A Novel Concept of Engineering Finishing Schools for the Development of Industry 4.0 Employability Skills in Fresh Engineers for India's Micro Small and Medium-Sized Manufacturing Enterprises

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Abstract

Unemployability of engineers in manufacturing is mainly due to the massification of education and is a larger problem to solve than unemployment to make India a developed country. Most of the unemployable engineers are produced by privately financed institutes and especially located in the rural areas. It's found that private engineering institutes in India are nearly 3,000 and have an annual intake capacity of one million undergrad engineering seats with an average enrollment of 50% capacity. All these institutes are approved by All India Council of Technical Education (AICTE)but only few accredited by National Board of accreditation (NBA) for quality. These institutes are classified as Tier 3 institutes and the subject matter in this paper. The average annual campus placements in Tier 3 institutes are around 100,000 and the remaining 400,000are a mix of unemployed, unemployable and dropped out students.

On the other side, Micro, Small and Medium Enterprises (MSMEs) are the backbone of India's manufacturing and fueling the growth of the nation but lack innovation due to the shortage of industry ready engineers. The MSMEs can't afford to train the fresh engineers unlike the large companies and struggle to find the right skilled engineers. To solve the unemployability of engineers and shortage of skilled engineers for MSMEs, a novel approach of finishing school is proposed in this paper. To validate the need for the proposed finishing school, a short survey of the voice of the employers is conducted and results of participants around one hundred shown that a finishing school is the need of the hour for MSMEs and Tier 3 engineering students. A roadmap of the finishing school from concept to a physical prototype school is proposed in this paper to train fresh engineering Tier 3 graduates for the MSME sector. The future work will be concentrated in a specific MSMEs region in the combined states of Andhra Pradesh and Telangana.

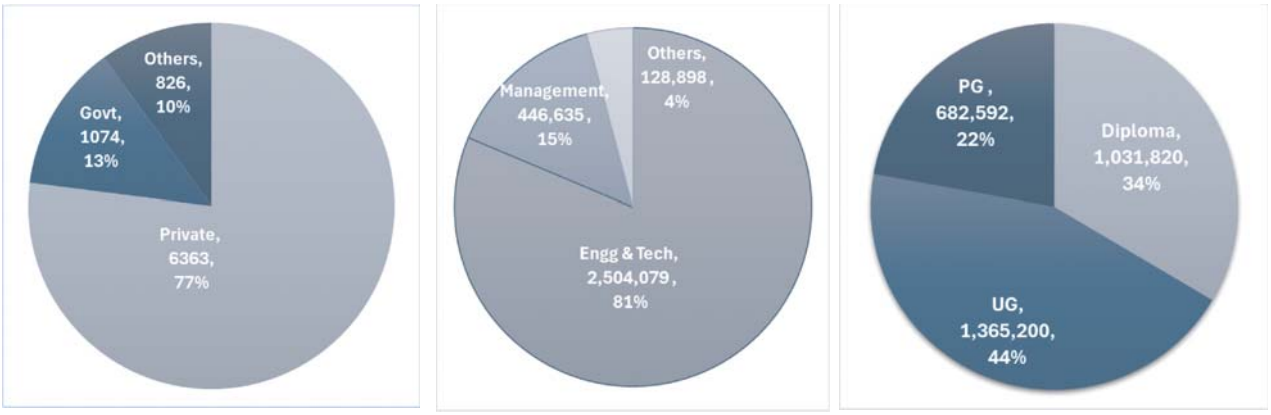
Keywords: Unemployment, Unemployability, Engineers, Skills, MSME's, Finishing School, India,Manufacturing, MSME

Education, Employment and Employability of Indian engineers:

The industrial revolution 4.0 (4IR) brings about a paradigm shift in the technologies, economy, social life, health, education, lifestyle including employment and employability. This is due to the development of advanced technologies that will replace the human workforce with automation and robotics and is changing the skills required for employment. Simultaneously, there is an increasing need for advanced cognitive abilities, social skills, and various skills related to adaptability to new technologies which is widening the skills gap and thereby, increasing unemployability. In this context, there is a growing need for changes in technical education, reskilling and upskilling to keep up with technological change and at the same time generate employment to balance the growing workforce in India.

The technical education in India is under All India Council of Technical Education (AICTE) which regulates diploma, post diploma, undergraduate and postgraduate programs in many disciplines including engineering and technology, architecture, applied arts and crafts, design, pharmacy, MCA, management, hotel management planning and town planning. As per latest AICTE's data illustrated in Fig.1, It is to be noted that over 6300 institutes are privately self-financed amounting to 77% of the total number of institutes. The government institutes are only about 13% and the remaining 10% institutes are miscellaneous. Out of all the technical education programs, the major program is engineering and technology with a share of 81%to a total available seat around 2.5 million for the year 2024.The next major program is management containing 15 % of seats and the rest are other programs. According to the number of intake capacity by type of degree, the diploma, undergrad and postgraduate degree courses constitute 34%, 44% and 22% respectively

Fig 1. AICTE data on all technical programs - 2024 (https://www.aicte-india.org/).



