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Education in the Age of Artificial Intelligence. Conclusions from Sweden's Decision for Pedagogy and the Design of Educational Environments

Abstract

The decision of the Swedish government to limit digital technologies in early school education has been taken as a starting point for reflection on the design of didactics in the age of artificial intelligence. The analysis was embedded in the framework of digital pedagogy, Marian Mazur's theory of autonomous systems, and pedagogical cybernetics. OECD data (PIAAC, PISA) and national statistics (GUS, BN) concerning basic skills and reading practices were used. A comparison of trends from 2011/12 to 2022/23 shows that in Sweden the percentage of people with very low skills remains stable (12–14%), while in Poland it reaches almost 40% in reading and mathematical reasoning and 48% in problem solving (see also Díaz et al., 2024). The results indicate that mere access to technology does not guarantee the development of competences and, with a weaker foundation, may deepen inequalities. The conclusions emphasize the need for sequential didactic models "offline-first, AI-assisted," in which traditional practices form the foundation and artificial intelligence supports only critical and autonomous thinking.

Keywords: digital pedagogy; artificial intelligence in education; internal control; design of educational environments; functional illiteracy.

Introduction

Digitization has become, over the past two decades, one of the main directions of educational reforms. Information and communication technologies

(ICT) have been presented as tools of the democratization of knowledge, the personalization of teaching, and the development of future competences. The decision of the Swedish government in 2023 to limit the use of ICT in early school education – including a return to printed textbooks and handwriting – has sparked a broad debate. It is interpreted not as a resignation from digitization, but as an attempt to restore balance between online and offline practices at key stages of education. As Selwyn, Nemorin, Bulfin and Johnson (2017) emphasize, digital technologies in schools should not be treated as neutral tools but as political and cultural instruments, embedded in broader social contexts, which makes critical reflection on their implementation essential.

As Prof. M. Piasecka (2022) notes, "every epoch has its important questions, which are posed in the face of successes, failures, crises, and challenges. Educational reality, immersed in broad social and cultural contexts, concentrates within itself like a lens the problems of the macro-world." One such question is the relationship between technology and basic competences.

The research problem concerns the discrepancy between access to technology and the level of basic skills. In the PISA methodology, basic competences are understood as the ability to read and to reason mathematically above the Level 2 threshold, that is, the minimum level of proficiency enabling further learning and social participation (OECD, 2023). PIAAC and PISA data indicate that the mere presence of ICT in schools does not automatically translate into higher results in reading, writing, or mathematical reasoning. Research results on the popular flipped classroom concept confirm that the effectiveness of methods depends on the quality of didactic preparation and teacher support (Diaz Gomez et al., 2024). Moreover, with differentiated initial competences, technologies may deepen educational inequalities instead of reducing them. In the Polish debate, however, the digitization of schools is still reduced mainly to the issue of equipment, although the data show the greater importance of the quality of tasks and teacher preparation.

The aim of this analysis is to juxtapose Sweden's decision with OECD data and the situation in Poland, as well as to interpret the results in the light of Marian Mazur's theory of character. The cybernetic perspective makes it possible to treat the student as an autonomous system, whose rigid control parameters constitute the basis for development (Mazur, 1999). From this perspective, the role of the school is not to attempt to change the student's character, but to design educational environments conducive to internal control and cognitive autonomy.

The analysis focuses on three research questions:

1. How have the indicators of basic competences (PIAAC/PISA) changed in Sweden and Poland in the years 2011/12–2022/23, and what significance do these changes have for policies limiting screens in lower grades?

2. In what way do Mazur's theoretical categories (autonomous system, internal control, "control parameters") help to interpret the effects of different online/offline mixes for students of different characters?
3. What design solutions – the selection of tools, the sequence of activities, the task-based use of AI – support the strengthening of internal control, and in what situations is there a risk of its weakening?

The structure of the article includes a discussion of the theoretical framework, a presentation of the methodology and comparative results, an analysis of the case of Sweden, and a discussion leading to conclusions and recommendations concerning the design of educational environments in the era of artificial intelligence.

