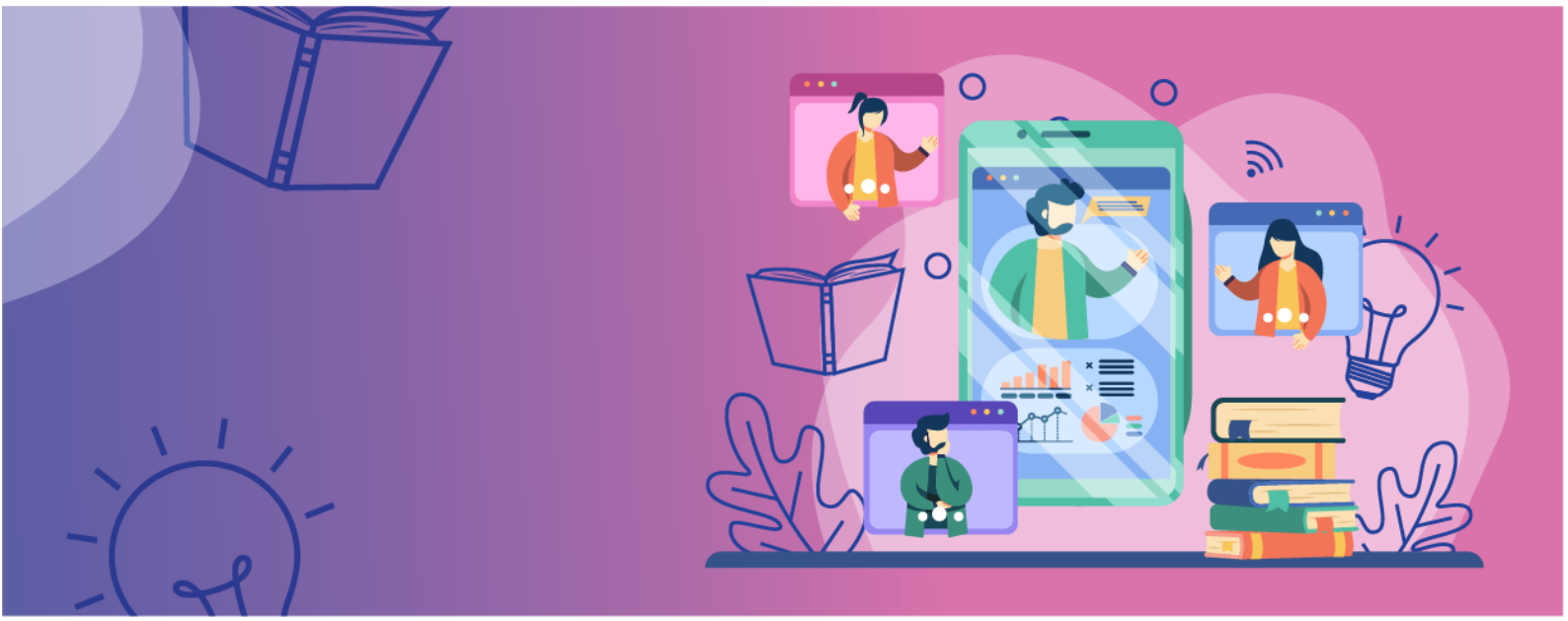
DIGITAL FIRST

Digital Tech as the First Language:

Informatics for Digital Natives

D7.1 Theory and practice of learning analytics for informatics: Research and Results



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MAIN AUTHORS	
Name	**Organization**
Daranee Lehtonen	UTU
Valentina Dagienė	VU

QUALITY REVIEWERS	
Name (Quality Reviewer 1, Quality Reviewer 2)	**Organization**
Maja Šarić, Maja Brkljačić	Algebra University

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1 Introduction

The **Digital First** project (*Digital Tech as the First Language: Informatics for Digital Natives*) is a Europe-wide initiative that aims to enhance the teaching and learning of informatics in primary and secondary schools. As digital technologies increasingly shape how young people live, learn, and communicate, the project recognises the need to adapt teaching practices to support these "digital natives better." It aims to explore more effective pedagogical approaches, enhance the consistency of teacher training, and align classroom practices with the diverse learning styles of today's students.