(i). Number of institutes (ii). Number of students by course (iii). Number of students by degree

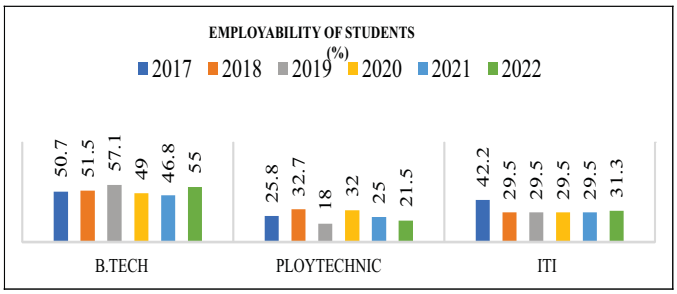
Our current study is specifically focused on the education, employment and employability of undergraduate engineering technology programs in private institutes. As per the AICTE data and illustrated in Table 1, it can be estimated that the average annual intake of engineering undergraduate students is about 1.3 million out of which only 61% of the seats are filled. It indicates that there are too many colleges and too many seats. The intake capacity has been reduced gradually over a period but not significantly.

Table1.Data on engineering undergrad education and employment.(https://www.aicte-india.org/)

All the institutes	*Intake*	*Enrolled*	*Passed*	*Placed*
2017-18	1475348	750277	754543	343834
2018-19	1404640	722269	759834	396702
2019-20	1328067	740881	648938	397740
2020-21	1286725	728443	597664	369599
2021-22	1254507	896439	636024	428823
2022-23	1274190	1035977	478096	427984
Average	1,337,246	812,381	645,850	394,114
Total	8,023,477	4,874,286	3,875,099	2,364,682
%	100%	61%		
%		100%	80%	49%

On average, about 80% of the enrolled students are completing their degree studies on time and about 49% of the enrolled students are securing employment through the campus placements. For the remaining 51% of students amounting to around 400,000, getting mainstream jobs might be bleak due to their unemployability or failure to complete the undergraduate degree on time.This statement is endorsed by the India Skills Report-2024 as illustrated in the Fig.2, by stating that only 50% of the undergraduates in engineering are employable on average over the last six years. It is much worse for diploma and ITI students which is 26% and 32% respectively.

Fig 2. India wide unemployability of technical students(India Skill report,2023).



To address the quality of technical education, the National Board of Accreditation (NBA) in India was formed and functional in 2010 by the AICTE (All India Council of Technical Education) to evaluate and accredit the quality of programs approved by AICTE. As per the data available, there are about 5,800 technical institutions approved by AICTE under engineering & technology.NBA's accreditation is given to about 2,800 institutes to run engineering programs and classified as Tier 1 and Tier 2 institutes. The remaining approximately 3,000 institutes are primarily private institutes running programs that are not accredited. In short, these kinds of engineering and technology institutes may be categorized into Tier 3 institutes, and it is to be noted that these institutes are mostly private, still approved by AICTE and produce engineering and technology graduates who are potentially dropouts, unemployable and unemployed.There is no formal data or framework to track and report these dropouts and unemployed.As per the estimates detailed in Table 1, there is an accumulation of1.5 million engineering undergrads looking for employment and over 1.0 million are dropouts or struggling to complete their degree since 2017. As per the latest literature review, the issues in education, employment and employability of the engineering and technology students may be summarized as follows.

In India, the expansion of higher education was fueled by non-state finance, market-friendly reforms, and growing societal demand from the country's middle class.The elite Tier 1 and Tier 2 institutes continued to grow slowly and serve the upper classes of society. Currently, a significant portion of higher education institutions (Tier 3) and student enrollment are owned and operated by the private sector(Varghese, N. V., & Sabharwal, N. S., 2022). Privately owned are potentially producing dropouts and

unemployable human resources due to the limited resources including shortage of trained faculty(Sharma, P., & Pandher, J. S., 2018).To increase the employability of recent engineering graduates, we must raise the bar for engineering education by collaborating with industry and updating the curriculum and syllabus to meet industry demands. The government agencies must guarantee the caliber of the engineering schools' infrastructure(Mann, K. S., Kumar, M. N., & Saini, H. S., 2015, October).Government of India offer a wide range of programs but most of these are youth employment-focused skill development programs concentrate on entry-level work (Behera, B., & Gaur, M., 2022).