1. Theoretical framework

1.1. Digital pedagogy and the online/offline mix – definitions and risks of competence inequalities

Digital pedagogy is understood as the practice of combining information and communication technologies (ICT) with traditional forms of education. The key challenge remains the balance between digital and analog elements – not for the mere presence of screens, but for the purpose of strengthening basic competences (Fullan & Langworthy, 2014).

Research shows that technology in itself does not improve the quality of learning, and the lack of teacher preparation deepens inequalities (Zawacki-Richter et al., 2019). Polish studies have indicated that teachers often have equipment at their disposal, but they lack tools for designing tasks that develop critical thinking and cognitive competences.

Diaz et al. (2024) show that well-designed digital books can surpass paper materials, but their effectiveness depends on the methodology of work. Without appropriate instructional design, e-books foster the shallowing of practices and the reinforcement of competence differences, especially with unequal school and family support (Holmes et al., 2022).

In this context, there is talk of "second-generation inequalities" – resulting from the quality of didactic tasks and the way online/offline is integrated, not from mere access to equipment. As Bussesund, McGarr, and Engen (2024, p. 268) noted, teachers are at the same time "key actors and main obstacles" of the digitization process, because it is their design decisions that determine whether technologies support students' development or merely deepen differences. This aligns with Hattie's (2011, p. 22) findings that visible learning depends primarily on the teacher's ability to set explicit goals, provide and seek feedback, and actively engage students in the learning process. Recent research

further confirms this perspective: Ning and Danquah (2025) show that teachers' pedagogical readiness for digital innovation is shaped not only by their individual competences, but also by institutional support, targeted professional development, and their own beliefs about the educational value of technology.

1.2. Mazur's theory – Key concepts

Marian Mazur defined the human being as an autonomous system, capable of self-regulation through feedback mechanisms and a homeostat that maintains functional equilibrium in the face of disturbances (Mazur, 1976; 1999). The central concept of this theory is character, understood as "a set of rigid control properties" (Mazur, 1976)[1]. These are relatively stable regulatory traits that determine how an individual responds to stimuli and makes decisions.

Internal control means the ability to maintain balance despite disturbances and in didactics corresponds to processes of self-regulation. As Mazur emphasized, "the behavior of other people can be influenced only by affecting the registration potential Vr" (Mazur, 1976). This means that the school does not change the student's character but can design educational environments consistent with his or her parameters.

Although the theory was developed in the 1970s, its categories remain relevant. The concepts of character and internal control allow us to redefine the boundaries of the school's influence on the development of cognitive autonomy and critical thinking. These interpretations have been further elaborated in Polish pedagogical literature, where Wilsz (2005, 2012, 2015) developed systemic and cybernetic analyses of human functioning as a basis for educational research.

1.3. Pedagogical cybernetics – adaptive control

Pedagogical cybernetics approaches the educational process as a cycle of adaptive control: identification (recognition of the student's state), intervention (selection of didactic actions), and re-identification (evaluation of effects and adjustment of the process) (Barot, 2017). Empirical studies have shown that students were "repeatedly identified by a teacher" in order to adjust tasks and tools to changing needs (Barot, 2017).

In this approach, the teacher does not change the student's control parameters but adjusts stimuli and the environment so as to support the cognitive homeostat. Adaptive control requires not only cyclical diagnosis and re-diagnosis but also the conscious design of feedbacks between teacher and student (Barot, 2017). Practice understood in this way constitutes a development of Mazur's concept, transferring it to the ground of school didactics.

[1] All translations into English of the original texts are the author's own translations.

1.4. Knowledge Management and Artificial Intelligence (AI)

Generative artificial intelligence carries the risk of flattening knowledge structures and lowering cognitive curiosity (Fazlagić, 2018, 2022). The effectiveness of knowledge management in schools, however, depends on the ability to create "organizational memory" – repositories of experiences, examples, and practices (Fazlagić, 2020). Knowledge management understood in this way makes it possible to counteract the effect of superficiality generated by AI, because students can use authentic sources and institutional reflection, and not only content provided by algorithms.

Shifting the burden of regulation from the student to technology weakens the processes of internal control. Therefore, didactics should include "AI-resilient" tasks, such as the reconstruction of reasoning, working with sources, counter-argumentation, and diversifying ways of acquiring knowledge (print, discussion, digital resources). An important element is also knowledge management practices in schools – the creation of communities of practice (groups of teachers and students exchanging experiences) and joint reflection on mistakes (Fazlagić, 2020). In this perspective, the role of AI is to support the planning, monitoring, and correction of the student's actions so as to strengthen, rather than replace, his cognitive autonomy.