With partners from **ten European countries**, the project's overarching ambition is to **develop and test innovative, evidence-based approaches** that focus on the functional aspects of informatics teaching competencies. In doing so, it aims to empower teachers and students to move beyond passive technology use and become active, creative participants in the digital world.

To achieve this, **Work Package 7** – *Data for Success: Modelling Learning Analytics for Informatics* – focuses on two key areas:

1. Building a supportive network for informatics teachers.
2. Developing a forward-looking framework for applying learning analytics (LA) in informatics education.

Within this work package, **Task 7.1 – Research on Existing Practices of Learning Analytics for Informatics in the EU** – examines how learning analytics is currently understood and used across Europe. The resulting **Deliverable 7.1 – Theory and Practice of Learning Analytics for Informatics: Research Results** – provides an overview of theoretical perspectives and successful practices of LA in teaching informatics. These insights lay the foundation for future outputs of the work package (**Deliverables 7.2–7.4**), which will develop a practical guidebook to help teachers and schools introduce LA for informatics education.

This report brings together contributions from partners in **Bulgaria, Croatia, Cyprus, Finland, Greece, Italy, Lithuania, Portugal, Slovenia, and Spain**. Together, they provide a rich and varied picture of how LA is being used in informatics education across Europe. While the national contexts differ, the findings reveal shared challenges, common practices, and promising directions for the future. Ultimately, the insights presented here aim to inspire educators and policymakers to harness the power of LA to support more effective, data-informed teaching and learning in informatics.

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2 Theoretical background of learning analytics

Providing evidence for strategic instructional planning has always depended on the systematic use of data, particularly student-generated data (Prinsloo, 2023). In recent years, LA has emerged as a rapidly growing field that leverages data science to collect, analyse, and interpret educational data for the purpose of improving learning and teaching processes. With the expansion of technology-enhanced learning environments, LA has gained increasing attention as a means of automating and refining academic data analysis to enhance the overall learning experience.

The proliferation of online learning platforms, digital courses, and educational technologies has further accelerated interest in LA, as institutions and researchers recognise its potential to support data-informed decision-making at multiple levels—learners, teachers, and administrators alike. Importantly, LA serves not only institutional objectives, such as monitoring performance and improving curricula, but also personal learning goals by helping students and teachers understand and act upon meaningful learning data.

Formally defined at the First International Conference on Learning Analytics and Knowledge (in 2011), learning analytics is the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs (Ferguson & Buckingham Shum, 2011; Shum & Ferguson, 2012; Nistor & Hernández-García, 2018). This definition underscores the dual focus of LA on both understanding learning processes and optimising educational environments.

In practice, learning analytics involves an interconnected process: learners generate data through their interactions with digital systems; this data is then collected and transformed into meaningful indicators or metrics; and finally, these insights inform pedagogical interventions aimed at improving learner performance and engagement. When effectively implemented, LA empowers both teachers and students to interpret learning data critically, fostering self-awareness, reflection, and adaptive learning strategies.

Looking ahead, learning analytics is expected to play an increasingly central role in shaping open, networked, personalised, and lifelong learning ecosystems. Its integration promises to shift educational practices toward more data-informed, equitable, and responsive forms of teaching and learning.

2.1 Overview of Learning Analytics and Global Trends

Learning Analytics (LA) refers to the measurement, collection, analysis, and reporting of data about learners and their contexts, with the aim of understanding and optimising learning and the environments in which it occurs. Over the last decade, the number of publications on Learning Analytics has increased exponentially. According to Kılıç and İzmirli (2024), more than 1,000 articles were published between 2014 and 2024, reflecting a rapidly growing interest in data-informed education. Research now spans diverse domains, including higher education, corporate training, and increasingly, primary and secondary schools (K–12).

The field has evolved from early exploratory analyses toward evidence-based, technology-supported decision-making. LA combines methods from educational data mining, artificial intelligence, and learning sciences to uncover patterns in learner behaviour, provide actionable insights for teachers, and improve institutional practices.

2.2 Learning Analytics Methodologies

The Society for Learning Analytics Research (SoLAR) identifies four core methodologies in Learning Analytics: descriptive, diagnostic, predictive, and prescriptive analytics. Each methodology serves a distinct purpose and collectively supports a comprehensive data-informed approach to improving learning outcomes.