Most of the students studying in Tier 3 institutes are from rural areas and with low socio-economic backgrounds.Most of these students took jobs as sales executives, in call centers, and BPO units when they are unable to pass or unemployed after four years. Furthermore, as there is no connection between their non-technical employment and education, when they fail to apply the engineering knowledge they acquired in college, they eventually forget it and stay underemployed or unemployed (Maheshvari, R., 2024).Almost all the students who passed got jobs due to the demand in industry and service sectors. Still, there is a shortage of manpower in engineering and technology, and this can be fulfilled by bringing dropped out students into the labor market by improving their employability skills (Choudhuri, P.,2021).

As a result of unemployability in undergrad engineers who are about 400,000 annually, India is losing pool of human resources who are going out of the industrial employment on whom middle class citizens, private sector and government enterprises are investing. With India's economy predicted to grow at the fastest rate in the world and its position as the nation with the greatest working-age population, the country's human capital development is of worldwide significance.The current paper investigates opportunities for unemployed and unemployable engineering undergrad students to train in a finishing school and utilize them in industry, especially in micro small and medium manufacturing (MSME) sector through structured training.

Indian MSMEs: Accelerator of growth and Employment

MSMEs consistently generate job opportunities in the industry and significantly contribute to economic growth. India's MSMEs compared to their counterparts in industrialized nations, which see significant growth, enterprises in developing economies typically remain tiny or shrink even further.The MSMEs are the major force behind the India's socio-economic transformation including manufacturing, trade and other services. As illustrated in Table 2, MSME's have a total of 63 million units and employ about 110 million workers (MSME annual report 2022-23). The manufacturing units are about one third of them and employ more in rural areas than in urban areas.The current MSMEs details, barriers to growth and opportunities are discussed in the following sections.

Table2. Estimated MSME units and employment in millions.(https:www.msme.gov.in)

# Units	**Rural**	**Urban**	**Total**	**Share (%)**
Manufacturing	11.414	8.25	19.665	31
Trade	10.871	12.164	23.035	36
Others	10.203	10.486	20.688	33
Total	32.488	30.900	63.388	100
Employment				
Manufacturing	18.656	17.386	36.041	32
Trade	16.064	22.654	38.718	35
Others	15.059	21.71	36.229	33
Total	49.779	61.75	110.988	100

The MSME sector plays a vital role in the GDP, creation of jobs, overall exports, and green development, all of which support the Indian economy.The government and business community must work together to create programs that will teach MSMEs about Industry 4.0 (Shelly, R., Sharma, T., & Bawa, S. S., 2020).In addition to reducing labor migration from rural to urban areas, MSMEs, and particularly microenterprises, can be the unsung heroes of rural industrialization, balanced regional development, mass employment, and economic growth. Furthermore, it is observed that these microunits create the greatest number of jobs (52.7%), followed by small and medium-sized businesses (41.5% and 5.6%) respectively (Sarmah, A., Saikia, B., & Tripathi, D., 2021).

Indian SMEs are clearly growing slower than their global competitors, despite their enormous potential. These businesses are more likely to produce things that are driven by the market than to develop novel products. Innovations in SMEs have the potential to grow the industry and bring Indian SMEs up to speed with developed nations (Gunjati, S. B., & Adake, C. V.,2020). For every manufacturing sector, from global corporations to small and medium-sized businesses, the shift to Industry 4.0 has become imperative. Embracing Industry 4.0 appears to be simple for multinational corporations with plenty of resources and support. However, due to a shortage of resources, MSMEs are finding it challenging to adopt Industry 4.0 technology (Karuppiah, K, et.al., M.,2023). MSMEs may encounter external and internal obstacles, including labor force shortages, inefficient technology, inadequate marketing, and competitiveness, obstacles relating to knowledge, issues with governance and administration, and infrastructure ineffectiveness. These obstacles have an impact on promoting the expansion of MSMEs (Prakash, B., Kumar, I., & Verma, J. K., 2021). It was discovered that there are five things that prevent MSMEs from innovating in technology: money for technical innovation, human resource quality, government backing, market conditions, and business partners. Innovation in MSMEs could be enhanced by the caliber of human resources via corporate collaboration, seminars, workshops, on-the-job training, and apprenticeships (Indrawati, H., Caska and Suarman., 2020).

Table 3. Estimated MSME's units and employment in millions (https:www.msme.gov.in).

