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The Practical Usefulness of Programming Skills in Professional Work: A Tool for Efficiency and Innovation

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Abstract:

Purpose: *The main objective of the study was to assess the significance of programming skills in professional work, particularly in the context of business management, as perceived by students.*
Design/Methodology/Approach: *The study employed a questionnaire survey conducted knowledge in enhancing efficiency and innovation within enterprise management. Both the respondents' previous experience and their expectations regarding their future professional work were taken into account.*
Findings: *The results of the survey allowed for the identification of key skills developed through learning programming, such as logical thinking and problem-solving, which were considered important by the respondents. These insights provide a basis for refining the educational process to better align with both student expectations and industry demands.*
Practical Implications: *Based on the analysis, it is possible to design a didactic process that emphasizes the skills students deem important while also focusing on those valued by employers. This approach will help prepare students for the growing importance of programming skills in modern business management, Industry 4.0 environments and the optimization of resource use, which is so important in sustainable development.*
Originality/Value: *The study aims to reduce the research gap on the impact of programming skills on the development of key competencies such as critical thinking, problem solving, and creativity. The study provides insight into how programming education can be more effectively tailored to the needs of future managers and industry expectations.*

Keywords: *Programming skills, management skills, enterprise management, Industry 4.0, sustainable development.*

JEL Codes: *I21, I25, J24, L23.*

Paper Type: *Research article.*

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1. Introduction

In the rapidly changing economic environment and modern business, technological competences such as programming are increasingly recognized as key to increasing efficiency, innovation and competitiveness. New challenges related to enterprise management also result from the requirements related to the implementation of sustainable development assumptions by optimizing the use of resources such as energy, water, and raw materials.

A real-world example of supporting sustainable development is smart grids, which use software to optimize the distribution of electricity to reduce waste and ensure that energy is used where and when it is most needed. Similarly, algorithms can help optimize supply chains, reducing waste and carbon footprints.

Nowadays planning enterprise operations is becoming even more complex and requires increasingly higher competences in the preparation of business processes and procedures related to them. Therefore, better competences in the field of algorithmic thinking for solving problems seem to be particularly desirable.

With the advent of Industry 4.0, which emphasizes automation, data exchange and smart technologies, the use of existing programming skills in various management contexts has become a valuable asset. Additionally, an agile approach and algorithmic management is often a response to the speed of a changing business environment and the need to embrace changes.

However, despite the clear need for digital literacy and technical competences in today's workplace, there is still a gap in understanding how programming skills contribute to management practices and decision-making processes. Therefore, learning programming (regardless of the programming language) and algorithms has become the basis for the education of young engineers in every field. Learning programming brings many skills that are demanded by employers and managers nowadays. These are the competences of the future.

There is a growing interest in the literature on the impact of programming skills on the development of key competencies such as critical thinking, problem-solving, and creativity in the context of STEM education (Hebebci and Usta, 2022; Topsakal *et al.*, 2022). Studies indicate that teaching programming can positively affect problem-solving skills and logical thinking (Kalelioğlu and Gülbahar, 2014; Psycharis and Kallia, 2017).

However, there is a research gap in understanding the extent to which these skills are perceived as important by management students, especially in the context of their future careers. Most of the existing studies focus on high school students or science students, which means that there is a lack of relevant research in the population of non-computer science students (Elbyaly and Elfeky, 2023; Budak *et al.*, 2021).

This study aims to fill this gap by assessing the perceived importance of programming skills among students, especially in the context of their future roles in business management. By identifying the specific skills that students consider important, this study provides insight into how programming education can be more effectively tailored to the needs of future managers and to industry expectations.

2. Literature Review

New solutions in management and organization, adapted to the specifics of the work performed, bring numerous benefits to both employees and employers, while supporting economic growth and the competitiveness of enterprises (Claus, 2019; Tataru, 2019; Burak *et al.,* 2020; Górny, 2009; Harasim, 2013). In the context of ongoing globalization and dynamically developing technologies, the systems approach, which treats the organization as a complex social system, allows for a better understanding of the interactions between individual elements of the organization (Ormerod, 2020; Maass *et al.,* 2018; Roth, 2019; Koźmiński and Piotrowski, 2013).

At the same time, global economic processes and accelerating technological progress make knowledge a key competitive resource for both enterprises and entire economies (Yang and Usman, 2021; Stavytskyy et al., 2019; Almeida and Chase-Dunn, 2018; Szalkowski, 2006).

