of change. “We are currently preparing students for jobs that don't yet exist, using technologies that haven't been invented, in order to solve problems, we don't even know are problems yet.” Most of us have come across this famous insight from former Secretary of Education, Richard Riley. Here are some key pointers from a recent publication (Walsh).

- 65% of children entering elementary school this year will work in a job that hasn't been invented yet.

- 49% of current jobs have the potential for machine replacement, with 60% having at least 1/3 of their activities automated.

- 80% of the skills trained for in the last 50 years can now be outperformed by machines.

- At a global level, technically automatable activities touch the equivalent of 1.1 billion employees and $15.8 trillion in wages.

The rapidly changing landscape of the workplace and associated uncertainty has raised a lot of questions about the future of our education system. The impact of different industrial revolutions on education, just like all other parts of society, has been profound.

Table 2 - Industrial Revolution and Education Paradigms

Education 1.0 - No education at all. At that time children worked in manual jobs and child labor was the order of the day. Education was not necessary to earn a living, it was merely a luxury for the elites and the rich.

Education 2.0 - Originated from the need to read and write and was developed in the model of Industry 2.0, with emphasis on production orientation such as repeatability, uniformity, efficiency, and mass production.

Education 3.0 - Did not constitute much of a paradigm shift. The advent of automation meant that the education system now could do the same thing they were doing but faster and more efficiently.

Education 4.0 - Accelerated speed of technological change, impact of COVID-19 on instruction and learning, domination of legacy systems and outdated business models with all financial burden on the backs of students.

Source: Das, Kleinke and Pistrui, 2020

The disruptions associated with the central transforming forces are forcing both industry and educators to in essence reset, recalibrate, and create new types of collaborative partnerships. This requires that industry, educators, and policy makers collectively collaborate to re-skill, up-skill and develop completely new combinations of skills and capabilities to meet the demands of the rapidly changing socio-technical environment.

Meanwhile there is complacency and resistance to change by both industry and education. Industry is frustrated because traditional education can't scale to accommodate transforming – emergent skills, new micro credentialing methods and learning models are needed

The challenges and opportunities associated with this period of disruption and uncertainty represent a "tipping point" that demands new models and methods be prototyped, tested, and scaled. This research offers up a new model prototype as an example of how to address constructive engineering education reform to address both industrial and societal needs.

Key Challenges and Opportunities

The transforming forces shaping the landscape are also shaping where we live and how we work. The impacts of remote work, e-commerce, automation and artificial intelligence mean that a growing number of people will need to change jobs and learn new skills.

Both industry and education are currently facing challenges to existing business models, but more importantly, new opportunities to innovate and create new value to meet society's needs and foster well-being. These insights provide data and direction that can be utilized to prototype and develop new models of collaboration to drive socio-economic growth, essential education reform and the general well-being of society in general.

According to Michael Richey, an executive with Boeing Company, industry faces a series of noteworthy challenges in today's environment. Three themes emerge. First is a human dimension including a limited supply of talent who have new and changing needs and desires. The second theme is structural misalignment between education and industry, primarily around digital competencies. Third, technologies are advancing rapidly especially those associated with Industry 4.0 (automation, artificial intelligence, machine learning and the internet of things as examples) without readily available or a sufficiently skilled talent pipeline to develop a digital centric workforce.

Table 3 - Key Challenges Facing Industry

1. 2M+ workers have left the workplace, resignations and rates are up – industry wide
2. US Labor Market nearing full employment
3. Employee retention and turnover at historic rates
4. Structural misalignment between educational and industry digital competencies are amplifying the market labor/skills dynamics
5. Adjustment in flexible work arrangements – the new gig economy
6. The impact of AI and ML in accelerating automation and learning

Source: Richey, 2022

Dr. Richey has identified six key challenges confronting industry today. They cluster into three central themes around labor, misalignment and acceleration of technology. This includes the challenges associated with having a limited and finicky labor force and talent pool. Another example of changing socio-technology system dynamics and needs is found in the acceleration of AI and ML. This includes not just the technical systems, but also the human systems and the interface between them. This has direct ramifications for building innovative and inviting cultures and organizations.

