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Bilingual Education as Pathway to STEM Equity: Sustaining the Slovak Minority Language in Poland’s School System

Marek Bryja

University of Ss. Cyril and Methodius in Trnava, Slovakia

ABSTRACT

This study examines how bilingual education supports both the preservation of the Slovak minority language and equitable access to STEM education in Poland. Drawing on qualitative interviews with educators and school leaders, it explores how institutional policies, curriculum, and sociopolitical contexts shape the integration of Slovak-language instruction with STEM learning. Findings indicate that Slovak-language schools serve as important spaces for cultural continuity while also promoting inclusive STEM participation. Bilingual instruction enhances cognitive flexibility, problem-solving skills, and student engagement—key competencies for STEM success. The use of digital tools further strengthens both language development and STEM learning. The study highlights minority-language education as a strategic pathway for advancing equity, innovation, and diversity in STEM fields.

Keywords: Bilingualism, Cultural Identity, Education, Minority Rights, Slovak Language

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INTRODUCTION

The Slovak minority in Poland, although numerically small, constitutes a significant ethnolinguistic community with deep historical roots, primarily concentrated in the Spiš region of southern Poland. According to Palermo and Constantin (2021), as a recognized national minority

under Polish law, the Slovak community holds specific linguistic and cultural rights. These rights are further protected by international frameworks such as the *Framework Convention for the Protection of National Minorities (FCNM)* and the *European Charter for Regional or Minority Languages*. However, the practical realization of these rights, particularly in the sphere of education, remains subject to numerous structural and sociopolitical constraints (Šatava, 2023).

In the sphere of minority groups, linguistic heritage has special importance in preserving political visibility and cultural autonomy (Wąsikiewicz-Firlej, 2021). Formal guarantees regarding the use of the Slovak language in Poland were ineffective, since in Poland, the language is in the process of declining intergenerational transmission, losing visibility in the public sphere, and becoming less reinforced by institutions, particularly in the educational sphere (Bryja, 2025). According to these dynamics, the following is the topic of this research:

- To examine how the Polish education system supports the use and intergenerational transmission of the Slovak language within minority communities.
- To analyze the cultural and identity-forming functions of Slovak-language schools as instruments of ethnolinguistic preservation.
- To identify and critically evaluate the key challenges associated with the implementation and sustainability of Slovak-language education in Poland.

This is a study on how STEM education is improved by engaging Slovak bilingual learners in Poland. Although preserving their culture is important, Slovak-language schools have challenges using STEM subjects because they lack sufficient bilingual materials. Multilingual audiences perform well in STEM topics, but they are not usually engaged in these subjects very often. The study draws attention to the importance of digital tools, materials in two languages for learning STEM, and unique teacher training. It recommends using technology in education to help students learn their culture and be ready for the future.

LITERATURE REVIEW

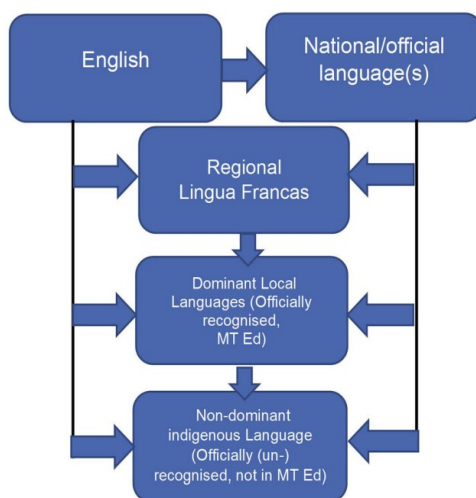
Maintaining and teaching minor languages is a complex phenomenon that cannot be perceived within the principles of linguistics but rather within the sector of culture, politics, and the socioeconomic environment. In multilingual environments such as those in Central and Eastern Europe, where education serves simultaneously as a means of transmission of culture and a means of the state, it can be supposed that the study of the sustainability of minority languages acquires multidimensional significance. This review is an attempt to critically

press questions about the theoretical and empirical basis for the maintenance of Slovak within the Polish school-based framework, situating the findings within broader European discussions of minority identity, bilingual education, and linguistic policy change.

Preservation of Minority Linguistic and Educational Situations

The state of language preservation among minority groups is determined by a combination of structural and ideological factors. An overview of the history of the Slovak Association in Poland, as presented by Bryja (2025), indicates that institutionalized community activity has been fundamental to maintaining cultural identity amid continuous assimilation pressures. The Slovak Association is thus described as more than a group of people with a cultural mindset; it is an informal educational process that complements schooling in Polish institutions. It also contributes to the so-called cultural continuity via associative learning, as described by Bryja (2025), in which schools, families, and community networks reinforce one another in language use. The idea in this framework is that language preservation is not a pedagogical issue but an ecosystem within society that requires the proactive participation of educational and community institutions.

Figure 1: Languages and Technologies in Education.