In this context, programming skills are becoming increasingly important in the modern professional environment, especially in the face of increasing automation, digitalization and the development of technologies related to Industry 4.0. As emphasized in the literature, programming is no longer the domain of IT specialists only, but is widely used in various industries, such as management, marketing or data analysis (Hebebci and Usta, 2022; Kalelioğlu and Gülbahar, 2014; Ragin-Skorecka and Hadaś, 2023).

These skills allow employees to optimize processes, manage data more effectively and implement innovative solutions, which is becoming indispensable in a dynamically changing business environment. Thanks to this, organizations can better adapt to the requirements of the modern economy and effectively compete in the global market.

Programming skills are essential for implementing and promoting sustainable development. They enable the development of software tools, systems and technologies that support environmental protection and resource efficiency. Sustainability is increasingly dependent on data, automation and technological innovation, where programming plays a key role.

By incorporating sustainable development principles into software development, programmers can contribute to solving global challenges (Wolfram *et al.*, 2017;

Suiçmez and Ozansoy, 2024). As sustainable development becomes more important in various sectors, there is a growing need for developers to incorporate sustainability into their skills. Educational frameworks and curricula are changing to include sustainable development in university courses (Yin, 2024; Abdulbaqi and Mhaibes, 2024).

Programming can be defined as the process of creating software, which includes stages such as defining and developing assumptions, coding and testing (Blackwell, 2002; Broy *et al.*, 1987; Shi *et al.*, 2005; Piotrowski, 2010). The goal of creating good software designs, as described by Martin *et al.* (2018), is to "minimize the number of people required to build and maintain a given system."

The key element of programming is an algorithm, a step-by-step procedure that solves a specific problem, and writing a program is the implementation of this algorithm in practice (Yanofsky, 2011; Sakoe and Chiba, 1978; Bemporad and Filippi, 2006; Aroba, 2010). The goal of programming is to efficiently write programs or parts of programs, which is implemented as a project (Rentsch, 1982; Stroustrup, 1988; Stefik and Bobrow, 1985; Jablonowski, 2012).

Learning to program develops a number of key cognitive skills, such as logical, abstract, and critical thinking, as well as the ability to solve problems (Budak et al., 2021; Psycharis and Kallia, 2017). Abstract thinking allows us to decide which details of a problem are important and which can be ignored (Wing, 2008). Using abstraction can often reduce the level of complexity of a problem. Learning to program also contributes to the development of computational thinking skills.

Selby (2014) distinguished 4 categories of activities that can contribute to the development of computational thinking skills. The first category is the ability to distinguish information needed to solve a problem from unnecessary information. The second category is the ability to understand the constraints of the problem. The third category is the ability to decompose a problem into its components. The last category is the ability to formalize logical ideas using some acceptable conventions.

These competencies are invaluable not only in a technical context, but also in managerial work, where decision-making is based on data analysis and the search for optimal solutions. Programming teaches a systematic approach to problems, breaking down complex issues into smaller elements and searching for the most effective methods of solving them. Research shows that these are key skills in many professions, both technical and non-technical, which makes programming a valuable competence on the labor market.

Both in management theory and in the context of contemporary economic processes, these skills are becoming increasingly desirable because they support process optimization, increase innovation and competitiveness of enterprises. Combined with new organizational and management solutions, programming is an important

element in building a competitive advantage in the face of increasing automation and digitalization of the economy.

Although there are many studies in the literature on the importance of programming skills, most of them focus on students of technical or STEM fields. In the context of programming education in secondary and higher education, many studies confirm the positive impact of learning programming on the development of problem-solving skills and analytical thinking (Kalelioğlu and Gülbahar, 2014; Psycharis and Kallia, 2017).

These studies show that technical students learning programming notice a direct impact of these skills on their professional competences. Elbyaly and Elfeky (2023) and Topsakal *et al.* (2022) indicate that in many cases non-technical students do not see a direct connection between programming skills and professional work, which may be due to the lack of appropriate educational experiences.

However, the literature lacks detailed analyses that would examine how management students perceive the usefulness of programming in the context of their future professions. For this reason, it is important to investigate what programming skills are considered important by these students and how these skills can affect their effectiveness and innovation in professional work.

3. Research Methodology

The aim of the study is to assess the usefulness of programming skills in the context of current and future jobs and to analyze the practical applications of programming in professional work. The study aims to identify how programming skills can increase efficiency and innovation in everyday professional duties. The research goal and research questions allowed for the selection of a research method – questionnaire survey.