2. Methodology

The study employed a comparative case study (Sweden–Poland), secondary analysis of international data (PIAAC, PISA) and national data (GUS, BN), as well as an analysis of education policy documents announced in Sweden since 2023 (Regeringskansliet). Quantitative data made it possible to capture trends in basic competences and reading practices, while the analysis of documents enabled the reconstruction of the logic of policy (e.g., limiting screen time, investments in textbooks) (OECD, 2016; OECD, 2019; U.S. Department of Education, NCES, n.d.; OECD, 2023a, 2023b; Biblioteka Narodowa, 2016–2024; GUS, 2023; Regeringskansliet, 2023; UNESCO, 2023).

The trend analysis covered the years 2011/12–2022/23: in PIAAC – cycle 1 (2011–2016) and cycle 2 (2022/23), in PISA – the 2012–2022 editions, and in national data – annual BN indicators and GUS aggregates. The analysis of documents concerned the period 2023–2024, including communications of the Swedish government on skärmfri förskola policy and directions of digitization (Regeringskansliet, 2023; UNESCO, 2023).

Five indicators were adopted (Table 1):

1. **Adult competences (PIAAC) –** the percentage of people with a score ≤ Level 1 (≤225 points) as a measure of very low skills, identified with functional illiteracy (OECD, 2016).

2. **Student competences (PISA) –** a score below Level 2 means the absence of a minimum proficiency threshold and the risk of cognitive deficits (OECD, 2023a; OECD, 2023b).
3. **Reading practices (BN) –** no reading of books (0 per year) as an indicator of the marginalization of literacy practices (Biblioteka Narodowa, 2016–2024).
4. **Demographic-educational context (GUS) –** structure of education and participation in lifelong learning as the background for interpreting differences in PIAAC and PISA (GUS, 2023).
5. **Theoretical categories (Mazur)-** character as "a set of rigid control properties" and internal control as the ability to self-regulate the learning process (Mazur, 1976; 1999).

The analysis focuses on the percentage of people ≤ Level 1. Other measures, e.g., average scores, were omitted due to clarity and usefulness for education policy.

Table 1
Operationalizations of the Studied Variables

Variable	Operational Definition	Threshold/ Category	Interpretation	Source
Adult Competences (PIAAC)	Score in the literacy and numeracy scale in the PIAAC survey (ages 16–65)	≤ Level 1 (≤ 225 points)	Proxy of functional illiteracy – performing only simple text and numerical tasks.	OECD (2016), *Skills Matter: Further Results from the Survey of Adult Skills*, OECD Publishing, Paris; OECD (2019), *Technical Report of the Survey of Adult Skills* (*PIAAC*), OECD Publishing; OECD (2023), *Do Adults Have the Skills Required to Succeed in the 21st Century?*, OECD Publishing; NCES (n.d.), *What PIAAC Measures*, National Center for Education Statistics
Student Competences (PISA)	Score of fifteen-year-olds in reading and mathematics.	< Level 2	Risk of cognitive deficits – difficulty in identifying the main idea and applying basic strategies.	OECD (2023), *PISA 2022 Results: Country Note – Poland*, OECD Publishing; OECD (2023), *PISA 2022 Results: Country Note – Sweden*, OECD Publishing
Reading Practices (BN)	Declarations of Poles regarding the number of books read in a year.	0 books / year	Indicator of the marginalization of reading; proxy of the decline of cultural practices supporting literacy.	Biblioteka Narodowa (2016), *Stan czytelnictwa w Polsce w 2016 roku*; Biblioteka Narodowa (2020), *Stan czytelnictwa w Polsce w 2020 roku*; Biblioteka Narodowa (2022), *Stan czytelnictwa w Polsce w 2022 roku. Komunikat o badaniach*; Biblioteka Narodowa (2024), *Stan czytelnictwa w Polsce w 2024 roku*

Table 1 (cont.)