Descriptive analytics answers the question 'What happened?' by summarising past data on student participation, performance, and engagement. Diagnostic analytics explores 'Why did it happen?', identifying patterns and anomalies that explain learner behaviours. Predictive analytics uses statistical and machine learning models to forecast future trends, such as identifying students at risk of dropping out. Prescriptive analytics goes a step further, recommending specific interventions—often automated—such as alerting teachers or sending reminders to students.

2.3 Learning Analytics Techniques and Tools

Learning Analytics employs various computational techniques to detect meaningful patterns and relationships in educational data. Two of the most prominent techniques are *data mining* and *machine learning*. Data mining focuses on collecting, filtering, and structuring large data sets to reveal trends, while machine learning models learn from historical data to make predictions or recommendations for future learning.

Selecting the right tools for Learning Analytics depends on the educational context. In schools and universities, effective tools identify students at risk and support teachers in early intervention. These tools typically include dashboards with data visualisations for quick interpretation. Examples of educational Learning Analytics tools include Blackboard Predict, Intellischool Albatros, and Moodle plugins with analytics functionality.

In corporate settings, tools like Learning Pool and 360Learning provide predictive analytics and AI-powered insights to personalise employee training. The choice of platform depends on learning goals, accessibility, and ease of use, ensuring that data-driven insights can be utilised even by non-specialists.

2.4 Models of Learning Analytics

Learning analytics enables the systematic analysis of educational data to generate actionable insights into learning and teaching processes. By applying statistical, computational, and machine learning techniques, data from Learning Management Systems (LMS), Student Information Systems (SIS), and other educational platforms can be transformed into meaningful information that supports instructional decision-making and organisational improvement (Aguilar et al., 2022). Different models of learning analytics serve distinct purposes, ranging from describing past performance to predicting future outcomes and prescribing optimal interventions. The main analytical models commonly used in education include descriptive, predictive, prescriptive, social, and cluster analytics.

2.4.1 Descriptive Analytics

Descriptive analytics focuses on summarising and interpreting past learning activities and outcomes. It provides a foundational understanding of educational phenomena by identifying trends, patterns, and distributions within existing data. In the context of LMS platforms, descriptive analytics can track various indicators such as user participation, attendance, assessment results, and time spent on learning activities. Educators and training specialists use these data to monitor both individual and organisational progress, assess engagement, and refine instructional practices. For instance, descriptive analytics can reveal how a student's test performance changes over time or how engagement patterns differ across course modules. This model forms the basis for understanding what has happened and serves as a prerequisite for more advanced analyses.

2.4.2 Predictive Analytics

Predictive analytics extends descriptive approaches by using statistical modelling and machine learning algorithms to forecast future learning outcomes based on historical data. This model enables educators to identify students at

risk of underperformance or dropout, predict completion rates, and anticipate learning challenges. Predictive models typically follow four iterative steps: describe, diagnose, predict, and prescribe. By recognising early warning signs, teachers can intervene proactively, offering targeted support or personalised resources to improve learning outcomes. For example, predictive analytics can help identify learners who may disengage from online courses, allowing institutions to provide timely feedback or mentorship to prevent attrition. Beyond student support, predictive analytics also informs professional development by forecasting how effectively educators or employees will apply newly acquired skills.

2.4.3 Prescriptive Analytics

Prescriptive analytics goes a step further by recommending specific actions to optimise learning processes and outcomes. It integrates data from descriptive and predictive analyses to suggest the most effective interventions for achieving desired goals. Rather than merely describing or predicting, prescriptive analytics answers the question of "what should be done next?". In education, this may include recommending adaptive learning pathways, tailoring instructional strategies to different learner profiles, or providing automated, personalised feedback. By offering data-driven guidance, prescriptive learning analytics supports educators in selecting the most effective teaching approaches for diverse student groups and enhances the overall efficiency of the learning process. For instance, prescriptive models can suggest individualised learning paths or adaptive assessments that respond to each student's needs.

