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A Study on the Perspective of Industrial Technicians on Developing High-Speed CNC Machining Competencies for Mechanical Engineering Students in Higher Vocational Colleges

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ABSTRACT: Nowadays, modern manufacturing is being transformed by advanced technologies that make production faster, more accurate, and less dependent on repetitive manual work. Machines and systems can now perform tasks with a level of precision that was once difficult to achieve, while also saving time and resources. As the primary focus of cultivating skilled personnel, higher vocational colleges must precisely match technical requirements, particularly by strengthening adaptive skills development within relevant professional courses. This study aims to explore the perspectives of industrial technicians on the development of high-speed CNC machining competencies for mechanical engineering students in higher vocational colleges. This study seeks to identify the specific skills, knowledge areas, and professional qualities that technicians consider essential for future workforce readiness. By gathering insights directly from industry practitioners, the research aims to bridge the gap between vocational education and industrial requirements, thereby supporting the creation of a more relevant and effective CNC competency training framework.

Keywords: High-speed CNC Machines, Professional Competencies, Industry technicians, Higher Vocational Schools.

I. INTRODUCTION

In today's rapidly evolving manufacturing sector, it is crucial to gather the views of industry technicians to align educational outcomes with the needs of the industry. Technicians have first-hand experience of the practical skills, knowledge, and problem-solving skills required in real-world CNC machining environments.

They help to bridge the gap between academic work and the actual needs of the workplace so that the students are properly equipped to work [1]. Research consistently demonstrates the critical need to align educational outcomes with industry requirements through direct industry input. The technology gap between engineering schools and industrial standards represents a significant challenge, with outdated curricula and poor learning outcomes failing to meet hi-tech industry workforce needs [2]. Industry-academia collaboration is essential for analytical thinking that links theory with practice, requiring efficient joint ventures between learning institutions and industry partners [3]. Statistical analysis confirms that skill development is indispensable for bridging the academia-industry gap, with stakeholder involvement from academia, industry, and government being crucial for success [4]. Technical and vocational education institutions particularly struggle with weak outcomes in qualifying graduates for industrial sector requirements, necessitating direct verification of job requirements against educational program outputs to ensure graduates possess the technical skills demanded by employers [5]. Besides, research on aligning mechanical engineering vocational education with industry needs reveals significant gaps and opportunities for improvement. Studies demonstrate that product-based learning models integrating industrial activities can effectively enhance mechanical engineering competencies when industry stakeholders are involved throughout the learning process [6]. Work readiness among machining engineering students is substantially influenced by problem-solving skills (54.6%), which are themselves affected by technology, teamwork, and self-management capabilities [7]. Assessment of competency relevance shows strong alignment between vocational machining practices and manufacturing industry needs, with CNC/computer-aided manufacturing competencies achieving 97.10% high relevance [8]. However, despite high curriculum alignment rates (85%) and strong technical competencies in cognitive (86%) and psychomotor (86%) aspects, significant deficiencies persist in soft skills, including workplace safety culture, work ethics, and industry-standard practices like 5S principles [9].

II. RESEARCH METHOD

This study is quantitative and uses a descriptive research method to examine the level of importance of competencies in high-speed CNC (Computer Numerical Control) machining for industry technicians. Because this research method focuses on measurable outcomes and applies rigorous statistical analysis, the effectiveness of the training is determined by the conclusions drawn, which are based on empirical evidence and not on narratives or subjective judgment.

For this study, it mainly focused on three basic Competencies (Technical, Cognitive, Behavioral), and a five-point scale questionnaire was used, which ranges from “Not important” to “Very important”. This scale helps the respondents to express the degree to which they agree or disagree with the items in the study, therefore making it easier to determine the level of importance of the factors under study.

2.1. Population and Sample

A study on the perspective of Industrial technicians on development of competence in high-speed CNC (Computer Numerical Control) machining was conducted on participants Average job experience of the

industrial technicians was 7 years, and some of the technicians had up to 20 years of technical experience in the industry, including some who held senior positions like CNC shop managers, lead machinists, or technical consultants in China, Tianjin City. Industrial Technicians, however, held a variety of educational levels from technical diplomas to advanced levels of mechanical engineering. Also, all participants had undergone strict training in CNC machining and were currently engaged in the industry, thus making their inputs credible.