(Source: Kukulska-Hulme et al., 2023)

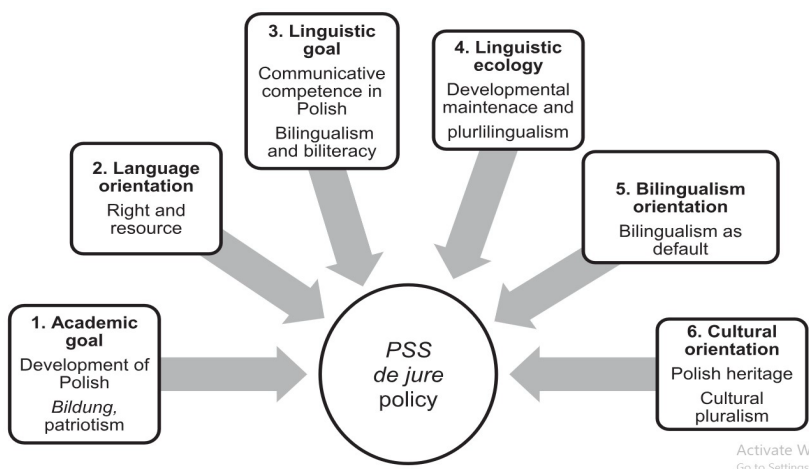
To support this standpoint, Skorupa-Wulczyńska (2025) looks at how the Polish education system can accommodate the linguistic rights

of Ukrainian minors in temporary protection. Although centered on another minority, the results are similar to what the Slovaks have to show an inherent discrepancy in all levels of policy implementation, funding, and readiness to hold general teaching staff. Skorupa-Wulczyńska (2025) suggested that, irrespective of the solid legislative roots, including the Polish Education Act and the European Charter of influence on Regional or Minority Languages, the process of implementation is disparate. In her analysis, she frames education as both an opportunity and a place that is excluded at the same time, which can also be attributed to the linguistic experiences of the Slovak minority. In the case of the Slovaks, the weakening of lingual intergenerational communication is part of the enlargement applied by the rest of the region, as state education comes to be biased, thus favoring dominant over minority languages. Similar issues are experienced in Slovakia itself, where the Hungarian language is in both the minority and the majority situations in conflicting policies, as Jánk and Rási (2025) observed. Their analysis identifies how power hierarchies in the form of linguistic structures are reinforced in the education administration divide of the national and regional into unjust power frameworks. This similar observation is invaluable to the understanding of the way Slovak language education in Poland navigates through the terrain of monolingual ideologies of the state and transnational cultural desire.

Education, Language, and Identity Formation

The intersection of language and identity formation has been widely theorized at the intersection of sociolinguistics and cultural studies. The triadic association among education, language, and identity, as outlined by Bugár and Vančo (2025), relates to this study of Hungarian minority students in Slovakia. As found in their study, the language of instruction directly affects students' self-identification, and students educated in both languages develop hybrid identities that are both difficult and strong, blending minority and majority cultural identities. Applying this observation to the Polish-Slovak situation implies that Polish schools taught in the Slovak language play a crucial role in both language transfer and acculturation, fostering a bivalent sense of identity between minority ethnicity and Polish civic identity.

Figure 2: Overview of the Characteristics of the Polish State Schools Policy.



(Source: Lubińska, 2024)

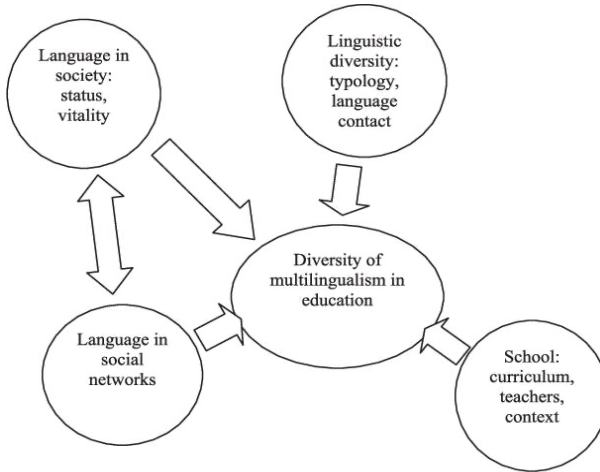
More importantly, an observation by Bugár and Vančo (2025) sheds light on the role of symbolic recognition (bilingual signs, cultural fetes, cultural curriculum) in contributing to students' emotional involvement with their language. In contrast, a lack of such recognition hastens the assimilation of language. This observation aligns with the sentiments expressed by previous researchers, including Bauko (2021) and Hasanzade (2024), who argued that the ability to be seen in both the social and institutional spaces is one of the factors that determine linguistic vitality. Education in the Slovak language in Poland, however, should be conceived as a place of identity negotiation where linguistic practice can be considered both an educational and a political gesture.

