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Supporting and Developing Talent in Technical Education in the Context of Industry 5.0*

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Abstract

Industry 5.0 has placed new demands on education, notably a greater emphasis on preparing graduates of technical fields for a labour market that is evolving quickly. A key part of this preparation is the support and development of talent, which provides the ground for innovation, creativity and the ability to respond to technological as well as social changes. This study examined how teachers at secondary schools and universities view talent support in technical education and how they assess its effect on graduates' readiness for future employment. The study used a qualitative methodology based on focus group discussions. Thematic analysis of the data revealed that talent in technical education is seen as a dynamic phenomenon that is expressed in creativity, independent thinking and especially in the practical use of knowledge. Project-based teaching, participation in research and industrial projects, mentoring and dual study programmes are highlighted as the main forms of support. The results suggest that systematic work with talent increases graduates' preparedness for the labour market in the era of Industry 5.0, where soft skills, adaptability, resilience and interdisciplinary cooperation are crucial.

Keywords: career readiness, Industry 5.0, interdisciplinary collaboration, talent development, technical education

Introduction

Research within the framework of inclusive education has increasingly focused on the identification and support of talented students in both secondary schools and universities in recent years. While some studies have focused solely on the process of identifying talent (Johnsen, 2024); Olszewski-Kubilius and Thomson, 2015), others have placed greater emphasis on pedagogical support and the systematic development of gifted learners in the school environment (Gierczyk and Pfeiffer 2021; Rinn 2023). The STEM fields have formed a specific line of inquiry in which both the identification and targeted strategies for talent development are addressed (Kim et al., 2023; Makkonen et al., 2022; Makkonen et al., 2023).

Technical education can be seen as a practical realization of STEM principles that combines theoretical knowledge with the capacity to create innovative and functional applications. Placing talent development in technical education within a broader theoretical discussion also requires consideration of how giftedness itself is understood and defined. While STEM demonstrates the practical use of knowledge and skills, conceptions of talent have shifted in line with developments in biology and psychology. In particular, the scholarly debate has moved from unidimensional, IQ-based models to multidimensional and systemic approaches (Subotnik et al., 2017). Our research team has therefore approached talent as a layered and context-dependent phenomenon. Talent, in this sense, is not limited to results on intelligence tests or standardized examinations. It is understood as a complex interplay of cognitive abilities, practical skills, creativity, motivation and a supportive environment. Talent within technical education, which is tightly linked to STEM, is seen above all in the innovative application of theoretical

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knowledge to practical contexts, the integration of perspectives across disciplines and the ability to adapt flexibly to changing labour market demands.

This perspective aligns with systemic models of giftedness (Subotnik et al., 2011, Subotnik et al., 2017), which stress that excellence does not arise solely from individual predispositions but from interactions between individuals and their environment (Subotnik et al., 2017). For this reason, our study focused not only on the characteristics of talented students but also on pedagogical and didactic strategies, institutional support mechanisms and the role of the wider context – from the school setting to cooperation with companies and employers. This study sought to determine how teachers at secondary schools and technical universities perceive the support and development of talent in technical education, as well as how they assess its significance for graduates' readiness to enter the labour market. This aim included not only examining how talent is conceptualized and supported in educational practice, but also analysing how such support shapes the relationship between education and labour market needs. These needs are increasingly defined by the dynamics of Industry 5.0 and by broader socio-economic transformations.

Industry 5.0 and New Theoretical Educational Frameworks

Since the mid-2010s, both the educational and industrial sectors have been shaped by the transition from Industry 4.0 to the emerging concept of Industry 5.0. While the fourth industrial revolution was primarily associated with automation, artificial intelligence (AI), robotics, additive manufacturing and the Internet of Things, the current phase appears to emphasize a human-centric orientation, sustainability and the ethical dimensions of technological development (Koch et al., 2025). Industry 5.0 therefore differs from a purely technological paradigm by integrating human creativity, social responsibility and environmental considerations into the core of industrial processes. These shifts have a significant impact on educational institutions and influence both their organizational strategies and the structure of the teaching and learning process.

The labour market no longer demands only technical expertise but also increasingly requires a balanced combination of technological and social competences, as evidenced by surveys of students, graduates and practitioners (Koch et al., 2025). This confirms that, alongside professional proficiency, graduates must also develop teamwork, ethical decision-making, creativity and adaptability skills, as highlighted by the European Commission (European Commission, 2021). Technical and engineering education is thus confronted with the task of moving beyond traditional single-discipline models towards multidisciplinary curricula that incorporate elements of sustainability, digital competences and human-machine collaboration (Lagorio and Cimini, 2024). This approach, often referred to as *Engineering Education 5.0*, stresses preparation not only for technical challenges but also for the broader social and environmental consequences of professional practice, including inclusive education and talent development (Ciolacu et al., 2023).