III. RESULT AND DISCUSSION

3.1. Analysis of Industrial Technicians' Perspective

In this study, the Statistical Packages for the Social Sciences (SPSS), Version 27.0 for Windows, was applied for the analysis of quantitative data. The Likert scale 5 (Not Important=1, Least Important=2, Moderate=3, Important=4, Most Important=5) was used as the main method of data analysis for measuring basic Competence development on High-speed CNC machines for students in higher vocational Schools. Descriptive analysis techniques were used to analyze the data collected for this study. It uses descriptive statistics to present the data in a convenient form to describe the data set, using measures such as the mean, median, standard deviation, etc. In order to determine the level of importance of the competencies in high-speed machine technology, a Friedman test was conducted using SPSS version 25. The mean rank of 29 variables was identified and presented. The test statistics reveal that the Friedman test yielded a Chi-Square value of 250.955 with 44 degrees of freedom in Table 1. The associated asymptotic significance (Asymp. Sig.) value is reported as < .001, which indicates a statistically significant result. The very low p-value indicates that the observed perception differences between selected competencies by industrial technicians are very unlikely to have occurred through chance alone.

Table 1- Friedman Test Statistics

Test Statistics	
N	29
Chi-Square	250.955
DoF	44
Asymp. Sig.	< .001
a. Friedman Test	

3.2. Competence Data Analysis of Industry Technicians

The analysis of Behavioral Competencies, Cognitive Competencies, and Technical Abilities gives a clear picture of the skills that are critical for the success of higher vocational students in their chosen paths. Thus, based on the data, recommendations can be made for curriculum development, training methodologies, and industry alignment. The behavioral competencies are mainly on workplace safety, effective tool usage, and operational precision. Safety skills such as the use of personal protective equipment (PPE), fire extinguishers, and safe handling of tools were highly rated in terms of importance, with average scores above 4.5. The low standard deviations in this category show that there is a high level of agreement on their importance in the workplace. Quality assurance-related competencies like preparing checklists and inspection reports were also found to be important. These findings indicate that it is important to incorporate safety features and quality control into the training modules to create a safe and effective work environment. Cognitive competencies are focused on analytical and decision-making skills, machining requirements, technical drawing interpretation, and the selection of tools and processes. Skills such as verifying the 4th and 5th axis requirements and referencing machining operations were rated highly, with average scores of 4.66 and low standard deviations (0.614). On the other hand, some skills for instance, understanding surface roughness symbols, had slightly more varied ratings, which could be attributed to the need for specific guidance on their application. Simulation-based learning and advanced software tools can help students acquire these skills and be ready to handle any machining task. Technical abilities are the practical and applied competencies that are critical for vocational students. Basic skills such as identifying work-holding devices, basic milling and cutting operations, and programming with G-code and M-code were all rated as “Most Important,” with average scores of about 4.69 and very low variability. Simulation, hands-on experiments, and video clips can be used to address these gaps, while incorporating real-world machining projects in training programs will also address these gaps in addition to reinforcing the necessary skills. The data also shows that a harmonized curriculum should address safety, cognition, and technology. Safety and basic operation skills are viewed as essential and straightforward, while the more complex technical skills need a more focused approach to meet particular industry needs. Furthermore, the low variability in some core skills indicates that there was a good agreement on the important areas, which can be used as guidelines in curriculum development.

V. CONCLUSION

In this study, the behavioral competence analysis shows that the industry cares about safety in the workplace, emergency measures, and knowledge of production processes to ensure that students can work safely and properly in high-speed CNC environments. These findings support the need for practical and applied training, SOPs, and actual machine operation for students to be fully industry-ready. On the other hand, Industry Technicians' feedback reveals that students need to acquire sufficient cognitive skills in the process, including analysis, programming, and machine operation. They should, therefore, be trained in theoretical knowledge integrated with practice to enable them to face industry challenges. Therefore, Higher vocational schools should

concentrate on critical thinking and problem-solving to develop very efficient CNC machinists who can easily solve problems in the ever-changing manufacturing industry. Lastly, industry technicians believed that students need to acquire good technical skills in work-holding, process planning, CNC programming, and machining operations to the level of industrial standards. Thus, theoretical knowledge combined with practical application can help students to solve high-speed CNC machining tasks.

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