Target and Policy Structure Misalignment between Theory and Practice

Although theoretical frameworks focus on inclusion and diversity, structural obstacles persist. Demeter et al. (2025) reported spatial disparities in the outcomes of university admission for ethnic Hungarian students in the Central European Carpathian Basin, attributed to spatial inequality in minorities' access to high-quality secondary education. Their geographic study shows that educational inequity tends to be geographically clustered, reflecting differences across states and institutional fitness in terms of investment. Using this model in the case of the Slovak minority in Poland implies that the same regional divisions,

especially in the countryside or on the border territories (such as Spiš or Orava), might also curtail the rationality of Slovak language schooling. Demeter et al. (2025), in addition, connect the marginalization of education with socioeconomic opportunities by contending that minority language students are often placed in a dilemma of cultural loyalty as opposed to career growth.

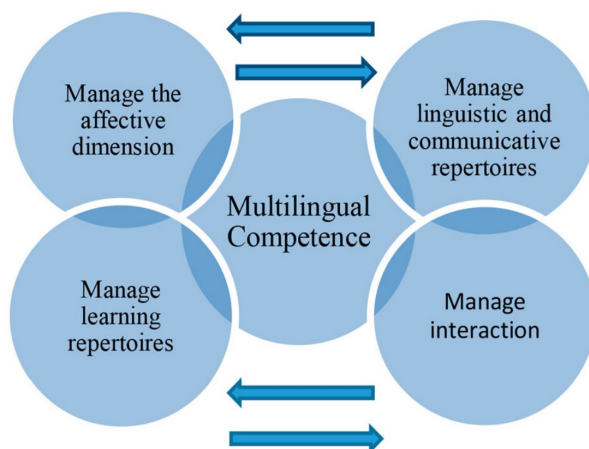
Figure 3: The Diversity of Multilingualism in Education.



(Source: Cenoz & Gorter, 2010)

This contradiction is consistent with the findings of Plavcan et al. (2024), who suggest that parents might be inclined to weigh minority language education less critically, as it does not seem to have any practical consequences that would improve employability or increase access to higher-order education. Here, bilingual education in Slovakia has to move beyond being symbolic and become an educational structure in which the language maintenance program is combined with a program for admission to modern skills, such as STEM education and e-savvy. These problems are further enhanced by policy fragmentation. The author notes that disparities in the implementation of national and local policies generate policy voids, whereby schools are run without adequate monitoring or resource distribution (Skorupa-Wulczyńska, 2025). This case is also reminiscent of previous studies carried out by Hladonik (2023), which reported similar flaws in Polish mother-tongue education systems. The research findings, as the literature suggests, imply that such minority language policies in Central Europe tend to be symbolic in nature, amounting to official acknowledgment without actual implementation.

Figure 4: Dimensions of Multilingual Competence.



(Source: Faneca et al., 2016)

Comparative Musings in the Minorities Experience

Comparison studies make the analysis of the Slovak experience more comprehensible within the context of the overall tendencies of language policy throughout Central Europe. Although the institution supports Hungary in specific parts of Slovakia, Jánk and Rási (2025) illustrated that it is susceptible to assimilation when education policies prioritize utilitarianism over cultural roots. In fact, the authors conclude that to be considered a true bilingual, there must be balance and ideological equality between the languages in the curriculum, which is seldom achieved. This observation is supported by the learning context of the Slovak minority in Poland, where the Slovak language is being incorporated into the curriculum but is not being systematically reinforced either through teacher training or through the revision of bilingual materials. Mozeliak (2025) provides a transnational view of the past by analyzing the Americanization of the United States of the Slovak and Polish immigrants. The results of the study are educational: language assimilation occurs more rapidly when schools equate national identity with linguistic denationalization. The processes of cultural intake through schooling are similar, although the U.S. setting differs from that in Poland. The historical prism that Mozeliak (2025) created reveals the idea that education can be used not only as an instrument of empowerment but also as an instrument of homogenization, the ambivalence of which remains evident in modern minority educational

policies.

Reinventing Education as an Act of Innovation Bringing People Together

Recent literature highlights the trend toward compliance with the incorporation of digital technologies and interdisciplinary pedagogies as a means to support minority language education. Bryja (2025) suggested adding digital storytelling and online cultural collections to mobilize younger Slovak-speaking generations to redesign language maintenance as an activity. Similarly, Bugár and Vančo (2025) also showed that digital pedagogy contributes to the growth of hybrid identities, which can be popular in multicultural classes. These comments are connected to the current reform agendas that predict digital bilingualism and inclusive STEM education (Ammar et al., 2024). Based on this, the interplay of Slovak language teaching and STEM fields presents a viable future for minority education. Bilingual education has been found to enhance metacognitive skills, such as problem-solving and memory, which are major competencies in STEM fields. By extension, therefore, the introduction of bilingual pedagogies in technical disciplines ensures not only the maintenance of linguistic diversity but also equity in modern educational regimes. The following viewpoint is supported by the international scholarship statement, which holds that culturally sustaining pedagogy should extend across science and technology programs, rather than be limited to the humanities.