In the context of Industry 5.0, inclusion is understood as a core principle linking technological progress with human needs. Augmented and virtual reality are not seen merely as tools of digital transformation but as instruments that foster equitable access to learning through personalized and adaptive educational environments. These technologies allow students with diverse abilities, including talented learners, to engage more fully in education – an approach that reflects the human-centric orientation of Industry 5.0, where technological innovation is inseparably connected with social inclusion and sustainability (Mukherjee et al., 2023; Supriya et al., 2024).

Nevertheless, educational frameworks often struggle to adapt flexibly to these dynamic changes, which has resulted in a mismatch between school-based learning and labour market requirements. This gap is particularly visible in technical fields. In these areas, graduates are expected to connect innovative technological solutions with humanistic values (Koch et al., 2025). Building on this theoretical background, the present study explored how teachers at secondary schools and technical universities perceive the support and development of talent. Understanding their perspectives is crucial for evaluating whether current strategies can effectively prepare students for careers within Industry 5.0, where professional competence must be accompanied by creativity, social responsibility, independence, resilience and a strong motivation for lifelong learning (European Commission, 2021).

Research Methods

The present study was carried out in a qualitative design, using focus groups as the principal method. In focus groups, a moderator poses questions prepared in advance that are intended to elicit participants' shared views and opinions on a given topic (Fontana and Frey, 2005). Studies employing focus groups often rely on purposive sampling strategies, such as typical case or maximum variation sampling (Patton, 2015). In this study, purposive sampling emphasized homogeneity to compare the perspectives of secondary and higher education teachers in technical fields. The homogeneous characteristics of participants allowed a focus on their views of talent support in technical education and its impact on graduates' career preparedness. These characteristics included, for instance, teaching experience ranging from 6 to 30 years and educational attainments ranging from a bachelor's degree to a full professorship in the case of university staff. The respondents were from the Czech Republic – more specifically, from three secondary vocational schools in Prague and three technical universities located in Prague and northern Bohemia. Participants ranged in age from 30 to 58 years, and they held various professional positions, such as vocational training teachers, university lecturers, heads of departments or deputy principals of secondary schools.

Altogether, 10 respondents took part in the focus group discussions. They were informed in advance about the purpose of the research and participated on a voluntary basis. The deliberate choice of five teachers from a secondary school and five from a technical university not only allowed for a comparison of the perspectives from the two levels of education but also for an examination of their continuity in supporting and developing talent with a view to graduates' career readiness in the context of Industry 5.0. Participants were fully briefed about their rights and options and confirmed their participation by signing informed consent forms.

The focus group was facilitated with the help of stimulus prompts in the form of thematic questions that directed the discussion towards the core of the research problem. This targeted facilitation not only elicited participants' views on the implementation of inclusive education but also opened up a debate on possible innovations reflecting the changing requirements of the labour market. The data collected were processed through thematic analysis (Braun and Clarke, 2006; Braun and Clarke, 2019). The procedure involved familiarization with the interview transcripts, initial open coding, the identification and revision of thematic categories, and their subsequent interpretation in relation to the research objectives.

Results

The analysis of the focus group data produced a coherent body of qualitative evidence that made it possible to identify key areas related to the support and development of talent in technical education. Following the six-phase procedure of thematic analysis, the data were systematically coded and then grouped into thematic categories (Braun and Clarke, 2006; Braun and Clarke, 2019). This resulted in the identification of several main themes reflecting the views and experiences of secondary and higher education teachers concerning the preparation of talented students for their future careers. At the same time, these themes highlight how respondents perceive the links between educational practice and labour market demands in the context of Industry 5.0.

Each of the identified themes is introduced and interpreted in detail in the following section. The analysis is supplemented by authentic statements from respondents, which have been anonymized for ethical reasons and are marked with codes (R1–R10). These quotations are included to illustrate central ideas and to strengthen the validity of the analytical findings. The table below summarizes the main themes identified through thematic analysis together with the codes that emerged from the data.