2.4.4 Social Analytics

Social analytics examines the structure and dynamics of interactions within learning communities. Drawing on techniques from social network analysis and data mining, it explores how learners collaborate, exchange knowledge, and influence one another in digital environments. This model indexes and filters learner-generated content to uncover patterns of communication and participation, offering insights into group dynamics, collaboration quality, and information flow. Social analytics can identify influential students, assess peer relationships, and evaluate how social interactions contribute to learning outcomes. For example, by mapping discussion forums or group projects, educators can identify key contributors and understand how peer interactions shape engagement and academic performance (Aguilar et al., 2022).

2.4.5 Cluster Analytics

Cluster analytics groups learners or learning resources according to shared characteristics, behaviours, or performance patterns. Using unsupervised machine learning methods, such as clustering algorithms, this model reveals natural groupings within educational data without prior labelling. Educators can use cluster analysis to identify distinct learner profiles—such as high performers, disengaged learners, or students requiring additional support—and design targeted interventions accordingly. Similarly, clustering can highlight patterns in learning styles or resource usage, enabling institutions to tailor curricula and teaching methods to better meet student needs. For instance, grouping students with similar difficulties in mathematics or reading allows for more focused remedial instruction and personalised support strategies.

Collectively, these models represent a continuum of analytical sophistication, from describing past learning behaviours to prescribing future actions. When combined, they enable a holistic understanding of the learning process—providing educators, institutions, and policymakers with powerful tools for improving teaching effectiveness, student success, and institutional decision-making. As learning environments become increasingly digital and data-rich, integrating these models within AI-driven systems will further enhance the potential of learning analytics to support personalised, adaptive, and evidence-based education.

2.5 Learning Analytics in Schools (K–12 Contexts)

In recent years, the application of Learning Analytics in schools has expanded significantly. Research highlights its potential to improve engagement, personalise learning, and support teachers in decision-making. Studies have shown that LA can help track student progress, provide real-time feedback, and enhance inclusion by adapting to students with diverse needs. For example, Valtonen et al. (2025) found that dashboards used in primary and secondary education increased teachers' awareness of learning processes, enabling more targeted pedagogical actions.

Kılıç and İzmirli (2024) emphasise that K–12 Learning Analytics requires alignment with curriculum standards and pedagogical goals. Projects such as CT&MathABLE illustrate how integrating LA into digital learning environments can create meaningful connections between analytics, assessment, and classroom practice.

LA refers to the systematic use of data generated in educational contexts to better understand and support teaching and learning processes (Long & Siemens, 2011). Although LA has gained significant traction in higher education, its implementation in K–12 settings remains relatively limited and uneven, highlighting the need for stronger teacher engagement and contextual adaptation to school environments (Zamecnik et al., 2022; Sousa et al., 2021).

The use of data to inform educational decision-making has a long tradition in schools (Hase & Kuhl, 2024; Schildkamp & Kuiper, 2010). Today, digital learning environments—such as learning management systems (LMS), adaptive learning platforms, and digital assessment tools—continuously generate large volumes of trace data. These data are transformed into feedback and analytics to guide teachers' instructional planning and to support student learning (Selwyn et al., 2023). School data ecosystems increasingly rely on tracking, sensing, and analytics technologies, positioning digital data as a key driver of educational transformation (Jarke & Breiter, 2019).

This shift requires teachers to develop new forms of data literacy and analytical competence, enabling them to interpret learning data and design pedagogically meaningful actions (Celik et al., 2022; Howard et al., 2022; Mandinach & Abrams, 2022). Teachers often engage with these data through digital dashboards (van Leeuwen et al., 2021), which visualise student performance and engagement metrics. Effective use of such tools demands the ability to transform raw data into actionable instructional insights—a competence defined as data literacy: *"the ability to transform information into actionable instructional knowledge and practices by collecting, analysing, and interpreting all types of data to inform instructional decisions"* (Mandinach & Gummer, 2016, p. 367). Thus, teachers' capacity to use digital data effectively is central to both classroom-level decision-making and the broader digital transformation of schooling.

Despite this potential, empirical research on LA in school contexts remains limited. Systematic reviews have identified a scarcity of studies addressing how learning analytics is adopted and contextualised within actual school settings (Sousa et al., 2021). The heterogeneity of school systems—across cultural, technological, and pedagogical dimensions—complicates large-scale adoption. Cross-national research (e.g., Finland, China, South Africa, Uruguay, and the USA) shows that data use in schools is often more complex and heterogeneous than data collection itself, revealing significant differences in how schools interpret and act upon analytics insights (Aguerrebere et al., 2022).