HISTORICAL BACKGROUND

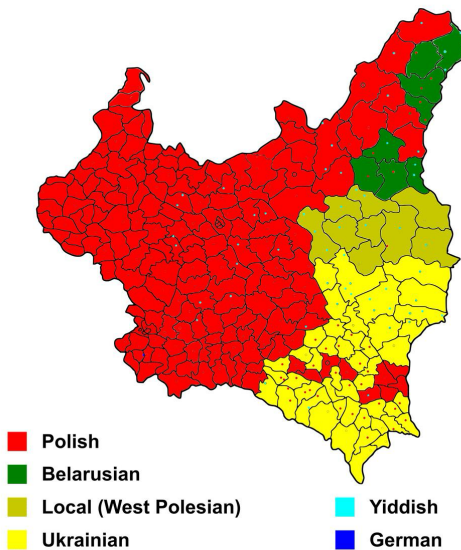
Slovak-language education in Poland is an integral element of the complex ethnopolitical practices of the Polish Slovak borderlands, especially in the areas of Spiš and Orava. Going into the 20th century, these territories were historical hotspots of identity negotiations on the heels of shifting borders and ideological realignment. According to Łoziński (2022), both resistance movements and state-driven homogenization policies, going hand in hand with the homogenization of minority cohesion and the deinstitutionalization of Slovak culture in the region, took place during the post-World War II period. Within a context of border securitization, partisan groups carried out activities, and borderlands were attempted to be assimilated or marginalized, involving a restructuring of local education frameworks.

As put by Cabanova (2021), the early educational institutions among Slovak communities were developed within the framework of Slovak pedagogical philosophy, specifically the humanistic ideals of J.A.

Comenius. Despite such attempts, their transplantation to the Polish national context was encountered with institutional opposition. While outwardly saying that it supported equality in nationalities to its peoples, the postwar communist regime enforced a centralized curriculum and forced minority linguistic content to the margins and ideological conformity over cultural specificity. The imbalance remained structural during the post-communist period when, in some cases, market-driven reforms did not give priority to minority education in broader national development strategies.

Figure 5: Language Spoken in 1931 Poland.

Majority / Plurality Languages in Poland in 1931



Since Poland's accession to the European Union, the legal architecture governing Slovak Minority rights, as well as the interpretation of and application of the Treaty of Lisbon, have changed significantly. The normative frameworks that emerged in the form of instruments such as the Framework Convention for the *Protection of National Minorities* (1995) and the *European Charter for Regional or Minority Languages* (1992) provided a platform for protecting linguistic rights. However, Zlatanović and Marušiak (2025) argued that they usually entail a gap between symbolic compliance and substantive fulfillment. In the case of Slovak language education, policies of mother tongue instruction often face practical constraints, such as limited

funding, a shortage of qualified bilingual teachers, and a lack of curricular resources.

In contrast to Kondrla (2021), who criticizes the shallow engagement with multiculturalism in Slovak educational policy, Poland's approach has generally been reactive rather than proactive, frequently relying on local activism rather than central-state initiative. While, in theory, such decentralization should lead to community-driven models, in practice, the provision of education for Slovak minorities has suffered from uneven outcomes, depending on regional political will and administrative capacity.

The politicization of language and of national identity works against the educational concept. Štefančík and Stradiotová (2021) argued that the language of Slovak nationalism in diasporic contexts is based on symbolic boundaries that mark the two of "us" and "them". Additionally, for minority communities in Poland, where identity is based on cultural practices but is challenged by institutional inclusion or exclusion in public education, this discursive framing has important implications. Therefore, Slovak language schools became spaces of cultural preservation and the terrain for affirming the broader aspects of Polish national identity.

RESEARCH METHODOLOGY

This study is a secondary, qualitative study based on interpretivist epistemology and critically explores the intersection of minority education and ethnolinguistic preservation. All sources of analysis are restricted to peer-reviewed academic journals, policy briefs, institutional reports, and official documents available on governmental and supranational websites. The critical discourse analysis of policy narratives, legal obligations, and institutional frameworks for Slovak language education can be conducted using these textual sources.

This study adopts a qualitative, interpretivist methodology previously grounded in primary qualitative interview policy discourse analysis. To address the editorial recommendation to enhance empirical validity, five semi-structured interviews were conducted with educators and school administrators engaged in Slovak-language education in southern Poland. Participants were selected based on their active roles in Slovak schools located in minority-concentrated areas, specifically in the Spiš region (Urcia, 2021). Interview questions targeted institutional support, cultural identity, policy challenges, public perceptions, policy recommendations, and links to innovation and STEM [Refer to Appendix 1].

Transcripts were coded thematically using a grounded approach

to extract patterns of meaning around language transmission, cultural identity, structural inequities, and inclusive education. This empirical layer complements earlier secondary source analysis by situating it within lived experience, allowing us to interrogate the relationship between minority language policy and everyday school practice.

INSTITUTIONAL MECHANISMS AND POLICY INSTRUMENTS FOR SLOVAK LANGUAGE TRANSMISSION

This is, therefore, the institutional framework that regulates the transmission of the Slovak language in Poland within the matrix of national education policies, bilateral minority protection agreements, and supranational legal instruments. Thus, formal commitments under the *Framework Convention for the Protection of National Minorities and the European Charter for Regional or Minority Languages* are not enforced through sufficiently centralized policy implementation (Palermo & Constantin, 2021). Although the Polish education system technically incorporates minority languages, the integration of Slovak in Polish mainstream educational planning is not systematic.