Table 1: Overview of Themes and Codes Identified through Thematic Analysis

Topics	Codes
The definition of talent in technical education	The ability to quickly grasp new knowledge, practical skills, creative problem-solving, talent understood as a process, a creative approach, the role of environment and pedagogical support, the limitations of traditional assessment, the later development of talent, self-education and practice as a catalyst, and the ability to take advantage of opportunities
Pedagogical strategies and institutional mechanisms for supporting talented students	Project-based learning, the development of creativity, teamwork and critical thinking, knowledge competitions and Olympiads, early identification of talent, independence, an inquiry-based approach, participation in research projects, student conferences, mentoring, cooperation with companies, start-ups, grant programmes, research centres, Erasmus+
Innovative visions and pedagogical strategies for supporting talent in the context of Industry 5.0	Development of digital competences, work with artificial intelligence, programming, big data analysis, soft skills, talent understood as leadership ability, mismatch between education and the labour market, the need for adaptability, partnership projects, dual education, talent as a dynamic interaction of abilities and environment, the school environment fostering experimentation

Source: Authors' elaboration

Defining talent in technical education

The question of how talent is defined and identified in education is currently one of the central topics in pedagogical and adult education debate. The thematic analysis carried out in this study showed that teachers working both at secondary technical schools and at technical universities understand talent in a multi-layered way. In contrast to traditional approaches, which emphasize intellectual abilities or exceptional performance in cognitive tests, talent in technical education is viewed as a complex phenomenon that includes not only cognitive skills but also practical, creative and personal dimensions.

Respondents repeatedly pointed out that talent is not simply the ability to master subject matter beyond expected standards, but above all the capacity for independent thinking, understanding connections and applying theoretical knowledge in concrete situations. According to their accounts, talent is perceived as a dynamic quality that becomes visible in the process of problem-solving, rather than only in the outcomes of written tests or examinations. One respondent summarized this as follows:

(R3): "I recognize talent in students not by their grades, but by how they approach tasks in workshops or laboratories, where they need to come up with something different from what is written in the textbook, where they have to look for unconventional, original approaches and devise new solutions or improvements that often go beyond what the textbook offers."

Creativity is another characteristic of talent highlighted by the respondents. In technical fields, creativity is often linked to finding alternative ways of reaching a goal, making original use of available resources or combining knowledge from several domains in unusual ways. In this context, respondents frequently stressed that talent is not exclusively innate but can manifest and grow in a stimulating and motivating environment. As one focus group participant explained:

(R6): "We have students who don't stand out in any way during their first year of secondary school, but once they are given the chance to work on a project in computer labs or technical workshops – and receive the right kind of support – they develop quickly and show abilities that would otherwise remain hidden."

This view underlines the importance of pedagogical guidance and the effective choice of teaching methods that create space for active engagement, teamwork, experimentation and opportunities for self-realization. In the academic literature, this understanding is consistent with so-called dynamic theories of talent, which emphasize the interaction between individual abilities and the socio-educational environment (Subotnik et al., 2011). These theories argue that talent is not a fixed characteristic of the individual but rather a process that develops over time and depends on both intrinsic motivation and external support.

Respondents also reflected on certain difficulties in recognizing talent. Some noted that traditional forms of school assessment often fail to capture the potential of students who do not conform to standard expectations. One teacher observed:

(R1): "Sometimes a gifted student ends up with poor grades because they are not willing to complete tasks mechanically. But when it comes to practical or project-based learning, their full potential shows: They are active, original and think creatively."

A noteworthy finding from the thematic analysis is the relatively high level of agreement between teachers at secondary schools and those at technical universities regarding the very definition of talent. Differences, however, appeared in their evaluation of students' educational pathways. University respondents repeatedly emphasized that many of their students had not been recognized as talented during secondary school and thus had not been deliberately supported. This lack of support often meant that such students returned to higher education only later in life, after gaining work experience and developing technical expertise through self-study or other forms of lifelong learning. As one respondent explained:

(R8): "At our technical university, we often receive applicants who already have several years of work experience. They often say that nobody identified them as talented in secondary school, so they had to study many things on their own."

Finally, university teachers also stressed that they consider talented not only those students with strong cognitive and practical capacities, but also those who make full use of available opportunities, engage actively in projects and, at the same time as their studies, secure employment linked to their project work, technical outputs or research activities.