Another theme, one critical to this work is the continuing and expanding misalignment between industry and education. This is especially true relating to the development of a new world class digital workforce needed to meet the needs of industry and society in this rapidly changing world.

In an effort to uncover "the next new normal" Irene Petrick, Ph.D., Senior Director Industrial Innovation: Intel Internet of Things Groups co-led a four-year study collecting data from 500 executives across 400 companies in the U.S. In their research they reported that industry leaders expect rapid changes in how we work, and the skills that we will need to perform the work.

This includes not just where and how we will work, but more importantly how we interact with each other (across a 5-generation workforce), and how we interact with new technologies. This requires the development of an innovative socio-technical system of systems that have not previously been successfully modeled. Put simply this is new territory for both industry and education.

Table 4 - Industry Workforce Dynamics - Skills and Knowhow

Areas of Technology Investments	Type of Work to Perform
+ Cloud and edge computing systems + Network and connectivity systems + Cybersecurity and network administration + Big data analytics and management science + Data management, storage & preservation	+ Workflow and systems automation + Worker performance management + Self-optimizing systems of systems + Decision support management + Remote control of systems and processes

Source: Petrick, 2021

Dr. Petrick reported that out of 400 companies surveyed in 2021, 57% planned to accelerate digital investment. Table 4 presents which areas of investment and the subsequent type of work to be performed. This is an example of where industry needs are out of line with education traditions. Industry needs to move quickly to changing market dynamics while education struggles with a legacy of traditions that do not want to move at a similar pace.

This is the future of work unfolding before our eyes and provides some valuable clarity and justification for the immediate need to create rigorous new approaches to educating a workforce to meet the emerging needs of industry. Consequently, industry needs to evaluate and modify where and how it collaborates with education and society. It is also necessary to take a critical look at the entire talent pool which is highly diverse.   A large percentage of this pool is shut out of the current educational system due to a variety of reasons. We cannot afford to do that anymore.   It is therefore also necessary to ensure that reform includes everyone in the pool. Our proposed model is intended to advance the discussion to action as we present a viable option to prototype now.

Diversity Equity and Inclusion

Perhaps the term “inclusive education” [1] is best understood as one that removes barriers to entry and accommodates a wide range of learners. Legacy education systems were based on economic efficiency and are exclusionary by design. Whether intentional or not, these systems exclude economically disadvantaged students, students who do not meet a certain level of proficiency (e.g., as determined by standardized tests), and students who do not have access to a variety of resources such as high-quality teachers and challenging high school courses as well as information about programs that would be appropriate to them.

Furthermore, programs designed to suit the majority of students can exclude those that don’t fit the standard. It can be argued that the evolution of the education system, driven by economic viability, was unavoidable. But that does not mean the education system should continue as-is because “that’s the way it’s always been done.” The absurdity of that argument might best be illustrated by a metaphor. If we think about the education system as a highway and the learners like drivers in vehicles, we might say that prior to the introduction of technology, the education highway had very few on-ramps. If they could reach an on-ramp and enter the highway, the driver would quickly discover that only one type of vehicle and only one speed was allowed. If their vehicle was slightly smaller or larger, or slower or faster, it would be quickly run off the road. In this metaphor, it is clear to see that a highway designed this way would be unacceptable, yet in traditional education systems this design has been acceptable. Specifically, some of the known roadblocks to inclusive education are:

1. Lack of Financial Resources: Poverty is probably the chief reason for exclusion. Poor children and poor youth not only lack the resources to afford education, they also have to get busy seeking work for sustenance of self and family. Without education they remain unable to move up the economic ladder and the cycle of exclusion continues from one generation to another. Also, quite often, there is a strong correlation between wealth and geography. As a result, poor students are also compelled to go to poorly performing schools. These schools are unable to prepare the students to cope with the expectations of the educational ecosystem. It is close to impossible to get out of this vicious cycle.

