JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Study on Developing High-Speed CNC Machining Competencies for Mechanical Engineering Students in Higher Vocational Colleges

Belay Abakuma Getachew[1,]

Tianjin University of Technology and Education, Tianjin 300222, China

School of Mechanical Manufacturing and Automation Engineering, Tianjin, China.

ABSTRACT: The rapid development of high-speed CNC machine tool technology is driving the manufacturing industry's transformation toward precision and efficiency, significantly increasing the complexity of related operational skills. 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. However, most higher vocational colleges currently lack a well-structured professional competency framework for high-speed CNC machine tools, resulting in insufficiently targeted professional skills instruction and a struggle to effectively bridge the gap between industry demands and student preparedness.

This study addresses the need for professional competency Development on high-speed CNC machines to bridge the gap between industry requirements and students' awareness and readiness. The primary objective of this research is to develop students' competencies in high-speed CNC machines, enhance the quality of training, and produce competent graduates.

Keywords: Higher Vocational Schools, High-speed CNC Machines, Professional Competencies, Competency framework.

I. INTRODUCTION

These days, the integration of advanced technologies in the modern manufacturing industry has really delivered in terms of improved precision, efficiency, and automation of production processes [1]. Among these innovations, CNC machines have become a foundational tool that enables the production of complex parts with a high degree of accuracy. However, as more industries implement CNC technology, there is a rising need for

qualified workers to take care of these complex systems. In the manufacturing industry, there is a growing need for qualified personnel to work on and lead teams that use high-speed CNC machines. These machines are very precise and very efficient, but to get the best out of them, one needs not only technical knowledge but also problem-solving skills, flexibility to change to meet changing production needs, and a good understanding of the fundamentals [2] [3]. Higher vocational schools are crucial in closing the gap between the market requirements and the capabilities of the current workforce. The growing demand for CNC machine operators and technicians cannot be addressed without adequate training programs that go beyond theoretical knowledge and emphasize practical competence [4]. To this end, the trend should shift from the traditional learning methods to the Competency-Based Training (CBT) model, which focuses on the development of skills, their application, and mastery [5]. It has been noticed that the application of CNC machines is leading to the transition from the objectivist instructional paradigms to the cognitivist and constructivist approaches. CNC machines are now essential in the modern manufacturing process, achieving precision, efficiency, and versatility to the highest degree. This has been made possible through the integration of computer programming in the management of machine tools to produce parts and components that are accurate and complex in shape. The accuracy is best noted in any industry where quality control is a major issue [10]. It is also a type of machining that can generate repetitive and accurate shapes and sizes of parts and components within a short time. The precision of the CNC machines is especially important in those industries where quality control is extremely important. These machines are capable of producing elaborate shapes and configurations of parts to the desired tolerance required by the client. Moreover, CNC machining is much faster than conventional methods. These machines can run without stopping once they are set up, by reducing downtime and enhancing productivity. CNC machining is also quite effective in terms of profitability. In this regard, the reduction in human interference and mistakes means that companies can minimize losses and rework, thus improving the utilization of resources [11]. Giving students practical experience of using such manufacturing technologies as CNC machines will be helpful for them to face the future requirements of the labor market [12] . These machines require a combination of technical skills and innovative thinking, which makes them an ideal choice for educational institutions aiming to equip their students with future-ready skills.

II. RESEARCH METHOD

This research adopts quantitative research, which uses the descriptive design. The quantitative research method was chosen because it can generate precise and accurate data that can be easily analyzed statistically. This methodological approach is characterized by the use of quantifiable variables, which are quantified and analyzed in order to make conclusions about the existing relationships and effects in the population under study. The main advantage of the quantitative method is that it produces conclusions that are generalizable to the population as a whole and that can be used to guide educational practices and policy decisions [13]. This study's data collection is an important part of this research. Quantitative data will be collected through surveys and standardized tests, thus allowing numerical values to be ranked, categorized, and analyzed.

2.1. POPULATION AND SAMPLE

A study on the development of competence in high-speed CNC (Computer Numerical Control) machining was conducted on participants from three different higher vocational schools in Tianjin City. This study was conducted to find out more about the development of competencies in high-speed CNC machining among Bachelor of Science (BSc) degree students and to evaluate the effectiveness of the educational practices and curricula used in these programs. Students, instructors, and industry professionals were part of the participant groups and were chosen for this study based on their relevance to the study's objectives.

III. RESULT AND DISCUSSION

3.1. ANALYSIS OF HIGH-SPEED CNC MACHINE STUDENTS' COMPETENCIES

The Statistical Packages for the Social Sciences (SPSS), Version 27.0 for Windows, was used in the analysis of quantitative data. The Likert-scale 4 was used as the primary method of data analysis for measuring the students' basic high-speed CNC machine competencies. These basic competencies for CNC (Computer Numerical Control) machine operation include all the skills and knowledge that a student needs to possess in order to be able to set up, program, operate, and maintain the machine. These competencies are usually classified as technical, cognitive, and professional behavior to make sure that students are not only competent with the machines but also able to solve problems and adhere to safety protocols in the real world. To determine the level of importance of the competencies of students in high-speed machine technology, a Pearson chi-square test was conducted using SPSS version 27.0. The mean rank of 26 variables was extracted and analyzed, and reported with a correlation analysis result > 0.5, which indicates a strong relationship between all three competencies [101]. Besides, the test statistics reveal that in the Pearson chi-square test, the asymptotic significance p-value is reported as <.001. , which suggests that the perceived differences in competencies among high-speed machine technology Students are unlikely to be due to chance alone.