Variable	Operational Definition	Threshold/ Category	Interpretation	Source
Educational Context (GUS)	Participation in education and lifelong learning; structure of the population's educational attainment.	GUS indicators (2011–2023)	Demographic-educational background for the interpretation of PIAAC and PISA.	Główny Urząd Statystyczny (2024), *Program badań statystycznych statystyki publicznej na rok 2024. Część I. Informacje o badaniach*, Warszawa
Theoretical Categories (M. Mazur)	Character and internal control	Definitions from Mazur (1976)	Interpretative categories: whether the educational environment strengthens or weakens self-control.	Mazur, M. (1976), *Cybernetyka i charakter*, PIW, Warszawa

Note. Author's own elaboration based on OECD (2016), U.S. Department of Education, NCES (n.d.), OECD (2024), Biblioteka Narodowa (2024), GUS (2023), and Mazur (1976, 1999).

PIAAC Poland (2022/23). OECD emphasizes problems with the quality of data in a significant part of the sample; the results require greater interpretative caution than in other countries (OECD, 2023, *Do Adults Have the Skills…*). **BN.** The "0 books" indicator in 2023 amounted to 57% of adults (readers about 43%), that is, slightly less than the over 60% observed earlier (Biblioteka Narodowa, 2024).

The analysis was deliberately limited to the percentage of people ≤ Level 1. Other measures, e.g., average scores, were omitted due to clarity and usefulness for education policy.

2.1. Limitations of the Study

Comparative studies carry the risk of simplifications. In the case of Poland and Sweden, significant demographic and linguistic differences mean that "measures of competence" also reflect the cultural and social context.

In PIAAC, the methodology has changed: cycle 2 (2022/23) differs from cycle 1 not only by the transition to tablets but also by the introduction of a new domain, adaptive problem solving, instead of the earlier problem solving in technology-rich environments (OECD, 2019). This means that comparisons of results may be misleading, especially in public debate. Also in PISA 2022 it is difficult to separate the results from the effects of the pandemic and remote learning. In

Poland, this crisis was exceptionally severe, which may have influenced declines in reading and mathematics. GUS and BN data have a different character – they show cultural practices rather than skills themselves.

The declaration "I do not read books" does not mean a lack of reading ability, but indicates lifestyle and generational differences. These limitations do not invalidate the comparisons but require interpreting them with caution, taking into account the context and with the awareness that differences of a dozen or so percent between countries are of a lasting character.

The analysis is based on published PIAAC and PISA data. Reported percentages should be treated as point estimates subject to sampling error. Standard errors (SE) and confidence intervals (CI) are available in the OECD technical documentation. In this paper a descriptive approach is applied, focusing on the mapping of patterns and their educational interpretation. No causal tests were conducted, and the comparisons are cross-sectional and interpretative in nature.

2.2. Selection of the Comparative Country

The choice of Sweden as the comparative country results from two premises. First, in 2023 the government in Stockholm decided on a clear correction of policy: limiting digital technologies in preschool and early school education and returning to printed textbooks and handwriting (Regeringskansliet, 2023). In Poland, where digitization has been developed for years – among others through laptop programs for students – this decision constitutes an important counterpoint.

Second, the percentage of adults with extremely low results in PIAAC (≤ Level 1) is low and stable in Sweden, while in Poland it remains high. The fact that a country with a large share of migrants maintains a low level of very low competences indicates that the Polish problem has other sources – systemic or cultural. This question constitutes a key point of the comparative analysis.

2.3. Analytical Procedure

The analysis comprised three stages. First, the PIAAC results of Poland and Sweden were compared in cycles 1 and 2, limited to the literacy and numeracy domains, which are comparable between waves. Next, a table "country × year × domain" was developed, also including APS from 2022/23, with the reservation of its incomparability with the earlier PSTRE (OECD, 2019). In the third step, a content analysis of Swedish policy communications was carried out.

Coding according to the scheme policy element → principle → expected mechanism revealed a logic in which limiting screens is justified by concern for the student's self-control and ability to concentrate. Such an approach corresponds both with Mazur's (1976) cybernetic categories and with the concept of

adaptive control (Barot, 2017), see also the approach of predictive control in technical cybernetics, which justifies the cycle diagnosis–intervention–re-diagnosis (Barot, Kubalcik, & Bobal, 2017). From the Polish perspective, it contrasts with the parallel modernization discourse: "more technology = a better school." This asymmetry is one of the most important findings of the analysis.