In technical terms, this research boils down to clearly defined people (respondents) answering questions that create a conscious, logical, consistent and coherent set of answers to solve a scientific problem (Matejun, 2016). The research technique used is an online survey. All collected data does not require anonymization. In the presented article, the following detailed questions were addressed:

- *How would you rate the usefulness of programming skills in your current or future job?*
- *How can programming skills be useful in your career?*

The answers to the first question were to choose one of the values: “unnecessary”, “not very useful”, “no opinion”, “useful”, “very useful”. The answers to the next two questions consisted in selecting any number of items from the list provided. In both cases, the list was as follows: logical thinking, abstract thinking, easier

troubleshooting, breaking down the problem into smaller parts, striving to search for optimal solutions, use of algorithms to solve problems, knowledge of concepts, improving your work, knowledge of programming structures, knowledge of the software life cycle, preparation of the simulator / prototype, awareness of the existence of different methods to solve the problem.

The geographic scope of the survey is related to the group of respondents. The subjects of the research are students of the Poznan University of Technology, Faculty of Management Engineering, which results from the need to collect opinions on the implementation of the teaching process at this university.

However, the place of residence of students can be any and does not affect the results of the study and is not subject to analysis (deliberately accepted limitation). The respondents for the study were selected on purpose by sending an e-mail with a request to participate in the study by means of a distribution letter to students of the Poznan University of Technology.

There are no prizes for participants. The request to participate in the study was sent to over 1,100 people. This means a maneuverability of 10%. In order to ensure the ethical nature of the research, an application was submitted and a positive evaluation was received from the Committee for Ethics of Scientific Research of the Poznan University of Technology.

4. Research Results

The study involved students from various countries studying engineer‘s and master's degrees at the Faculty of Management Engineering at the Poznan University of Technology. The study was planned as a series of surveys regarding the importance of programming skills in professional work.

Table 1. *Answers for the questions: „How would you rate the usefulness of programming skills in your current or future job?”*

	1	2	3	4	5
	unnecessary [%]	**not very useful [%]**	**no opinion [%]**	**useful [%]**	**very useful [%]**
I degree	24.7	23.5	29.4	14.1	8.2
II degree	20.0	5.7	25.7	20.0	28.6
Total I and II degree	23.3	18.3	28.3	15.8	14.2

Source: *Author’s study.*

In the analyzed series of surveys, students answered two basic questions. The first question, “How would you rate the usefulness of programming skills in your current or future job?” required selecting one of 5 possible answers: unnecessary, not very useful, no opinion, useful, very useful. The answers to the first question are

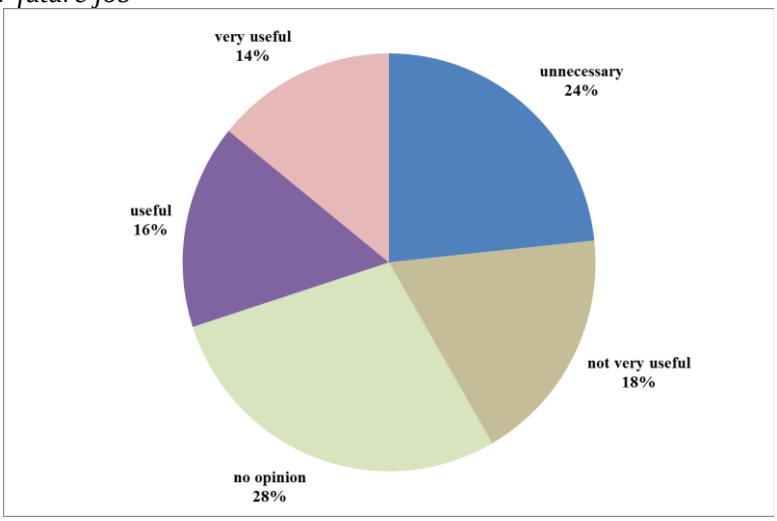
presented in Table 1.