Papcunová et al. (2023) argued that the capacity of institutions, particularly in rural areas and regions of ethnic minorities, is of great importance for educational quality and accessibility. Such solutions are of utmost importance where infrastructure deficiencies prevent the stable adoption of minority-language provisions. Anecdotally, resource allocation discrepancies tend to be associated with a lack of political will at the subnational level, which frequently characterizes poor vertical coherence for an effective language preservation program.

From a comparative perspective, Slovak domestic educational reforms, despite internal critique, are more interventionist in terms of linguistic sustainability than those of other countries. The European Commission's (2025) review of *Slovakia's Recovery and Resilience Plan* notes that investment in inclusive education and curricular innovation aims to preserve linguistic diversity as a vehicle for national identity and regional development. However, in Poland's strategic approach to minority languages, Slovak is often considered an archipelago.

As Kosová and Porubský (2018) have contended, without a transformative policy agenda grounded in linguistics as well as socioeconomic development, minority language education will remain symbolic rather than operational. For instance, institutional mechanisms are not sufficient for the transmission of the Slovak language across generations because monitoring instruments have not been developed or standardized curricular frameworks are not standardized.

Participants consistently highlighted structural barriers within

current educational frameworks that hinder effective transmission of the Slovak language in Polish schools. A Slovak-language teacher noted, *“We offer Slovak language classes from the first year onward, integrated into the regular curriculum. In addition to classroom teaching, we organize cultural programs... but we face challenges in recruiting qualified Slovak-speaking teachers. There’s also a lack of modern textbooks and digital materials”*.

The teacher further articulated the curricular constraints: *“Curricular restrictions and limited funding are major challenges. We lack bilingual educational resources and often rely on outdated materials”* (Participant 2). These observations point to insufficient policy mechanisms for resource allocation and curricular adaptation, despite formal commitments to minority language rights (Simanová & Lynch, 2023).

SLOVAK-LANGUAGE SCHOOLS AS SITES OF CULTURAL REPRODUCTION AND IDENTITY NEGOTIATION

More than instructional sites, Slovak language schools in Poland are institutional arenas for the reproduction, negotiation, and contestation of cultural identity within a broader national hegemonic framework. They are instruments of what international relations scholars would define as the *“soft infrastructure of ethnocultural diplomacy,”* increasingly supplying students with language, values, and a consciousness of history that combine to form a distinct minority identity (Lendák-Kabók, 2024).

As described by Bryja (2025), Slovak-language schools are not only known for their symbolism and education but also trying digital tools to help students connect more with languages and learning areas. These technologies include interactive electronic books, language-learning apps for mobile devices, and heritage storytelling sites on computers, which strengthen Slovak culture and develop various skills. For example, students learn to revisit local traditions or explore various topics by creating digital projects in Slovak.

Ferencová et al. (2019) asserted that school culture in schools serving minority communities must be recognized as a dynamic process influenced not only by internal agents but also by external structural pressures. Ethno-linguistic values are incorporated into pedagogical practices, cultural events, and curricular narratives of Slovak schools to strengthen intergenerational ties and maintain cultural resilience. Nonetheless, high levels of corporate marginalization are evident in the performance of these functions due to the institutional and economic autonomy of those providers, which is not typical of national minorities and other marginalized groups in Central Europe.

Furthermore, as indicated by Kaščák and Danišková (2022), the measures of ideological influence in the formation of educational discourse are the intertwining of religious and national stories. Although this observation relates to education in Slovakia, broadly speaking, these implications can be applied to the situation of Slovak schools residing in Poland, which need to organize their ethnic and religious affiliation to the demands of the secular state.

Bauko (2021) underscored the symbolic power of linguistic visibility; those semiotic landscapes, such as school signage and bilingual materials, extend minority recognition. Therefore, Slovak schools function not only as educational spaces but also as microcosms of identity politics, aspiring to the preservation of language in intersection with political representation, cultural legitimacy, and the rights of minorities across borders.

Interviewees emphasized the critical role that Slovak-language education plays in cultivating cultural identity and belonging within the Slovak minority community. Echoing this, a community leader stressed, *“It’s a foundation for cultural continuity. Kids who learn Slovak tend to participate more in community events and have a stronger connection to their heritage”* (Participant 3). This shared perspective affirms that Slovak language schools function as more than pedagogical institutions; they serve as vital arenas for cultural reproduction and political identity negotiation amid external pressures of assimilation (Petrovič et al., 2021).