2. Limited Access to Technology: Historically, first world countries have always enjoyed the technological advantage. New technology, whether it is the smartphone or internet access, has spread in first world countries much faster. With the world of education rapidly moving into a digital realm this is creating a new source of exclusivity. Transitioning to large-scale online learning brought about by the onset of Covid-19 has brought this aspect to the forefront.

3. Limited Social Status: Status in society whether it is due to the gap between the *haves* and *have-nots* or due to race, ethnicity, etc., all lead to large swaths of population being excluded.

4. Limited Physical Ability: Disability of any sort could be a cause for effective exclusion. People who are wheelchair bound, have prosthetics, of poor sight or hearing, etc. face significant barriers. Many of these barriers are starting to break down in the first world

but that is hardly the case in the developing world. Conditions such as Autism, while not quite a physical ailment, provides its own challenges as well.

5. Personality and Learning Style: Some students are good at learning by reading from a textbook or by passively listening to a lecture. Others feel stifled and bored in the classroom where the entire learning mode is passive listening. They learn by doing or through tactile activities. An overwhelming majority of our learning systems are set up to be used as a passive learning resource. This effectively excludes students who are not good at working in that mode.

Inclusive systems seek to remove barriers and provide the means for educating ALL students with high quality instruction, interventions, and support such that all students have the opportunity to be successful. In the current times there is plenty of discussion on the topic of Diversity, Equity and Inclusion (DEI). To most people the DEI discussion has been around racial exclusivity. And the emphasis in this discussion has been around opening up the classroom to diverse voices. While this is valuable and absolutely necessary, the problem of exclusion is a lot bigger and if we do not address the larger issue, we will continue to exclude a large fraction of the population.

Inclusive schools encourage and develop positive social relationships between peers and recognize all students as fully participating members of the school community, regardless of their financial standing, social status or physical ability. However, the current educational system, as applies to engineering education, has many practices which automatically makes it exclusive. Admission to the system is based on merit/meeting certain standards or levels of preparation. This effectively excludes students who come from schools that are poorly performing or schools that lack the resources to offer advanced or challenging classes.

Many first-generation students are severely disadvantaged when it comes to access to proper information. Usually, the percentage of these students is higher in schools that are overcrowded and resource challenged. So these students get excluded just because they do not have enough information about colleges, programs or application procedures.

Many early courses in the engineering curriculum such as the Calculus sequence are used as filters to essentially "weed-out" students who could have otherwise made fine professionals. The financial burden and all the risks of failure are squarely on the back of the students with the university, companies and the broader society bearing none. Government aid has attached to it many arcane rules which were devised many decades ago. So a lot of these rules come in the way of meeting the requirement for the aid and continuing on the path to success.

The entire engineering education ecosystem is modeled in a "survival of the fittest mode" while what is really needed is a system that needs to be more nurturing that lifts up everyone. In summary, every aspect of the educational system is set up to be exclusionary to large swaths of the population while making the playing field skewed in favor of many.