4.2 Pedagogical strategies and institutional mechanisms for supporting talented students

The focus group analysis revealed that respondents consider it essential to combine different pedagogical strategies with available institutional mechanisms to develop the potential of talented students purposefully. Project-based learning is among the most frequently mentioned pedagogical strategies, as it allows students to take an active part in solving practical tasks and to strengthen their ability to apply theoretical knowledge in real-life settings. According to the respondents, project work in particular encourages creativity, teamwork and critical thinking. One respondent noted:

(R4): "Students who are given the chance to tackle a real problem often surprise us with an original or creative approach and show their abilities far more than in standard written tests."

Other didactic strategies identified as effective include involving students in competitions and national Olympiads in technical fields, as well as international contests in areas such as robotics, AI or programming. These activities not only motivate students to perform beyond the requirements of the secondary-school curriculum but also give them the chance to compare themselves with peers at both the national and global levels and to receive feedback from practitioners who actively support such events. Teachers at secondary schools emphasized that competitions often serve as a tool for early identification of exceptionally gifted individuals whose potential might otherwise remain unnoticed.

At universities, the emphasis shifts more strongly towards independence and a research-oriented approach. Talented students can take part in research projects, collaborate directly with academics and researchers, or present their work at international student conferences. Mentoring is a significant support mechanism in this context, both through formal supervision of theses and through informal consultations. University respondents stressed that talented students should learn not only to apply knowledge but also to examine it critically, expand it and use it creatively in an interdisciplinary context.

Across both educational settings, talent support was often linked to students' future careers. According to university respondents, the most talented students are able to turn their projects into concrete opportunities. During their studies, they establish partnerships with companies, receive attractive job offers and in some cases push their ideas as far as patents or even start their own businesses. Talent, in this sense, is not seen merely as academic achievement but as a "ticket" to professional and entrepreneurial life. As one respondent put it:

(R10): "You recognize talent when a student knows how to make use of every opportunity – from working on projects here at the university to participating in both university-level and European projects and grants. The experiences and results they gain in this way are recognized by employers and often serve as a direct ticket to a successful professional career."

This shows that talent development in technical education is not regarded in isolation but is directly linked to graduates' employability. The institutional frameworks differ mainly in scope and degree of systematization. At secondary schools, support for talent tends to depend on individual teachers' initiative or on participation in grant programmes. At universities, more stable mechanisms exist, such as involvement in research centres, collaboration with industrial partners or mobility opportunities within programmes like Erasmus+.

4.3 Innovative visions and pedagogical strategies for supporting talent in the context of Industry 5.0

The analysis further showed that respondents at both secondary schools and universities recognize the need for a fundamental transformation of educational practice in connection with the emergence of the Industry 5.0 concept. This framework, formulated by the European Commission (European Commission, 2021), shifts the emphasis away from the pure digitalization and automation typical of Industry 4.0 towards linking technological progress with humanistic values, sustainability and inclusiveness. Technical education is thus faced with the challenge of preparing talented students not only to master new technologies but also to contribute to their development and application in creative, ethical and sustainable ways.

Respondents stressed that one of the key prerequisites for the future is the development of digital competences, especially in the context of using AI, which is accelerating professional work in many areas such as programming or handling and analysing big data. These skills are already seen by respondents as the basic minimum that talented students must master to remain competitive. At the same time, they also highlighted the importance of soft skills. The most frequently identified soft skills in the transcripts were creativity, teamwork and the ability to solve problems in an interdisciplinary environment. As one respondent put it:

(R7): "Today it's not enough for a student to be a good programmer. They must be able to work with AI, but also to explain and defend their solution within a team that includes people from different fields. That is where real talent shows – in the ability to promote an idea, coordinate collaboration and inspire others, which indicates the potential to become a leader."

The analysis also revealed that respondents increasingly perceive a mismatch between current educational preparation and the demands of the labour market. Students are often well equipped with theoretical knowledge but lack the flexibility and readiness to enter the dynamic environment of global organizations. This issue was mentioned especially by teachers from secondary schools, who emphasized that practice develops more quickly than curricula can adapt. University respondents added that the key task is not only to prepare students for the current requirements of companies but also to cultivate long-term adaptability and resilience. In this connection, respondents suggested innovations in pedagogical strategies and teaching approaches.

More specifically, respondents stressed the need to move technical education towards greater openness to innovation through project-based teaching closely connected with industrial practice and research institutions. An effective model identified in the discussions would be one in which students gain experience through internships, joint projects or dual education (i.e. a combination of study at school with practical involvement in a company, where part of the training takes place directly in the workplace). This would allow them to acquire authentic work processes while also developing the ability to solve complex problems that demand both creativity and teamwork. Respondents also increasingly emphasized the integration of interdisciplinary approaches into technological projects, where technical fields intersect with environmental and social issues. One respondent explained:

(R7): "When students work on a project with a specific company, it is no longer just about meeting the assignment. They have to think about how their solution fits into the broader context – from technology and economics to HR and the impact on society and the environment. They become most aware of this during the project preparation phase, when they must address these issues, and later during implementation, when they are forced to integrate such factors into the technological results."