3. Results

The analysis of data from the Programme for the International Assessment of Adult Competencies (PIAAC) and the Programme for International Student Assessment (PISA) reveals a clear contrast between Poland and Sweden in terms of basic competences (Table 2).

Table 2
Percentage of adults (*ages 16–65*) *reaching level ≤ Level 1 in PIAAC* (*literacy, numeracy, adaptive problem solving*), *Poland and Sweden, 2011/12 and 2022/23* [*%*]

Country	Literacy 2011/12	Literacy 2022/23	Numeracy 2011/12	Numeracy 2022/23	Adaptive Problem Solving 2022/23*
Sweden	13.3	12	14.7	12	14
Poland	38.3**	39	38.1**	38	48

Note. Author's own elaboration based on OECD (2016), OECD (2019), OECD (2023a), and OECD (2023b). *Adaptive Problem Solving (APS) is reported only in cycle 2 (2022/23). In cycle 1 a different construct, PSTRE, was used and is not directly comparable. **Exact values for Poland (2011/12) are taken from tables A.3.2 and A.2.2 in OECD (2016).

3.1. Trends in PIAAC

In Sweden, the percentage of adults with very low competences remains at the level of 12–15% and is stable between cycles, which indicates a lasting skill base. In Poland, this indicator is more than twice as high – 38–40% – and has practically not improved over the decade. Particularly alarming are the results of the APS domain from 2022/23: 48% of adult Poles do not reach the minimum threshold, while in Sweden only 14%.

Such data mean that nearly half of adults in Poland may have difficulties adapting to new professional and social situations. This contrasts with the narrative of education policy, which for years has emphasized digitization and "skills of the future." OECD results suggest that the real effect of these actions is limited. However, it should be remembered about the limitations: in Poland in 2022/23 problems with data quality were noted in a significant part of the sample, which requires more cautious interpretation (OECD, 2023a).

3.2. Trends in PISA

The results of fifteen-year-olds in the PISA study confirm the differences observed among adults. In Poland in 2022, about 25% of students scored below level 2 in reading and mathematics, which means the absence of a minimum proficiency threshold. In Sweden, the problem concerned about 17% of students, and the results were more stable. Poland ranks close to the OECD average, while Sweden maintains a level clearly above this average (OECD, 2023b; OECD, 2023c). The difference of eight percentage points translates into thousands of students: in Poland many of them remain below the threshold of minimum competences, while in Sweden they reach this threshold.

3.3. Interpretation of Differences

The Polish–Swedish contrast goes beyond dry numbers and has several dimensions.

1. **Competence base –** in Sweden, a stable level of skills is maintained both among adults and students. In Poland, the high percentage of adults with very low competences limits the effectiveness of the school – the system operates in the shadow of a weak family and social base.
2. **Cultural practices** – according to National Library surveys, in 2020 the indicator of at least one book read during the year was 42% (BN, 2020, p. 1), in 2022 it dropped to 34% (BN, 2022, p. 5), in 2023 it rose again to 43% (BN, 2023, p. 4), and in 2024 it slightly decreased to 41% (BN, 2024, p. 6). In Sweden, reading culture, supported by a dense network of libraries and state policy, remains a widespread practice. This is a difference not only of a statistical but also of a civilizational character.
3. **Demography and language-** factors such as the share of migrants or the structure of the language may influence the results but do not explain the scale of the contrast. Rather, they increase the demands on Sweden, which nevertheless achieves higher results.

3.4. Case Study: Sweden – Policy of Limiting ICT

In 2023, the Swedish government announced a package of measures limiting children's exposure to digital tools in preschool and early school education. It included the withdrawal of the obligation to use tablets in preschools, increased expenditure on printed textbooks, and the return to learning handwriting in grades I–III. In official communications, emphasis was placed on the protection of "cognitive health" and the need to strengthen educational foundations before intensive digitization (Regeringskansliet, 2023).

Studies by Holmes et al. (2022) and Pettersson, Hult, Eriksson, and Adewumi (2024) indicate that these decisions were interpreted in schools as a signal of

care for students' attention and for balance between the analog and digital environment. In practice, they can be treated as a conscious giving of a "breath from digitization" to students.