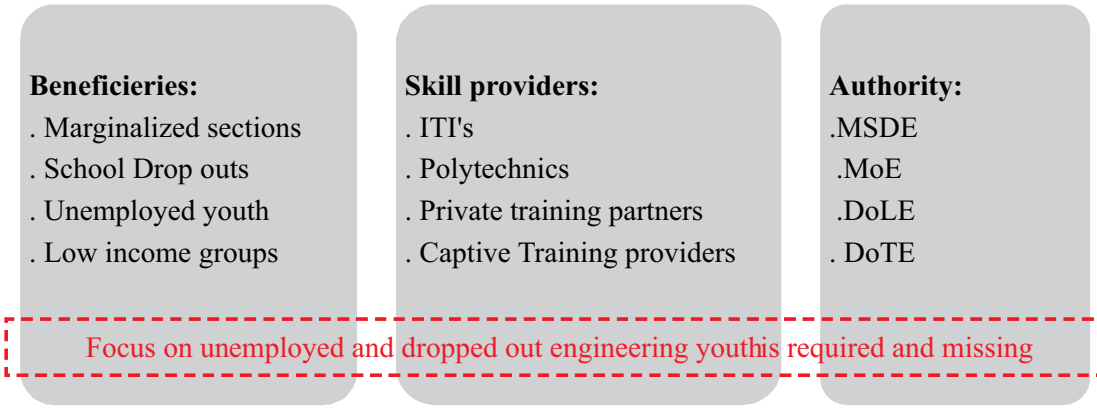
As per MSME portal	Micro	Small	Med	Total
Employment	78.262	11.645	5.351	95.258
# Units (having a turnover of Rs.10 million above)	1.42	0.1278	0.01323	1.561

According to the latest classification of MSME's UDAYAM portal, micro, small and medium enterprises as given in Table 3, are about 82%, 11% and 7% respectively. There are about 1.5 million units having a sales turnover of Rs.10 million and above. Assuming the manufacturing units are about one third, there are about 0.5 million MSME manufacturing units which can potentially absorb undergrad engineers. As estimated and illustrated in Table 1, annually, there are about 150,000 undergrad passed engineers who are unemployed and about 250,00 engineering students who may be having backlogs or dropped out from the market. If we employ one engineer for each MSME unit having a turnover of Rs.10 million, we can solve the unemployment of engineers at the same time boost innovation and Industry 4.0 skills. These students can be trained in a proposed finishing school to suit MSME's requirements and can be placed. For this, we shall create an ecosystem and framework with the MSME's and government schemes to deploy these engineers. It will generate value for MSMEs and improve quality of products, innovation and compete with the global market.

Literature review of skill development for unemployed engineers in India:

According to the Development Monitoring and Evaluation Office (DMEO),NITI Aayog, India report, 2021, there is a well-documented and monitored skill development eco-system for vocational, ITI, diploma and school/college dropouts as illustrated in the Fig.3.

Fig 3. India wide skill development eco system: Source(NITI Aayog report,2021)



The present focus of India's skill development initiatives is mostly on short-term skilling to give school and college dropouts, unemployed graduates, and informal laborers alternate avenues for earning cash. Most of this is the legacy of the inadequately performing Indian educational system delivering at scale high-quality formal education, whether it be vocational or general (Gupta, R., & Dharap, O.,2024). But there is no such system for unemployed engineers and engineering dropouts. The current higher education system is ill-equipped to handle the issue of massifying engineering education in growing nations like India and difficult to address by higher educational institutions in the last decade or soon since it entails significant adjustments in the investments and programs of the government. The present investigation suggests endorsing distinct finishing schools for engineering undergrads and getting them ready for MSMEs. Numerous research studies have reiterated training requirements of engineering students and their employability skills improvement after such focused training like the AICTE proposed finishing schools as discussed below.

It is suggested distinct vocational schools for jobless requirements for graduates in the IT services sector (Garcia, P. M., & Bafundo, F, 2014) to improve employability and employment opportunities. In addition to readily available and reasonably priced training choices, customized programs that cater specifically to the needs of rural communities can aid in closing the skills gap and fostering economic development in these places. (Waghulde, D., Kate, S., Ghuge, N., & Sharma, M. P., 2023).In the Industry Oriented Training (IOT) program, students can stay up to date on industry trends and technological advancements, enhancing their competitiveness and flexibility in an employment market that is changing quickly (Toney, G., Bhat, et.al., 2024). IOT courses aid with personal development, self-assurance, and cultivating a mindset of constant learning in addition to increasing work prospects. Programs for experiential learning, which emphasize learning by doing, almost always provide complementing active learning models, such as community-focused service learning, cooperative learning, which focuses on group dynamics, and situated learning, which emphasizes social context (Nair, P. R., 2020).Industry experts and HR managers state that the only way engineering students may obtain the technical skills needed is by completing their six-month industrial training program at an appropriate

location (Finishing schools) using market-driven technologies. In the current, internationally competitive industrial and economic contexts driven by new technology, industrial training is essential to meeting industry standards and expectations (Singh, H., & Arora, H., 2015).