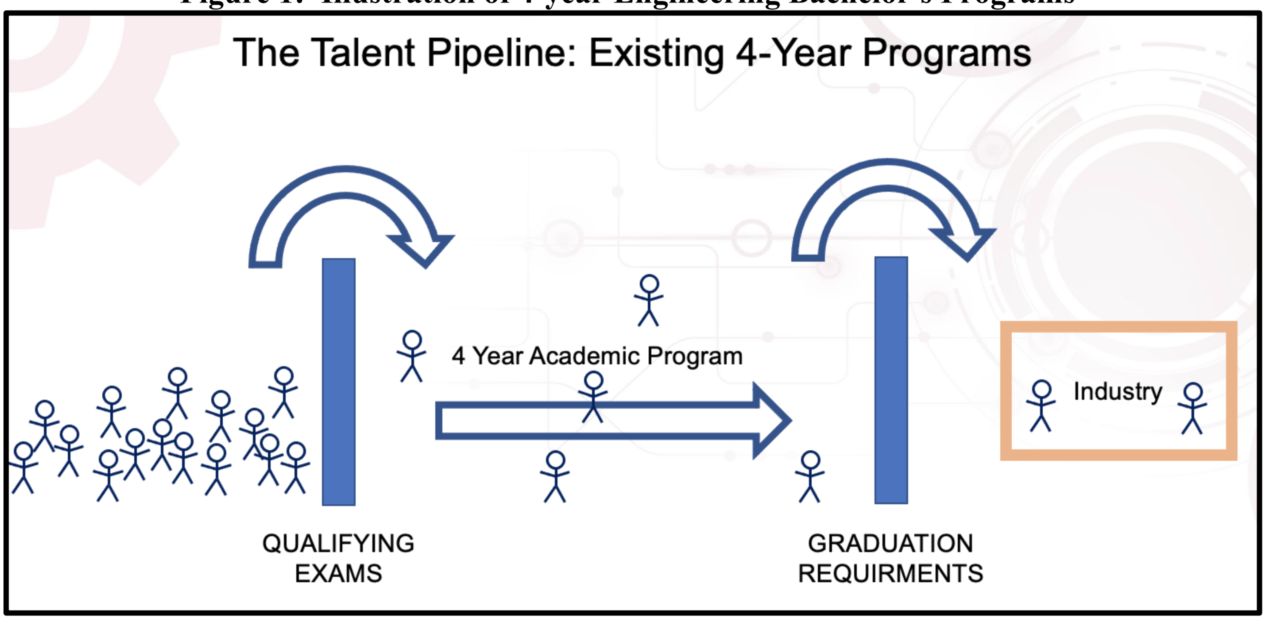
A New Paradigm, a Third Pathway for the Talent Pipeline

The existing paths, the 4-year engineering programs and the 2-year technician programs are well known, well established and continue to provide value, however; these cannot be the only paths. There are two major problems with these paths: 1) they are designed to deliver well-established, time-tested curricula, and 2) they are designed to parse-out students based on traditional assessment protocols, a standardized series of technical courses, and courses conforming to customary timing.

The technologies of Industry 4.0 are not well-established, they are not time tested, they do care about assessments, and certainly will not wait for any approved timing schedules. Technology breakthroughs occur when they occur, disruptions occur at any time and the demand for talent waits for no one, no school, no company, and no society. The socio-technical ecosystem is straining the talent pipelines of paths 1 and 2.

The issues associated with path 1 (and similarly for path 2) are illustrated in figure 1.