In March 2023 the National Agency for Education announced the phasing out of mandatory digital tools in Grades 1–3. In August 2023 the Ministry of Education confirmed the return to printed textbooks as the default in basic education, and in September the government allocated SEK 685 million for the purchase of printed materials and teacher training in reading instruction. In 2024 pilot projects were launched in selected municipalities in order to evaluate learning outcomes under a reduced digital load. These actions represent a reversal of the earlier "digital-first" policy. At the time of writing no outcome data are yet available; the analysis refers to the logic of policy design rather than to its measured results.

3.5. Political Justifications

The decision of the Swedish government had three sources: deteriorating competence results, concerns about the impact of screens on attention and memory, and the lack of evidence that early digitization improves the quality of learning (Regeringskansliet, 2023; UNESCO, 2023). This direction was assessed differently – as a necessary limitation or as a risk of weakening digital competences. In Poland, a similar debate practically does not exist: digitization is usually presented as a non-alternative solution.

In Poland, where nearly 40% of adults have serious deficits in basic skills, the priority should be the foundations of reading, writing, and arithmetic. Only on this basis is it worthwhile to selectively introduce new technologies and artificial intelligence into didactics. Otherwise, there is a risk of a paradox: modern tools end up in the hands of students who are unable to fully understand a simple text.

3.6. Mapping onto Didactic Design

In Mazur's (1976) cybernetic perspective, these actions strengthen the attention homeostat and the student's internal control. The limitation of screens and the emphasis on handwriting do not change character but tune the environment to natural regulatory mechanisms. Sweden's policy resembles an adaptive loop: diagnosis (decline in competences), intervention (print, handwriting, reduction of screens), and re-identification of effects in PISA and national tests. This is an example of practical feedback – rarely encountered in Poland. This logic can be further illustrated in Table 3, which maps Swedish policy elements onto design principles and expected mechanisms.

Table 3
Elements of Swedish policy – design principles – expected mechanism (*Mazur / adaptive control*)

Policy element (Sweden)	Design principle (for school/classroom)	Expected mechanism (Mazur / adaptive control)
Investments in printed textbooks ("more reading, less screens") Return to handwriting	Offline-first in grades I–III: most work with printed text, screen as support	Reduction of distractions → stabilization of the attention homeostat; strengthening of internal control
Investments in printed textbooks ("more reading, less screens") Return to handwriting	Daily handwriting practice (10–15 minutes)	Integration of motor skills and memory – deeper encoding – development of agency
Limitation of screens in preschool and lower grades	Gradual introduction of ICT only after reaching proficiency thresholds in reading and arithmetic	Dosing of stimuli- reduction of cognitive overload, prevention of external control
Introduction of "silent reading windows"	Fixed periods of focus without digital devices	Micro-loops of re-identification of progress; strengthening of self-regulation capacity
Caution toward "hyper-digitization" (AI and cognitive health)	AI as an assistant, not a substitute – tasks requiring reconstruction of reasoning	Minimization of "flattening" of knowledge; preservation of the student's cognitive autonomy

Note. Author's own elaboration based on Regeringskansliet (2023), UNESCO (2023); OECD (2023), Holmes et al. (2022), Pettersson et al. (2024).

The Swedish case shows that ICT limitations can be consistently embedded within a systemic logic. Strengthening analog elements – such as the textbook, handwriting, or silent reading – stabilizes attention and supports self-regulation. For Poland, with a high proportion of adults with low competences, this means the necessity of building foundations before digitization. Technologies, including AI, can support learning, but only when they are based on a solid foundation of reading and arithmetic.

4. Discussion

The analysis of PIAAC and PISA shows that without strong foundations in reading, writing, and arithmetic, the inclusion of digital technologies and artificial intelligence into didactics is risky. The "offline-first, AI-assisted" model assumes the dominance of analog activities in early school education, and the introduction of digital tools only after reaching the proficiency threshold (e.g., Level 2 in PISA; OECD, 2023). Technology makes sense when the student is able to work with text independently.