3.2. COMPRESSIVE ANALYSIS OF THE STUDENT COMPETENCIES

The survey results on students' professional competence with high-speed CNC machines in higher vocational schools reveal several major aspects in which students have some potential, as well as areas for improvement. Concerning the various aspects of CNC production, from the technical point of view, safety regulations, the environment, partnership, scheduling, and professional growth, the students can be described as having a basic to moderate level of competence. Nevertheless, the existence of gaps between their skills and knowledge indicates that they need more support, training, and motivation to be able to face the challenges of the CNC industry, which is growing rapidly. The results of the survey indicate that students are willing to learn and develop, and a majority of students are interested in the new CNC technologies, methods, and applications. Nevertheless, some groups of students are not proactively looking for training or even engaging in learning activities beyond the minimum required to maintain their employment in the field. Therefore, vocational schools

need to enhance the learning culture of continual development and ensure that students have access to information about the current issues in the CNC field. Moreover, students in the study reported some level of effectiveness in arranging their workspace, obeying safety rules, and having a new understanding of environmental concerns, but the use of these practices was not consistent.

Vital measures include enhancing students' organizational skills, reaffirming safety regulations, and increasing students' understanding of environmental standards in order to enable them to work efficiently and correctly in professional CNC settings. Therefore, students in the higher vocational schools have a good understanding of the CNC processes, but several areas need improvement. Thus, it is possible to increase the frequency of professional development, safety, and environmental responsibility, and increase the awareness of innovative technologies in order for higher vocational schools to guide students better equipped to face the future of the CNC machining industry. Promoting a positive attitude towards learning, safety, and the environment will help students to acquire the right skills and attitude to excel in the manufacturing industry.

IV. CONCLUSION

This research on the competence development in high-speed CNC (Computer Numerical Control) machining for students of higher vocational Schools was done in order to contribute to the body of knowledge on the competencies that are needed for high-speed CNC machine operation, programming, and maintenance in higher vocational education. The findings can help inform and enhance the curriculum of higher vocational schools by determining the various competencies that are associated with high-speed CNC machines, developing specific training programs that are in line with the needs of the industry, and determining the right balance between theoretical knowledge and practical application.

REFERENCES

[1] M. A. M. & I. K. Alokshe, "Advanced Manufacturing Technologies, Strategic Agility, Business Network And Sustained Competitive Performance: An Empirical Evidence From An Emerging Economy," Humanit Soc Sci Commun 12, P. 391, 2025.

[2] I. P. E. A. Okokpujie, "A Review of Recent Application of Machining Techniques, Based On The Phenomena Of CNC Machining Operations.", Procedia Manufacturing 35, Pp. 1054-1060, 2019.

[3] M. E. A. Wasif, "Optimization Of Simplified Grinding Wheel Geometry For The Accurate Generation Of End-Mill Cutters Using The Five-Axis CNC Grinding Process.", The International Journal Of Advanced Manufacturing Technology, Pp. 4325-4344, 2019.

[4] Ye, Ronan, "Is CNC Machining Hard: Learning, Misconceptions, Skills And Programs," 27 8 2024. [Online]. Available: Https://Www.3erp.Com/Blog/Is-Cnc-Machining-Hard/.

[5] Nelson Mbarushimana, J. Kuboja, "A Paradigm Shift Towards Competence-Based Curriculum: The Experience Of Rwanda," Semantic Scholar, 2016.

[6] D. G. Derek Yip-Hoi, "Adapting CAD/CAM And CNC Curriculum To Advances In Technology," ASEE Annual Conference &Amp; Exposition Proceedings, 2024.

[7] M. E. A. Yavartanoo, "CNC-Net: Self-Supervised Learning For CNC Machining Operations." In Proceedings Of The IEEE/CVF Conference On Computer Vision And Pattern Recognition, 2024.

[8] G. W. B. S. & T. H. Wibisono, "The Link And Match Between The Competency Of Vocational High Schools Graduates And The Industry On CAD/CAM And CNC.," Jurnal Pendidikan Teknologi Dan Kejuruan, Pp. 26-34, 2020.

[9] Indra Setiawan, Bernadus Sentot Wijanarka, Ruli Adrianto, "Implementation Of Discovery Learning To Improve CNC Machining Learning Achievement In Vocational High Schools," International Journal Of Social Science And Human Research, Pp. 9012-9019, 2024.

[10] Venkatesh Mani, Krishnan N, "The Role Of CNC Machines In Modern Industrial Automation," International Journal Of Advanced Scientific Research, Pp. 1-8, 2024.

[11] Boral, S., & Chakraborty, S., "Failure Analysis Of CNC Machines Due To Human Errors: An Integrated IT2F-MCDM-Based FMEA Approach," Engineering Failure Analysis, P. 130, 2021.

[12] P. Koleda, "Innovation Of CNC Machining Education At The Faculty Of Technology," Proceedings On Humanities And Social Sciences, Pp. 84-91, 2020.

[13] K. R. Rauteda, "Quantitative Research In Education: Philosophy, Uses And Limitations," Journal Of Multidisciplinary Research And Development, 2025.