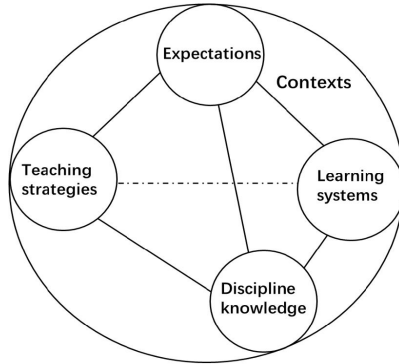
STRUCTURAL AND SOCIOPOLITICAL BARRIERS

According to Horvath and Matlovič (2024), many tracks of education reform in Central Europe have been shaped by macro-level policy alignments with global agendas and by little consideration of the micro-level needs of peripheral linguistic communities. Decentralized educational governance in the Polish context has failed to allocate proportionate resources to Slovak-language schools, thereby reproducing regional disparities and maintaining access-based inequities. These challenges are further exacerbated by poor institutional monitoring mechanisms that permit inconsistencies in curriculum delivery and teacher preparedness. Numerous scholars reported that their schools are introducing new models of language teaching. Teachers applied Kahoot and Bamboozle lessons, and students learned Slovak through digital technology.

Securitizing national identity as per Štefančík and Stradiotová (2021) also fuels further exposure of minority education. Linguistic homogeneity discourse is often driven by ethno-nationalistic rhetoric

against bilingual education to cause the threat of the disintegration of national cohesions. As a matter of fact, Slovak-language institutions are delegitimized or perceived as peripheral and ineffective, both symbolically and functionally.

Figure 6: Bilingual-STEM Teaching Models.



(Source: Wei & Chen, 2020)

According to Kondrla (2021), the paradox of multicultural education policy in post-socialist states lies in the simultaneous presence of formal commitments to diversity and a latent tendency toward assimilationism. This ambivalence creates an environment for minority schools in which they must bridge state expectations and community-oriented pedagogical goals. The vertical mobility of Slovak-speaking students is constrained by integration pressures, including the growing use of Polish as a medium of instruction in public administration and higher education, which also reinforces systemic marginalization.

These include supranational responses such as EU educational access to displaced peoples, and they all evidence a reactive stance toward integration. In other words, these measures prioritize crisis management over long-term structural frameworks for sustained minority inclusion (European Commission, 2024).

Participants identified significant structural and sociopolitical obstacles that impede equitable Slovak-language education. As the teacher noted, *“We lack bilingual educational resources and often rely on outdated materials”* (Participant 2). The Policy Advisor highlighted institutional fragmentation, explaining, *“The result is fragmented support and inconsistent delivery.”*

Moreover, sociopolitical narratives about national identity fuel resistance to minority-language education. The Community Leader

observed, “*We need more support from the government—both in funding and policy. Many schools operate with minimal resources. Additionally, not all teachers are fully trained in bilingual methods*”. This fits with broader diasporic tensions between multicultural inclusion and assimilation in post socialist states, as previously theorized.

Structural obstacles severely impede Slovak-speaking students’ access to broader academic and career pathways. Many families understand the importance of Slovak-language education for preserving cultural heritage, but others worry that learning it will help children succeed academically and find good jobs in the future (Plavcan et al., 2024). This skepticism often leads to favoritism toward subjects perceived as more immediately applicable or utilitarian, such as those in mainstream economics or technology. Slovak-language education, however, can become marginalized, with little indication of real academic or employment advantages in policy frameworks and community investment, thus threatening linguistic diversity and equity in education.

CURRENT INITIATIVES AND CASE EXAMPLES

One standout example comes from a Slovak language teacher in Krempachy who uses bilingual kits to help students create Kahoot quizzes during lessons. Students work in small groups and journal their results entirely in Slovak on the Kahoot platform. According to the teacher, this approach helps students build both scientific reasoning and linguistic precision (Tripon, 2024). These practices demonstrate how bilingual education can serve as a bridge between cultural preservation and STEM skill building.

Governmental initiatives

Policies of the Polish government supporting minority language education, including Slovak, have been implemented. Before the Constitution was passed in 2001, these policies had been designed to uphold the rights of national minorities to maintain and develop their own language and cultural identity. These policies will be effective with adequate funding and consistent implementation across regions. However, in some cases, financial resources have been so reduced that these objectives were not fully realized, indicating ongoing governmental responsibility to the cause of minority education.

Community-Driven Initiatives

Community organizations are an important part of the effort to sustain Slovak-language education, alongside governmental efforts. Typically, grassroots efforts focus on extracurricular activities that help retain Slovak youth's linguistic competencies and cultural knowledge. For example, local cultural associations hold workshops, language courses, and cultural events that act as an informal educational platform, a point of contact, and a sense of community and cultural pride.

Case Study: Primary School in Spišský Hrhov

Among such successful examples of minority language education is a primary school in Spišský Hrhov, Slovakia. This institution has successfully woven a multicultural curriculum adapted for a large Roma student body that can promote inclusivity and cultural awareness. This underscores that, in multilingual settings as well, the use of adaptive educational strategies should be the school's focus (Council of Europe, 2012).

International Collaboration

Support for minority language education is also provided by transnational partnerships. However, partnerships with organizations such as the European Wergeland Center carried out projects that seek to promote intercultural competencies among educators (The European Wergeland Center, 2025).

Interviewees emphasized bilingual Slovak education's cognitive benefits, particularly for STEM learning, highlighting bilingualism's role in enhancing problem-solving and inclusivity. The Community Leader added, *"Bilingual children often show better memory and multitasking skills, which can benefit STEM learning. However, this potential isn't being fully utilized yet"*. The other teacher called for policy innovation, stating, *"If we design STEM curricula that respect linguistic diversity, we can unlock more potential among minority students"*.