According to Mazur's (1976; 1999) theory, the goal is the protection of the attention homeostat and the strengthening of internal control. The implementation of such a model, however, encounters barriers: some teachers have become accustomed to tablets, and parents treat them as a symbol of a modern school. In Poland, the debate focuses more on equipment than on the quality of didactic practices. Such an interpretation resonates with Wilsz's (2012, 2015) argument that cybernetics provides a key to the interdisciplinarity of pedagogy and its application to practical educational design.

The design of learning environments should be based on the logic of adaptive control (Barot, 2017): identification of the student's level, intervention (greater share of offline when deficits are present; task-based use of AI after crossing the threshold), and re-identification of effects. The online/offline "mix" is not a slogan but a sequence of actions: textbooks, discussion, and handwriting must balance the screens. AI, in turn, should support the reconstruction of reasoning and additional tasks, not provide ready-made answers (Fazlagić, 2018).

Effectiveness also depends on the culture of the school. Fazlagić (2018, 2022) emphasizes the role of communities of practice and learning from mistakes, while Bussesund, McGarr, and Engen (2024) highlight the responsibility of teachers as both the main actors and the main barriers to digitization. UNESCO (2023) and Holmes et al. (2022) warn that AI, when used unreflectively, flattens knowledge and lowers cognitive curiosity. The answer lies in "AI-resilient" tasks that require recording the thought process and engaging in critical discussion.

Critics of the offline-first model point to greater motivation and personalization thanks to technology. However, OECD (2023) data suggest that this effect occurs only after reaching the proficiency threshold. Similarly, the argument about a "regression of digital competences" is misguided—offline foundations are a prerequisite for effective digital work.

The comparative difficulties of PIAAC and PISA stem from demographics and reading culture but do not invalidate the conclusions. Therefore, triangulation was applied: numerical data were combined with policy documents and theoretical frameworks. The paradox is clear: tools promised as "democratizing" access to knowledge may flatten its structure. This is confirmed by reports from the Supreme Audit Office, which indicate that the lack of teacher preparation effectively limits the impact of school digitization.

The scheme (Fig. 1) shows the flow of dependencies in the design of learning environments. The starting point is the online/offline proportions, which stabilize attention and support self-regulation. Internal control is monitored in an adaptive cycle (diagnosis – intervention – re-diagnosis) (Barot, 2017, p. 7). AI appears only after reaching the proficiency threshold and serves as an assistant – supporting analysis and the reconstruction of reasoning instead of providing

ready-made answers. In this way, a well-designed mix can both reduce inequalities and protect against cognitive overload.

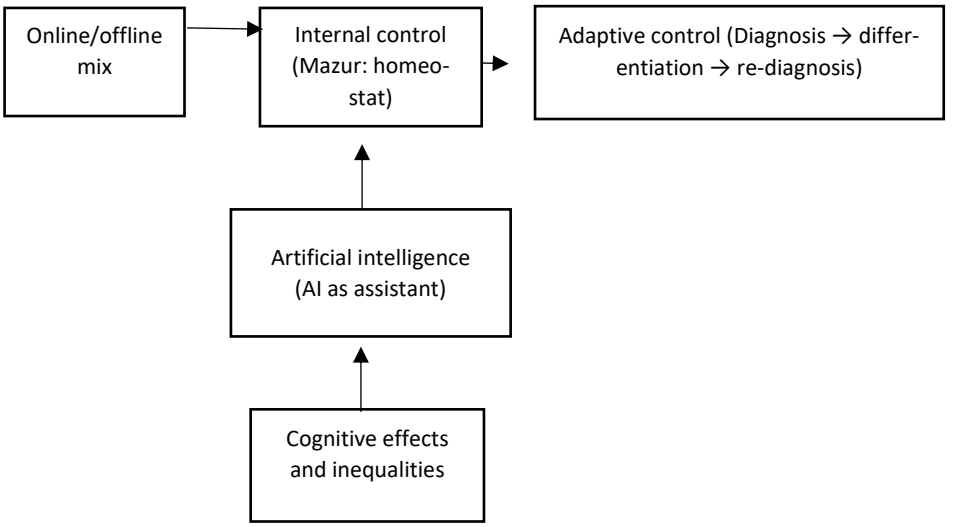

Fig. 1
Conceptual scheme
Note. Author's own elaboration based on Mazur (1976, 1999), Barot (2017), Fazlagić (2018, 2022), OECD (2023a), Regeringskansliet (2023).