From a pedagogical perspective, learning analytics research in schools frequently overlaps with innovations such as gamification, computational thinking, robotics, problem-solving, and collaborative learning (Hirsto et al., 2022). For example, several studies have explored the use of Kinect-based motion games, multimodal analytics, and AI-supported tools to enhance engagement and interactivity. In subject-specific contexts, learning analytics has been applied to teacher dashboards for mathematics instruction (Molenaar & Knoop-Van Campen, 2019), inquiry-based learning (Sergis et al., 2019), computer-supported collaborative learning (van Leeuwen et al., 2019), and formative assessment and feedback (Karademir et al., 2024).

Research on learning analytics in schools tends to focus either on (1) the use of analytics tools by teachers and students, or (2) the development of analytics methods for educational research (Hirsto et al., 2022). Increasingly, studies emphasise the importance of co-designing analytics tools with teachers to ensure their pedagogical relevance and usability. For instance, Karademir et al. (2024) found that time constraints were a major barrier to teachers' adoption of formative assessment dashboards, while Wiley et al. (2024) demonstrated that involving teachers with diverse backgrounds and experiences in co-design processes enhances tool acceptance and effectiveness in K–12 contexts.

In summary, teacher perceptions, competencies, and contextual factors significantly influence the successful integration of learning analytics in schools. While the growing use of digital data holds transformative potential for teaching and learning, most existing studies remain small-scale, emphasising the need for broader, longitudinal, and system-level research to understand how learning analytics can sustainably support evidence-informed education.

2.6 Linking Learning Analytics, Artificial Intelligence, and Computational Thinking

The convergence of Learning Analytics (LA), Artificial Intelligence (AI), and Computational Thinking (CT) marks a transformative shift in educational innovation. AI techniques such as machine learning and natural language processing extend the capabilities of LA, enabling more sophisticated predictions of learner needs, adaptive feedback, and personalised learning pathways (Holmes et al., 2021; Viberg, Hatakka, & Bälter, 2020). At the same time, CT provides the conceptual foundation for understanding how such data-driven systems operate—through abstraction, algorithmic reasoning, and data analysis (Grover & Pea, 2018). Integrating these domains allows learners not only to benefit from intelligent educational technologies but also to critically comprehend and design them. This synergy promotes a dual goal: developing informed users of AI-powered learning systems and nurturing future creators capable of shaping responsible, transparent, and human-centred technologies for education and society (Siemens, 2013).

Automatically assessed exercises with immediate feedback can be a powerful tool for enhancing the effectiveness of education. A collaborative learning tool called ViLLE has been developed (Laakso et al., 2018). The design is based on experiences gathered from a previously developed and thoroughly researched visualisation tool. ViLLE includes various exercise types which were designed to assist in the learning of computer science, mathematics, and other subjects.

2.7 Summary

The foundation of Learning Analytics (LA) lies in the collection and interpretation of educational data generated through students' interactions with digital tools and learning environments. As user-generated and cloud-based data sources continue to expand, LA is gaining prominence to enhance teaching and learning in schools. Its core purpose is not merely technical but inherently pedagogical and ethical—to support more effective, equitable, and personalised learning experiences.

While most LA research and applications have been concentrated in higher education, the potential for its use in K–12 settings is increasingly recognised. By analysing student activity and performance data, LA can help identify learners at risk of underachievement and provide insights for targeted interventions. However, implementing LA in schools presents significant challenges, including the integration of data from diverse sources, ensuring data privacy, and aligning analytics with the pedagogical realities of classroom teaching.

Future progress in LA for school education depends on developing robust predictive models, refining adaptive and personalised learning systems, and incorporating non-cognitive factors such as motivation, engagement, and mindset into analytic frameworks. As educational technologies evolve, learning analytics will play a growing role in

advancing evidence-based and data-informed education, ultimately improving the quality and inclusiveness of learning experiences across school systems.