Figure 1: Illustration of 4-year Engineering Bachelor's Programs



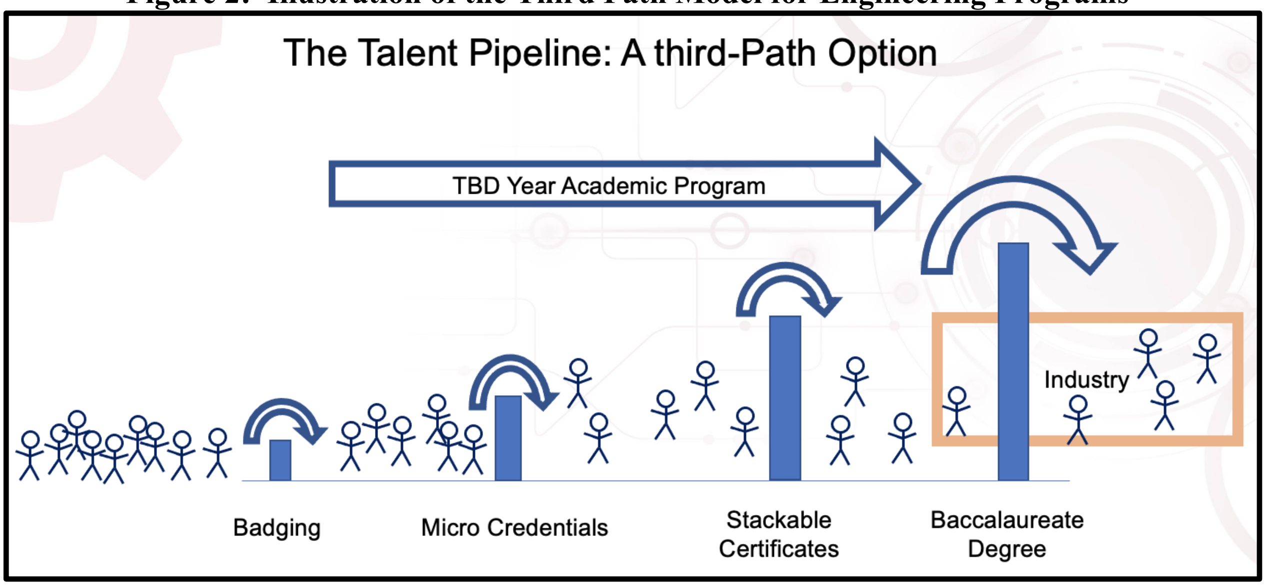
On the left of the illustration, we see the general population of high school students, typically 18-19 years of age. The general population comes from a wide range of high school districts. It is well documented that the quality of education varies widely and inequitably depending on a variety of stratifications [2]. The first hurdle, illustrated by the blue bar in the figure, is a set of qualifying exams based on well-established, traditional topics. The purpose of this hurdle is to pre-determine the probability of student success in the well-established, traditional programs. Clearly, the quality of the high school education is a major factor. Students from weaker high school districts are clearly disadvantaged, and disproportionately "filtered-out" of the talent pipeline. The third path will attempt to open doors for these students.

In the middle of the figure, the 4-year programs run in prescribed schedules of semesters, schedules, and class designations. For the sake of the academic institution's efficiency, students are grouped into classes (Freshmen, Sophomores, etc.) and processed in a one-size-fits-all system. It is well known that students learn at different rates, in different styles, with different effectiveness.[3] But, the 4-year programs march on, expecting students to conform to the schedule, or wash out. The third path offers students the option to learn how they want to learn, using learning tools that work for them, not forcing them to conform to how the instructors want to teach, and not forcing the pace the institution wants to enforce.

The final hurdle, indicated by the second blue bar, are the graduation requirements of the bachelor's degree. This hurdle includes requirements meant to assure a "well rounded" engineer, with knowledge in the arts and humanities, awareness of business fundamentals and cross-functional disciplines. The authors certainly support the principles driving the development of the well-rounded engineer, but question whether the broad scope of study MUST be completed in 4 years. The third path allows the students to gain this broad perspective when they are ready to learn it, when they are ready to appreciate it, when they are cognitively developed sufficiently to truly embrace it.

The third path approach is illustrated by figure 2. Notice the hurdles are smaller, and spread out over a longer period of time.

Figure 2: Illustration of the Third Path Model for Engineering Programs



Once again, the general population of high school students are shown on the left side of the diagram, but the third path acknowledges that they come from a variety of backgrounds, with extreme variations in their quality of education. The first hurdle, illustrated by the blue bar, is very different in nature than the large hurdle of the 4-year program. Instead of acting as a barrier, it is a means of identifying a path into the talent pipeline. The path is chosen to fit the student's needs, diaries and motivations. Badges are awarded as students engage in "learning modules" which align with their interests and backgrounds. Students are not excluded from the pipeline.

The next hurdle, labeled "micro-credentials", represents collections of badges. A micro-credential is awarded for competency demonstrations which may be in the form of presentations of a body of work, or completion of a set of discipline-specific tasks, or by the traditional mode of passing a course of study, or by passing a competency exam. For comparison to the traditional paths, a micro-credential might be thought of as the equivalent to completion of a 3-credit course. Each micro credential can be achieved at a pace that suits the student. The topics can be focused on the technical interests of the student, while ancillary courses can be completed at a different pace if desired.