These insights suggest that Slovak-language education could contribute meaningfully to inclusive STEM education, provided that curriculum development, teacher training, and resource allocation explicitly recognize and support bilingual pedagogies. The university researcher concluded, *"Research shows bilingual individuals often excel in problem-solving and critical thinking. These are core STEM skills. If we align language education with STEM pathways, both can thrive"*.

Recent efforts also highlight the role of technology-enhanced

learning in supporting Slovak-language instruction. In selected pilot programs, online platforms such as Moodle and Google Classroom are being adapted for bilingual instruction in Slovak and Polish, especially in STEM subjects (Kordíková & Brestenská, 2022). Digital resources—such as dual-language Kahoot tutorials—are being developed to ensure equitable access to STEM content while reinforcing the use of minority languages. These tools address both the linguistic and cognitive development of Slovak-speaking students and are particularly effective in rural or under resourced regions where physical teaching materials may be limited.

DISCUSSION

The evidence presented in this study is quite consistent with current research trends that highlight the enduring conflict between state-driven pedagogical systems and the desire to preserve minor languages. Even though legal and institutional protections for linguistic diversity are already enshrined in Polish and European policy models, their implementation remains fragmented. As Skorupa-Wulczyńska (2025) showed, the way Poland addresses the issue of minority language education, which is the most evident in the case of Ukrainian minors, replicates the tendency of symbolic subordination, as opposed to technical equality. This observation is consistent with the Slovak experience, where policies are aware of linguistic rights but do not provide the long-term material or pedagogical support needed to make the policy achievable. Minority education is therefore site-trapped on a mono-national logic that gives preference to the mainstream Polish language and cultural identity. In this dynamic, Bryja (2025) neutralizes this by placing the Slovak Association in Poland as an educational and cultural organization.

His discussion demonstrates that the schools in the Slovak-language can serve both as the location of teaching and the location that harbors the ethnicity. The tension in the structure of these schools' problems is that although they are designed to convey Slovak linguistic heritage, they exist in a larger policy context that is inclined to assimilation. Consequently, schools become fields of contestation between identities, that is, the interactions between belonging to a community, shaped by a language through its expression in daily activities and dealings within that linguistic community, and the pressure to standardize and fit in imposed by the outside community. The homogeneity of these forces illustrates what, according to Bryja (2025), is the identity duality of the Slovak minority in Poland.

This duality is also reminiscent of the results presented by Bugár

and Vančo (2025), in which the authors look into the case of Hungarian minority students in Slovakia and reveal how bilingual schooling creates hybrid identities, which are a combination of minority and majority aspects. Applying this lesson to the example of the Slovak minority implies that Slovak first-language schools will have an opportunity to develop versatile and integrative identities on the condition that they will be permitted to exercise pedagogical autonomy. However, bilingual policies, as Jánk and Rási (2025) were very wary, are mainly sabotaged when there is an ideological hegemony in one of the languages.

Their analysis of Hungarian as a minority and the majority language points out the fact that the effectiveness of being bilingual requires not only creating bilingual education systems but also the relative position and esteem of the languages at hand. The relation of inequality between the Polish and the Slovak in Poland still influences the classroom hierarchies in Poland, both the teacher practice and the motivation of students. These outcomes still revolve around historical and structural legacies. In the article by Kosová and Porubský (2018), the authors analyze and determine how path-dependent cultures in administration in the form of hierarchy prevent innovation in the minority education sector.

A rather complementary transnational angle with respect to learning, by Mozeliak (2025), the study unveils the interactions of education systems as institutions of cultural assimilation in the event that the assumption of linguistic reversal compared to social mobility is accepted. The analogy between modern Poland and the one in ancient times is very elephantine: both situations depict that the discourse of integration may conceal the procedures of language annihilation. These lessons indicate that to maintain minority languages, the purpose of education systems should alter the way linguistic diversity is conceived (as an asset, but not as a departure of national norms). Demeter et al. (2025) point out the opportunities of Central European ethnic minorities to have education based on spatial and socioeconomic disparities. Indeed, as they demonstrate using Hungarian students within the Carpathian Basin, the uneven distribution of resources and oversight of regions contributes to the development of the unequal distribution of education. In the southern border areas of Poland, geographic factors such as rurality, institutional underinvestment, and underdevelopment of teacher education make up the range of similar factors that contribute to inequity in the education system of the Slovak communities in Poland.

These inequalities support the view that poor control over policy decentralization may continue to marginalize and not empower the local community. The results of this paper also endorse Hasanzade's (2024) criticism of bilingual education schemes that stress socially significant

inclusion rather than substantial autonomy. These practices from the old curriculum and poor provisions in schools where the teaching language is Slovak serve as an example of formal bilingualism masking actual neglect. Even though bilingual instruction is officially allowed, the systemic deficit of investments prevents it from acting as a transformative pedagogy. This resonates with an analysis by Horvath and Matlovič (2024), who stated that educational reforms in Central Europe tend to be planned according to global policy imperatives rather than individualized solutions to the specific needs of minority groups. In this broader view, among others, bilingual and culturally sustaining education has become an important structural construct for redressing equity and fostering innovation in learning. Ammar et al. (2024) claimed that bilingual instruction cultivates critical thinking, creativity, adaptability, and honesty, which are fundamental to STEM subjects.