The interviews also revealed that university respondents in particular emphasized the need for inclusive talent support. Regarding future perspectives, they noted that talent development cannot be reduced to nurturing a small elite of high performers; instead, it must be conceived as a broader process that includes students from diverse social, cultural and educational backgrounds. Such an approach emphasizes that the potential of every student can, under appropriate conditions, be systematically developed in a technical direction and transformed into benefits for both companies and society.

From this perspective, talent is not understood merely as an innate individual characteristic but as a dynamic outcome of the interaction between personal abilities and an environment that provides sufficient stimuli for self-realization, experimentation and creative growth. The school environment in particular was perceived as a space where talented students can experiment relatively freely with new approaches and methods – an opportunity that is often limited in company settings by pragmatic demands for efficiency and performance. As one respondent noted:

(R1): "School gives our students the chance to experiment a lot and try things they could never afford to do in a company, where the focus is mainly on quick results, efficiency and economic profitability."

Discussion

The results of the study provide the shared perspective of secondary and university teachers on talent in technical education as a dynamic, context-dependent phenomenon, expressed less in test scores and more in the way students approach open-ended tasks, in their creativity, independence and ability to transfer theoretical knowledge into practice. Analysis of the focus group discussion highlights project-based learning and systematic links to practice (internships, partnership projects, dual models of education) as particularly effective, because they accelerate the professional maturation of talented students. A further important finding is that inclusion of talent is not understood as supporting an "elite", but rather as developing the potential of diverse students in an environment that legitimizes experimentation.

This conclusion is consistent with Pinto et al. (2025), who, in their study of the Self-Made Programme, show that preparing professionals for Industry 5.0 requires a combination of technical expertise with soft skills, adaptability and interdisciplinary collaboration. Similar to our findings, they emphasize that talent development depends on an environment that enables experimentation and innovative thinking, with strong links between educational institutions and industrial actors playing a central role.

These findings have both theoretical and practical implications. Talent should be seen less as a static quality and more as a situational process that is recognizable in solving complex tasks. The quality of didactic design (projects, interdisciplinarity, opportunities for experimentation and a scientific approach) thus emerges as an equally important predictor of talent development alongside individual abilities. For school practice (formal education), this implies the need to embed project-based learning more thoroughly across curricula and to link it systematically with companies and research teams, to institutionalize mentoring from both academic and industrial environments, and to expand dual or alternating models with clearly defined outcomes recognized in the form of micro-credentials.

These findings on the importance of systematic practice, mentoring and dual models are consistent with the educational framework for smart manufacturing outlined by Pinto et al. (2025), who stress a multidimensional concept of competence development that combines technological skills, deeper specialization and soft skills, implemented through on-demand microlearning complemented by laboratory activities and webinars. This approach also offers a concrete mechanism for developing both digital and human-centric competences, and it can be integrated into micro-credential systems. From the perspective of Industry 5.0, it represents a complementary way of addressing the mismatch between curricula and labour market requirements identified by our respondents. At the level of governance and educational policy, it appears crucial to create supportive frameworks for inclusive work with talent, to finance micro-scholarships for internships and projects, and to establish standards for the development of digital and AI competences in technical disciplines, including their ethical dimensions.

Conclusions

This study has shown that talent in technical education is dynamic and situated, and this is most clearly expressed in creative approaches to solving technical tasks and in the transfer of theory into practice. The most effective support mechanisms appear to be project-based learning, systematic cooperation with the world of work and targeted mentoring, all of which accelerate professional maturation and strengthen students' adaptability. At the same time, these practices foster both digital and human-centric competences in line with the vision of Industry 5.0. The findings thus confirm that talent development should be understood as an interaction between individual abilities and the surrounding environment, and that institutions which systematically cultivate this interaction enhance graduates' preparedness for a changing labour market.

A limitation of this study is the relatively small and purposively selected research sample, which increases contextual sensitivity but limits the scope for broader generalization. Moreover, the focus group method carries the risk that minority perspectives may be overshadowed by more consensual statements. Future research should track talent longitudinally from secondary through higher education into professional practice.

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