Table 2. *Answers for the question: „How can programming skills be useful in your career?"*

List of answers	I degree	II degree
logical thinking	26	67
abstract thinking	9	30
easier troubleshooting	16	53
breaking down the problem into smaller parts	14	40
striving to search for optimal solutions	13	45
use of algorithms to solve problems	22	45
knowledge of concepts	14	16
improving your work	20	46
knowledge of programming structures	18	25
knowledge of the software life cycle	16	13
preparation of the simulator / prototype	13	28
awareness of the existence of different methods to solve the problem	18	41

Source: *Author's study.*

Figure 1. *Survey results to assess the usefulness of programming skills in the current or future job*



Source: *Author's calculations.*

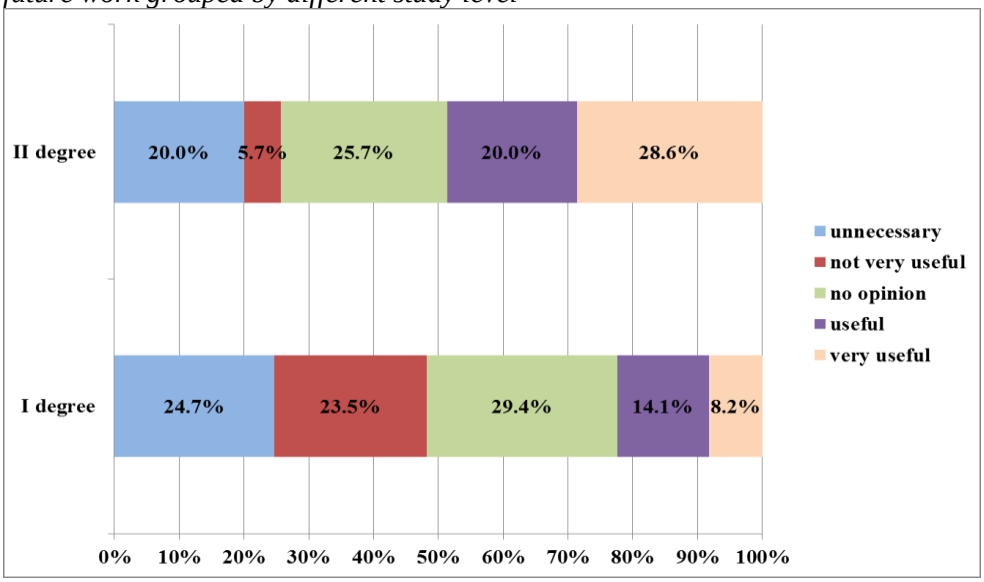
The answers to the next question "How can programming skills be useful in your career?" consisted in selecting any number of items from the list provided. The list was as follows:

a) logical thinking
b) abstract thinking

c) easier troubleshooting
d) breaking down the problem into smaller parts
e) striving to search for optimal solutions
f) use of algorithms to solve problems
g) knowledge of concepts
h) improving your work
i) knowledge of programming structures
j) knowledge of the software life cycle
k) preparation of the simulator / prototype
l) awareness of the existence of different methods to solve the problem

The answers to the second question are summarized in Table 2.

Figure 2. *Survey results to assess the usefulness of programming skills in current or future work grouped by different study level*



Source: *Author's calculations.*

The visualization of the percentage of individual responses to the question about the usefulness of programming skills in current or future work is presented in Figure 1. Figure 2 presents the obtained survey results grouped according to different levels of studies.

5. Discussion

It can be concluded that for the respondents programming skills are assessed as not very important in current or future job. Only 30% of positive answers were obtained in the survey, of these, 14% were responses "very useful" (Figure 1).

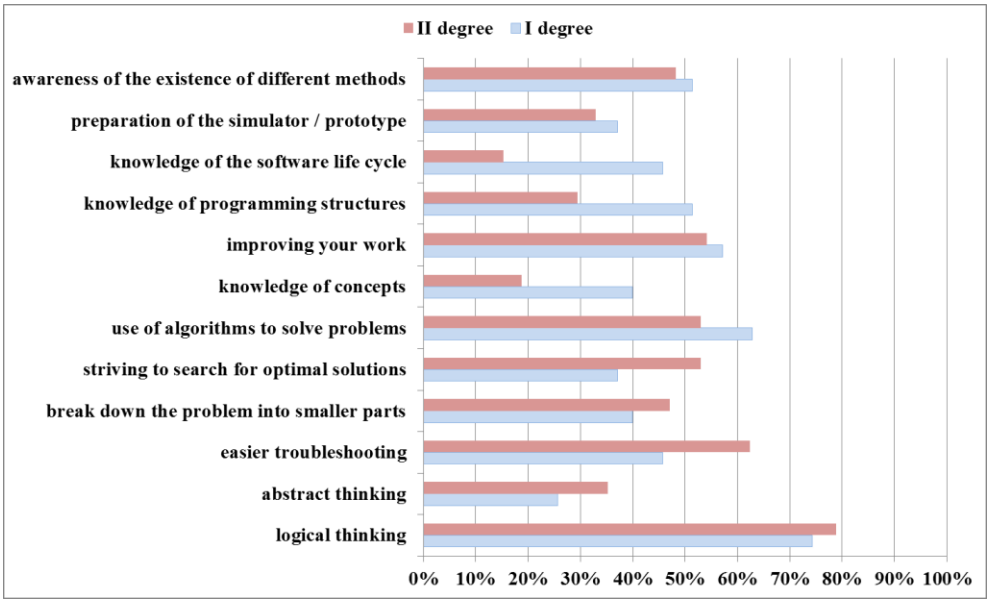
However, if we distinguish between the answers given by first-cycle and second-cycle students, it can be noticed that opinions are polarized. More graduate students appreciate the importance of programming, but more believe that programming is not useful at work. At the first stage of studies, the group of those undecided in this aspect is dominant (Figure 2).