Aguirre-Muñoz et al. (2024) also established that bilinguals and ESL teachers aligned with disciplinary literacy schemes enhance students' engagement and understanding of science learning. Applying the given principles to the case of Slovak-language education, it may be suggested that introducing Slovak as a so-called medium of instruction in STEM may positively impact both cultural and cognitive performance. Students should support linguistic competence by rotating the tea-back between Slovak and Polish in technology-bound lessons and come to acquire the ability of analytical reasoning. This overlap of bilingualism and STEM education indicated a larger shift to digitized and inclusive education. Bryja (2025) and Bugár and Vančo (2025) explained the importance of digital pedagogy for the acquisition of heritage languages by youth, highlighting that technology-based instruction can bridge the generational gap and help preserve minority languages in the contemporary educational context.

To help Slovak-language schools in Poland overcome the problem that minority-language education is irrelevant to modern career trajectories, incorporating digital storytelling capabilities, as well as concepts such as coding and virtual laboratories, into the envisioned method in the Slovak language may be beneficial. This is in line with Simanová and Lynch (2023), who emphasize that the use of culturally responsive digital tools can be important to inclusive curriculum innovation. The given research, hence, indicates that the schools teaching the Slovak language have potential opportunities that have not been exhausted thus far and can become great institutions that would allow preserving the culture and promoting the progress of science and technology concurrently.

To accomplish this transformation, a few persistent problems must be addressed: shortages of teachers fluent in the language,

insufficient funds to acquire new learning resources, and a lack of well-coordinated monitoring systems. To transform formal rights into any meaningful educational practice, it is necessary to improve policy coherence and resource allocation. Conceptually, the study builds on the statements by Bryja (2025) and Bugár and Vančo (2025) that minority schooling is an inseparable trio comprising language, education, and identity. Linguistic education, as both a mental instrument and a cultural force, strengthens social inclusion and raises academic achievement. In contrast, if the treatment of bilingualism is merely symbolic, it is likely to reinforce structural inequalities. The case of the Slovak Polish situation illustrates that effective bilingual education should strike the right balance between institutional acknowledgment and pedagogical empowerment.

RECOMMENDATIONS

Minority language education should be protected by regulations consistent with international goals, such as the Framework Convention for the Protection of National Minorities. To reduce regional disparities in Slovak-language provision, targeted funding and centralized oversight are essential (Wang et al., 2024). Equally important is the development of culturally responsive curricula, the updating of Slovak language teaching materials, and the continuous investment in teacher training.

To strengthen Slovak-language education as a gateway to STEM, it is vital to integrate bilingual pedagogy into STEM learning. Research shows that bilingualism enhances cognitive functions such as working memory, problem solving, and creativity—skills directly applicable to science, technology, engineering, and mathematics. For instance, students at a bilingual Slovak-Hungarian school participated in a robotics project in which instructions and documentation were delivered in Slovak. This allowed learners to reinforce native language proficiency while developing STEM competencies (Alvakili, 2024).

Certification initiatives and various mobility programs might encourage STEM professionals to teach in multiple languages. In addition, it is important to make it official for parents, cultural associations, and minority NGOs to be part of the education process. Stakeholders may team up to create educational programs and help pass on language and identity among different generations. Using both languages in STEM is a smart way to teach minority students that language opens doors to innovation and success.

Now, this section will discuss how digital platforms help in the education of minorities by ensuring that all students have equal opportunities to learn STEM. For instance, making Khan Academy and

Coursera available in Slovak would enable people in their region to explore top-quality STEM education online. Teachers can use the mentioned sites to select STEM lessons that fit diverse groups and are compatible with traditional classes (Hughes et al., 2022). It is emphasized that providing IT and teacher training is necessary for minority students to grow from learning STEM.

CONCLUSION

In the context of minority settings, the study highlights education for the maintenance of the Slovak language and ethnic language identity. Thus, Slovak language schools exist not only as educational institutions but also as institutions of cultural reproduction and soft power that challenge the hegemonic state discourse. It is the complex interplay of multiple institutional contexts, practices at the school and classroom level, and the agency of multicultural communities that mirror the contentious issues in the policy. Attention is given to bilingual teaching that is appropriate for the situation and to the potential results of mixing saving languages and STEM education. This suggests that schools in different countries can use affordable and straightforward solutions to support minority-language education.

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Bio

MAREK BRYJA, based in Poland, holds a master's degree in Ethnology from the University of Ss. Cyril and Methodius in Trnava – Slovakia. He is dedicated to preserving Slovak culture and pursuing a PhD on the Slovak minority in Poland, while also working as an educator. Email: marekbryja34@gmail.com

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