5. Conclusions and Recommendations

The comparison between Poland and Sweden shows that effective digitization of education begins with the basics. PIAAC and PISA data demonstrate that students who do not reach the minimum proficiency threshold in reading, writing, and arithmetic cannot fully benefit from digital tools—technologies may even weaken their independence. Therefore, in grades I–III, analog practices should be the priority: working with books, handwriting, and silent reading.

AI should serve as an assistant, not a substitute. Its task is to support the reasoning process—generating additional exercises or solution variants—rather than providing ready-made answers. The key is "AI-resilient" tasks that require recording the reasoning process and engaging in critical discussion, ensuring that AI strengthens internal control instead of replacing it (Fazlagić, 2018, 2022).

The practical implementation of this approach requires the logic of adaptive control (Barot, 2017): diagnosis of the level, adjustment of the online/offline proportions, and re-diagnosis. This cycle makes it possible to respond to the diverse needs of students and to protect against cognitive overload.

The organizational culture of the school is also crucial: communities of practice, repositories of student work, and learning from mistakes create resources that counteract the "flattening of knowledge" by generative tools (Fazlagić, 2018, 2022).

The Swedish experience shows that education policy should balance investments in traditional practices with the development of teachers' competencies for critical, task-based use of AI. In Poland, with a weaker baseline of adult competences, the necessary sequence is: first the fundamentals, then the careful integration of technology (BN, 2020, p. 1; BN, 2022, p. 5; BN, 2023, p. 4; BN, 2024, p. 6).

Thus understood, the "offline-first, AI-assisted" strategy minimizes the risk of deepening inequalities and prepares students for the conscious use of AI. This is not only a matter of education policy but also a civilizational challenge: how to design a school that strengthens cognitive autonomy instead of reducing the student to the role of a content consumer. This challenge is echoed in recent research on inclusive education, where the dynamism of character is proposed as a tool for supporting teachers in diverse classroom environments (Ziębacz, 2024).

Meta-analyses indicate a consistent advantage of paper-based reading over digital reading, especially in tasks requiring deeper reflection (Delgado et al., 2018; Clinton, 2019). At the same time, research on the flipped classroom model confirms its moderate effectiveness when appropriate instructional support is provided (Lo & Hew, 2017).

This paper does not test causal relationships between ICT use and learning outcomes. The analysis is descriptive and is based on international assessment data and one national case study. The focus is on policy logics and their possible implications. The results should not be overgeneralized beyond the cultural and institutional contexts of Poland and Sweden.

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Edukacja w epoce sztucznej inteligencji. Wnioski z decyzji Szwecji dla pedagogiki i projektowania środowisk dydaktycznych

Streszczenie

Decyzja rządu Szwecji o ograniczeniu technologii cyfrowych w edukacji wczesnoszkolnej została potraktowana jako punkt wyjścia do refleksji nad projektowaniem dydaktyki w epoce sztucznej inteligencji. Analiza została osadzona w ramach pedagogiki cyfrowej, teorii systemów autonomicznych Mariana Mazura oraz cybernetyki pedagogicznej. Wykorzystano dane OECD (PIAAC, PISA) oraz statystyki krajowe (GUS, BN) dotyczące kompetencji podstawowych i praktyk czytelniczych. Porównanie trendów z lat 2011/12–2022/23 pokazuje, że w Szwecji odsetek osób o bardzo niskich umiejętnościach pozostaje stabilny (12–14%), podczas gdy w Polsce sięga niemal 40% w zakresie czytania i rozumowania matematycznego oraz 48% w rozwiązywaniu problemów. Wyniki wskazują, iż sam dostęp do technologii nie gwarantuje rozwoju kompetencji, a przy słabszej bazie może pogłębiać nierówności. Wnioski akcentują potrzebę sekwencyjnych modeli dydaktycznych „offline-first, AI-assisted", w których tradycyjne praktyki stanowią fundament, a sztuczna inteligencja wspiera jedynie krytyczne i autonomiczne myślenie.

Słowa kluczowe: pedagogika cyfrowa; sztuczna inteligencja w edukacji; sterowanie wewnętrzne, projektowanie środowisk dydaktycznych; analfabetyzm funkcjonalny.