Badges leads to micro-credentials, which leads to stackable certificates, and eventually the baccalaureate degree. As the illustration shows, the degree may not be awarded until well after the student has entered the workforce, but all the while delivering value to an industry employer. The course of study is completed at a rate suited to the student.

Another important feature of the third path is the unique monetary relationship between the student, the academic institution and the industry employer. In this new paradigm, the student's relationship with industry begins immediately upon entry into the academic institution. It will be in the best interest of both the student and the employer to fast-track the studies pertaining to much needed specific technical needs. The student focus is on rapidly proceeding with the critical course of study, while covering ancillary courses where possible.

The employer will also want to assure the student exhibits employability skills such as regular attendance, cooperation with fellow workers and workplace etiquette. The students avoid crushing tuition debt, the employer has the opportunity to evaluate the student-employee and receives much needed technical support as rapidly as possible.

The academic institutions may resist the third path model. No longer are they the sole-provider of education for individual students. Students and employers will have the opportunity to "shop" for the best courses, the best instructors, and the best delivery methods to suit the corporate learning and development demands. academic institutions must compete for opportunities to deliver education services, and may also compete to become certified providers of badges, micro-credentials and stackable certificates.

Summary and Call to Action

In conclusion this work covered five primary areas leading the recommendation of a new industry centric technical education model that can be built out and prototyped.
To frame the socio-economic environment, we documented a series of four central transforming forces shaping the landscape and society in general. Next, we identified and validated the challenges and opportunities associated with creating a diverse and inclusive digital workforce to meet the needs of industry and foster social well-being.
And finally, we set forth a new alternative technical education model that can be built out, prototyped and evaluated in practice. The new model is intended to fill areas of emerging and unmet needs not replace other established models. There are plenty of indications that a transformative change is about to happen in the education ecosystem. This is a call to action

directed at all the key constituents in this ecosystem, challenging them to make changes before the market forces them to try to morph in ways that may become an existential crisis.

References

1. "Inclusive education." https://www.unicef.org/education/inclusive-education (accessed Feb. 18, 2021).
2. "Education Equity for All." https://eduequityforall.com/ (last accessed Feb 26, 2022)
3. Impact of COVID-19 on people's livelihoods, their health and our food systems, World Health Organization, https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people%27s-livelihoods-their-health-and-our-food-systems.
4. "Industry 4.0 Implications For Higher Education Institutions: State of Maturity and Competency Needs," Universities of the future, www.universitiesofthefuture.eu.
5. *"New Vision for Education: Unlocking the Potential of Technology*, 2015," World Economic Forum report, https://widgets.weforum.org/nve-2015/.
6. "The Education 4.0 revolution: An Analysis of industry 4.0 and its effect," Intelitek report, https://www.intelitek.com/what-is-education-4-0/.
7. "The Future of Jobs Report 2018," World Economic Forum, https://www.weforum.org/reports/the-future-of-jobs-report-2018.
8. "Transforming Undergraduate Engineering Education (TUEE), Parts I-IV," ASEE-NSF workshop Report, https://www.asee.org/member-resources/resources/transforming-undergraduate-engineering-education.
9. Benešová, A., Tupa, J., "Requirements for Education and Qualification of People in Industry 4.0," 27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy.
10. Das, Kleinke and Pistrui, Reimagining Engineering Education: Does Industry 4.0 Need Education 4.0?, American Society for Engineering Education, 2020.
11. Das, Pistrui, Kleinke, Gehrig, Bonnstater, "Inclusivity in Engineering Curriculum in the Age of Industry 4.0: The Role of Internet of Things," ASEE Annual Conference, 2021.
12. Duderstadt, J.J., "Engineering for a Changing World A Roadmap to the Future of Engineering Practice, Research, and Education," The Millennium Project, The University of Michigan, 2008, Ann Arbor, MI.
13. Fisk, P. "Education 4.0 the future of learning will be dramatically different, in school and throughout life," January, 2017, https://www.thegeniusworks.com/2017/01/future-education-young-everyone-taught-together/
14. Frank Romanelli, Eleanora Bird, Melody Ryan, Learning Styles: A Review of Theory, Application, and Best Practices. Am J Pharm Educ. 2009 Feb 19; 73(1): 09. doi: 10.5688/aj730109.
15. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafora, N., Jordta H., and Wenderotha M.P.; 2014, "Active learning increases student performance in science, engineering, and mathematics," PNAS, 2014, 111(23), pp. 8410–8415.
16. Ginda M, Richey MC, Cousino M, Borner K , "Visualizing learner engagement, performance, and trajectories to evaluate and optimize online course design". PLoS ONE 14(5): e0215964. https://doi.org/10.1371/journal. pone.0215964, 2019.
17. Goede, M. " Education in a World Where There Are Not Enough Jobs," Journal of Business and Economics, June 2017, 8 (6), pp. 502-521.