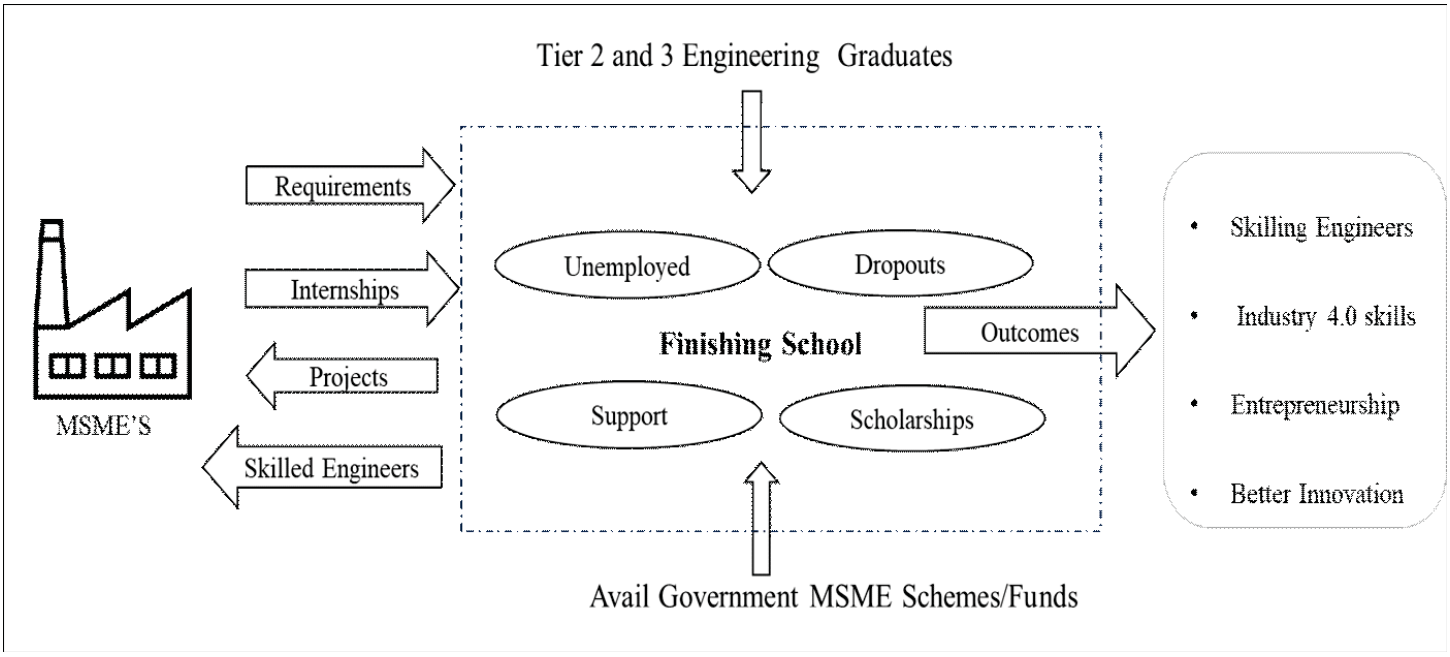
In summary, the MSMEs can benefit from finishing school as a bridge to their barriers of growth by employing engineers who will be trained to suit their specific Industry 4.0skill requirements. This will boost the growth of MSMEs along with the employment generation. The framework for a finishing school in line with MSMEs and Industry 4.0 skills is proposed in the next section.

Finishing Schools: A bridge between MSMEs and Engineers

A finishing school is a private school for students that prioritizes training for the development of an all-around personality, skill, knowledge, and ability required by the industry, according to the All-India Council for Technical Education (AICTE) suggested over a decade ago. The goal of the finishing schools is to equip students with both soft and technical skills so they can contribute to the industry's supply side problems and increase their employability. Programs for finishing school are a relatively new phenomena, despite being an ongoing trend that is being increased in several nations. Because this training platform has demonstrated satisfactory outcomes in terms of the objectives accomplished, India and the Philippines, leaders in ITO and BPO, are the most experienced countries in developing finishing schools for global services(Garcia, P. M., & Bafundo, F, 2014). A quick investigation into engineering finishing schools in India reveals that just a few government and private institutes have established a dozen schools since 2010. It has been noted that many finishing schools are addressing the needs of IT services and focusing more on training the newest IT-related technologies.

There is no finishing school offering or designed to meet the needs of MSMEs, Industry 4.0 and unemployed engineers for the Indian manufacturing sector. As illustrated in Fig 4, a framework for the finishing school is proposed between MSMEs, Government schemes and unemployed engineering undergraduates from Tier 2 and Tier 3 colleges.