When commenting on the results obtained, it should be noted that the programming course is part of the program of first-cycle study at the Faculty of Management Engineering at the Poznan University of Technology. The program of the second degree of the course does not include the programming course.

Thus, students who completed their first-degree studies at other universities may not have attended such a course. Differences in programming knowledge may have influenced the perception of its importance. This may explain such a large variation in the responses of first- and second-cycle students.

The usefulness of programming skills in professional work, based on students' responses, is presented in Figure 3. The answers were grouped by level of study. Respondents could choose many answers from a predefined list.

Figure 3. *Answers to survey question: how can programming skills be useful in your career?*



Source: *Author's calculations.*

The overwhelming majority of respondents emphasized the importance of "logical thinking". Most of them emphasized the importance of: "easier troubleshooting", "use of algorithms to solve problems", "improving your work", "awareness of the

existence of different methods", "striving to search for optimal solutions".

It is also worth noting that "abstract thinking" and "knowledge of concepts" were assessed at a relatively low level by the respondents, even though learning programming is most often associated with these skills.

On this basis, it can be concluded that some students do not notice the similarity between the construction of programming structures, for example in the form of conditions and iteration, with procedures in enterprise management. Therefore, in the education process, apart from the model approach, examples and projects relating to the business reality of enterprises should be presented.

The skills indicated and emphasized by the students, taught by programming, are demanded by employers in the case of various jobs positions, especially those related to management at different levels. Basic knowledge of programming is especially important when a company uses the principles of Industry 4.0. Skills acquired through learning programming can also contribute to the optimization of the use of raw materials and energy in production and logistics processes. These are significant components supporting sustainable development.

6. Limitation of the Study

The main limitation of the study is the limited professional experience of the people surveyed. For this reason, the next step should be to extend this study to include graduates of the same studies who have already taken up permanent employment.

7. Conclusions

The study demonstrates that while programming skills are highly relevant to modern professional work, particularly in fields driven by technological innovation, many students do not fully appreciate their significance. Although programming is a fundamental component of first-cycle studies at the Faculty of Management Engineering at Poznan University of Technology, a substantial portion of respondents, especially first-cycle students, rated programming skills as moderately useful or were undecided about their relevance.

In contrast, second-cycle students – who have had more exposure to technical education and work experience – perceived these skills as more valuable in their current or future jobs. This divergence may be attributed to the differences in exposure to programming education between the two groups, particularly given the lack of a programming component in the second-cycle curriculum.

The results also highlighted that students recognize the importance of programming for developing essential skills such as logical thinking, problem-solving, and optimizing work processes – competencies highly valued by employers across

various industries, especially in management roles. However, more abstract programming concepts, such as "abstract thinking" and "knowledge of programming structures", were rated lower, indicating a gap in understanding how these competencies translate into practical business applications.

In light of these findings, there is a clear need to better integrate programming education with real-world business examples, showing students how programming methodologies mirror management processes, such as decision-making and iterative improvements. This alignment could help bridge the gap between theoretical learning and practical application, making programming more accessible and relevant to students' future professional roles.

By adjusting the educational approach to reflect both student perspectives and employer expectations, programming education can be more effectively tailored to equip future professionals with the skills necessary for thriving in a rapidly evolving, technology-driven job market. This is particularly important when implementing Industry 4.0 principles in enterprises, which is the realization of the vision of a smart factory.

Logical and abstract thinking gained through learning programming can also contribute to optimizing the use of available resources and creating solutions that support sustainable development. It can help solve sustainability challenges like optimizing resource use, modeling climate, and predicting environmental impacts. Programming skills are essential to developing these tools.

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