18. Goldie, J. G. S., "Connectivism: A knowledge learning theory for the digital age?", *Medical teacher*, 2016, 38*(10), pp.*1064-1069. http://dx.doi.org/10.3109/0142159X.2016.1173661
19. Graham, R., "The Global State of the Art in Engineering Education," March 2018, MIT report, http://neet.mit.edu/wp-content/uploads/2018/03/MIT_NEET_GlobalStateEngineeringEducation2018.pdf.
20. Hussin, A.A.," Education 4.0 Made Simple: Ideas for Teaching," International Journal of Education & Literacy Studies, July 2018,6(3), pp. 92-98, www.ijels.aiac.org.au.
21. Klaus Schwab, The Fourth Industrial Revolution, New York, NY: Crown Publishing, 2016.
22. Mathewson, T.G., "One reason students aren't prepared for STEM careers? No physics in high school," The Hechinger Report, https://hechingerreport.org.
23. Petrick, I., Senior Director Industrial Innovation: Intel Internet of Things Groups, "How are IIoT and digitization changing the manufacturing landscape," Guest Lecture Series, Purdue University, Exploring the Applied Technologies, June 2021.
24. Pistrui, Kleinke, Bonnstetter, and Gehrig, Emerging Trends & Traits Shaping the Industry 4.0 Talent Pipeline, Automation Alley, 2018.
25. Pistrui, Kleinke, Das, and Mick, Closing the Skills Gap in Engineering Education: A Multidimensional Perspective, Automation Alley Research & Development January 25, 2021.
26. Pistrui, Kleinke, Das, "The Industry 4.0 Talent Pipeline: A Generational Overview of the Professional Competencies, Motivational Factors & Behavioral Styles of the Workforce," ASEE Annual Conference, 2020.
27. Puncreobutr, V. "Education 4.0: New Challenge of Learning," St. Theresa Journal of Humanities and Social Sciences, July-December 2016, 2(2), pp 92-97.
28. Richey, M., Chief Learning Scientist, Associate Technical Fellow, The Boeing Company, Personal Interview and Exchange, February, 24 2022.
29. Sinlarat.P, "*Education 4.0 is More than Education*," Annual Academic Seminar of the Teacher's Council 2016 on the topic of Research of the Learning Innovation and Sustainable Educational Management. Bangkok: The Secretariat Office of Teacher's Council, 2016.
30. Wallner, T., Wagner, G., "ACADEMIC EDUCATION 4.0," International Conference on Education and New Developments 2016, June 12-14, Ljubljana, Slovenia.
31. Walsh, B. L., "Education 4.0 — How We Will Learn in the Fourth Industrial Revolution," April, 2018, https://medium.com/@brianna_9.
32. White, S., Tesfaye, C.L.,"High School Physics Courses & Enrollments," Results from the 2012-13 Nationwide Survey of High School Physics Teachers, American institute of Physics, https://www.aip.org/statistics/reports/high-school-physics-courses-enrollments-0.