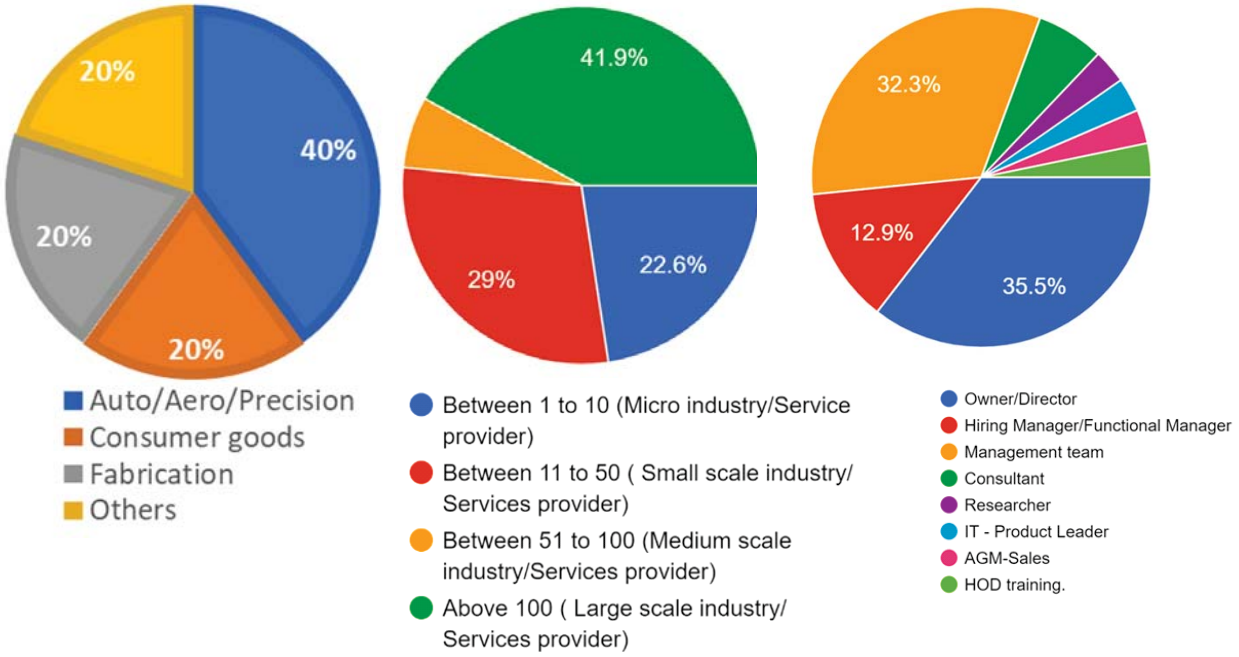
Fig. 4. Proposed engineering finishing school framework for MSMEs



Hypothesis: The finishing schools may be established in the surroundings of MSMEs industrial zones or district of a particular state in India in collaboration of specific manufacturing sector. The finishing schools must develop training and internship courses in conjunction with the MSMEs industry 4.0 skills requirements. The unemployed engineers may take the courses according to their interest of specific role and industry. The finishing school may coordinate with MSMEs to give students specific job-related training at the school through MSMEs projects and internships. The finishing school may create short term and long-term hybrid courses to fulfil the demands of MSMEs industry 4.0 skills. The student must get an opportunity to get on the job training like experience at the finishing school through MSMEs. Once the training is completed, the MSMEs can absorb the qualified and competent students as full-time engineers at their respective industry.

To support and validate the proposed hypothesis of a finishing school for manufacturing industries and employability of engineers, a short survey is conducted to understand the Voice of the manufacturing employers in Indian MSMEs. Over 100 employers engaged in Manufacturing and active in social media platforms have been contacted through a google form with a set of ten questions. The oobjective of the survey is to understand the perception of the employers about the need for a finishing school and how to train the unemployed with the industry 4.0 skills for MSMEs. The survey questions and results are discussed in the following section.

Fig. 5. Proposed engineering Voice of the employer survey - profiles of the employers



- *Q1 to 3- Profiles of the employer's:*

  The profiles of the voice of the employers surveyed are summarized in Fig 5. About 40 % are from Auto and rest are from fabrication, consumer goods and other manufacturing industries. The survey participants are mostly from MSMEs (59.5%) and are either owner/director (35%) or management (32%) or hiring manager (13%).

- *Q4- Do you support the concept of finishing schools to train engineers with diploma and degree and supply them to manufacturing industries?*

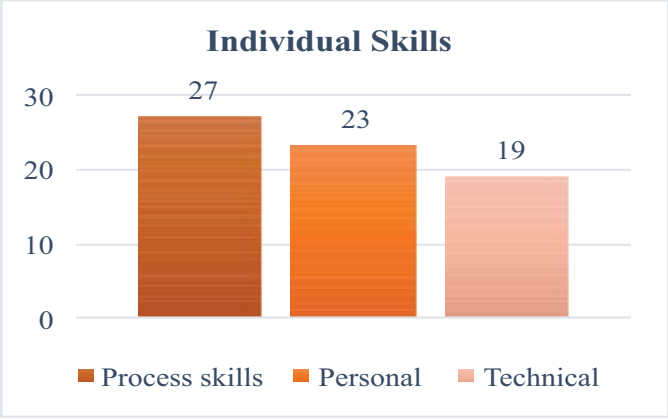
  The answer is yes from 90% of the participants and others need more information. This is good news for the author to pursue the hypothesis of development of a finishing school.

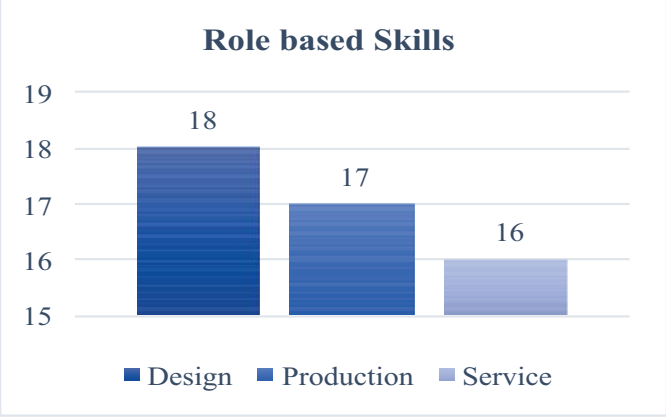
- *Q5- How difficult is it to find suitable engineers and how long does the training needs to be ?*

  About 40% of the employers said that there are plenty in the market, but they can't find suitable engineers. About 30% of the employers said that they must spend at least six months to one year in their training. Many MSMEs said they can't afford the cost and time of training in-house.

- *Q6- What are the employability skills sought out of process, personal and technical abilities?* The employer's topmost requirement is the process related problem-solving skills next to personality and the last requirement is the technical skills (Fig 6).

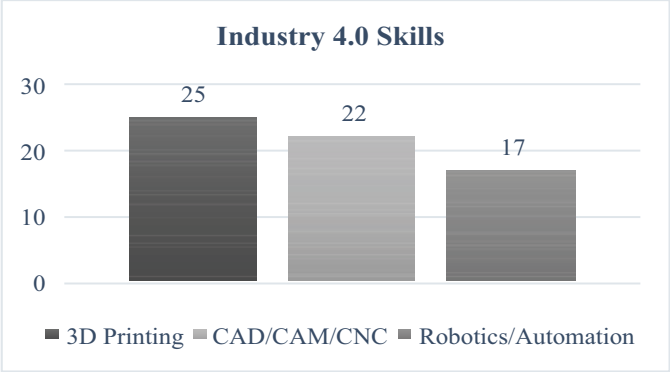
Fig 6. Voice of the employer survey - Employability skills

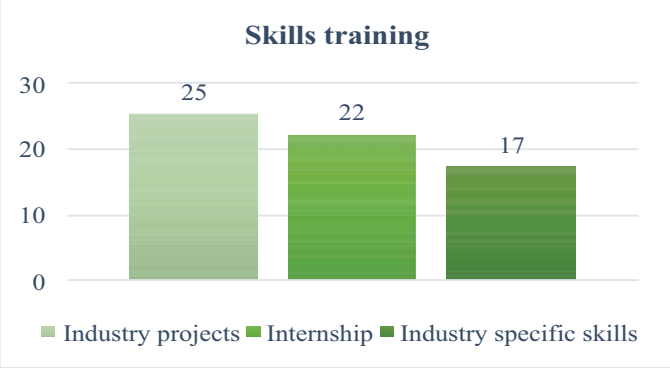




- Q7- What are the industry related roles in which the engineers must be trained in finishing school? The majority said the role-based training must be in design engineering related.

Fig 7. Voice of the employer survey - Industry 4.0 skills and Training





- *Q8- What are the industry 4.0 skills required to acquire by the engineers in finishing school?*

  Most employers need additive manufacturing and advanced manufacturing technologies including CAD/CAM/CNC/AI/IOT related skills (Fig 7).

- *Q9- How to train unemployed engineers in a finishing school?*

  The overall choice of training is hands on approach using industrial projects and spending time in an actual industrial environment rather than a classroom (Fig 7).

- *Q10- What must be the admission criteria for finishing school?*

  The employers' survey shows that there must be a screening criterion to admit the unemployed engineers into finishing school as not all the unemployed can be trained to meet the industry requirements.

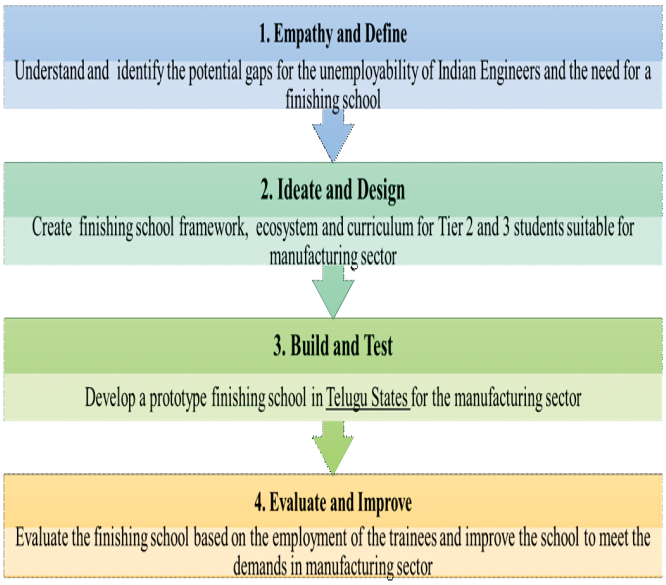
In summary, the preliminary voice of the employer survey results in favor of the hypothesis that a finishing school is the way forward to the fulfillment of MSMEs engineering

technology manpower draught and provide employability skills to the Tier-3 engineering college students for their employment needs. The future work is discussed in the next section.

Future work–Development of a roadmap to the finishing school

Finishing schools to bridge MSMEs and unemployed engineers from Tier 3 colleges in India is a novel concept to address unemployment and barriers of MSMEs to grow into Industry 4.0 environment. The finishing school concept needs to be developed and tested in a real MSMEs environment. There are four main objectives of the research as illustrated in Fig8.The design thinking process (Cross, N., 2023)is used to provide an innovative solution to the unemployability of engineers and MSME's growth through finishing school. These four objectives are mapped with the four steps in the design thinking process; Empathy, Ideate, build and evaluate respectively.

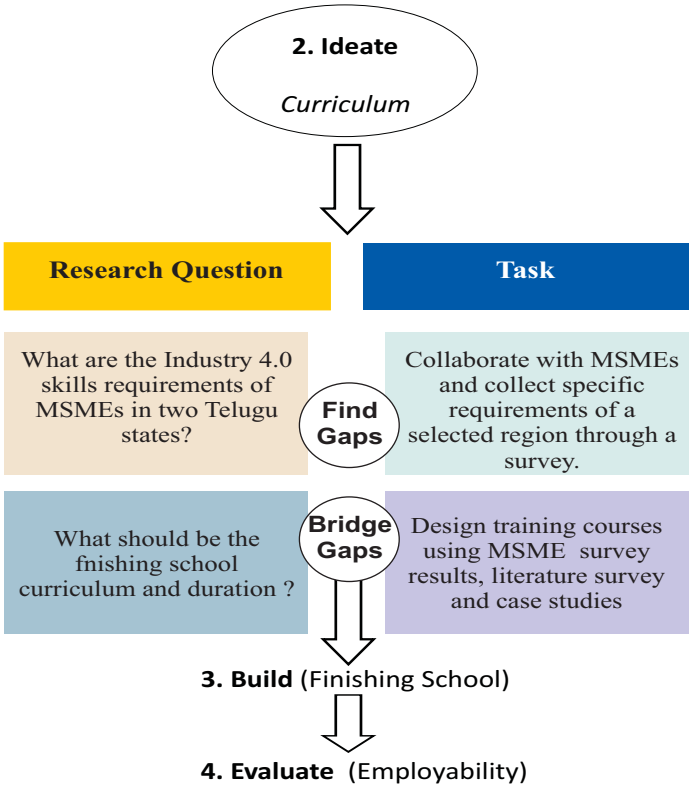
Fig 8.Steps and Objectives of the research: Design and development of a Finishing school using Design Thinking process.



The current paper fulfills the initial step of empathy, that is understanding the unemployability of engineers and the need for a finishing school for the MSMEs employees. The need for the finishing schools is very clear from the survey and the literature discussed in this paper. The future research is to work on the second step, Ideation in which the finishing school framework, eco system and curriculum is to be developed. The engineering accreditation bodies, such as ABET and NBA, outline the necessary skills but fail to address the crucial question of how they should be acquired. The primary issue in developing employability skills is how to effectively train students to be employable, as opposed to what qualities make someone employable.

Research question: The overall goal of the research study is how to develop a scalable and sustainable finishing school model for the fresh engineering graduates to acquire employability skills and empower to get employment in the MSME manufacturing sector.

Fig 9. Workflow of Stage 2: Ideation of the finishing school curriculum



Several studies found that training students in a controlled environment using Kirkpatrick's corporate training model through internship program yielded positive results. The intended ideation stage of the finishing school will be concentrated in the combined state of Andhra Pradesh to cater to the needs of MSMEs located in two Telugu states. The future workflow for the research is illustrated in Fig 9. The research will be concentrated in the two Telugu states and further around a selected region of MSMEs. After finalizing the locations of MSMEs, a survey will be conducted to collect the employability requirements of that specific MSMEs cluster to build finishing school for that particular rural engineering students of that location. Once the requirements are collected, the curriculum would be developed for the finishing school training pertaining to the specific MSMEs and to that regional engineering students. After the curriculum, a prototype finishing school will be built for the same region with the support of MSMEs, local stake holders and government schemes. The students will be recruited through a screening process and training will be completed. The students will be evaluated based on the desired employability skills required by the MSMEs and industry 4.0. All the stages are planned to be completed by the end of 2025.

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