3 Methodology

To build a comprehensive overview of successful practices in applying LA to informatics education across the EU, **Task 7.1 – Research on Existing Practices of Learning Analytics for Informatics in the EU** employed a **two-pronged research approach**. The study combined a **grey literature review** with **semi-structured interviews** to examine how LA is currently understood, implemented, and experienced in 10 different national contexts.

3.1 Grey literature review

Each partner country identified at least three examples of **grey literature**, including policy documents, strategy papers, white papers, and project reports, published between **2015 and 2025**. These materials focused on the use of LA in informatics education, as well as national strategies or guidelines related to digital education more broadly.

The purpose of the review was to **collect and synthesise information** from publicly available but non-academic sources to understand how LA has been introduced and implemented in practice. The review followed a common framework (see *Annex 1 – Grey Literature Review Guidelines*) and addressed several key dimensions:

- the **purpose** of using LA,
- the **guiding frameworks** or theoretical models,
- the **implementation and practical use** of LA,
- the **outcomes and insights** reported,
- **ethical considerations**, and
- aspects of **sustainability and scalability**.

In total, **35 documents** were reviewed across the ten partner countries. Each partner summarised their findings according to these common dimensions, enabling cross-country comparison and the identification of emerging patterns and successful practices.

3.2 Semi-structured interview

In parallel with the literature review, each partner country conducted at least **three semi-structured interviews** with **teachers, researchers, and/or policymakers** who had direct experience with learning analytics. To capture a wide range of perspectives, partners were encouraged to engage participants with varied professional backgrounds and expertise.

The interviews aimed to **gather first-hand insights** into how LA is being used, perceived, and supported within different educational contexts. The interview protocol (see *Annex 2 – Interview Questions*) covered several key topics, including:

- the **background and role** of each interviewee,
- their **experiences using LA**,
- relevant **guiding frameworks** and policies,
- **stakeholder engagement** and collaboration,
- the **institutional/national context**,
- a **SWOT analysis** (strengths, weaknesses, opportunities, and threats) of LA practices, and

- **future directions** for the field.

All interviews were conducted in accordance with **ethical research standards**, including obtaining informed consent and ensuring data confidentiality and security. In total, **31 interviewees** participated across the ten partner countries. Each interview was summarised using the same categories as the interview questions.

3.3 Data analysis

The **summaries of both the literature review and the interviews** were subjected to a **thematic analysis** to identify key patterns, promising practices, and shared challenges across Europe. This analysis enabled a synthesis of theoretical perspectives, policy approaches, and practical experiences, providing a rich, comparative picture of how learning analytics supports informatics education in diverse European contexts.

4 Findings from Grey literature review

In total, **35 documents** were reviewed across the ten partner countries—Bulgaria (3), Croatia (5), Cyprus (2), Finland (4), Greece (2), Italy (3), Lithuania (4), Portugal (4) , Slovenia (4), and Spain (4), providing a broad overview of how LA is understood and applied in different educational contexts. The review examined the **purpose of using LA**, the **guiding frameworks or theoretical models** underpinning its design, and the **implementation and practical use** of analytics tools and approaches. It also considered the **outcomes and insights** reported from these initiatives, along with key **ethical considerations** and issues related to **sustainability and scalability**. Together, these sources offer valuable evidence on current practice, emerging trends, and contextual differences shaping LA development across Europe.

4.1 Background Information

Types of the reviewed documents

The literature review covered a total of 35 documents representing a wide range of sources and perspectives on LA. The original aim was to focus on **grey literature**, such as policy documents, reports, and institutional documents; however, several **scientific articles** were also included where they provided valuable contextual or methodological insights. The reviewed materials comprised **institutional and national strategies or policy documents (8)**, along with **action plans and national initiatives (3)** outlining concrete steps toward LA implementation. A set of **reports and working papers (6)**, including project and annual reports, offered evidence of practical outcomes and lessons learned. The review further included **academic and student research outputs (10)**, such as theses and scientific articles, contributing theoretical and empirical perspectives. Finally, **public communications (8)**, including websites, public-facing publications, and a code of practice, presented accessible overviews and guidance for stakeholders. Collectively, these sources provide a comprehensive view of how LA is conceptualised, implemented, and communicated across the partner countries and beyond.

Authors of the reviewed documents

The reviewed documents were authored by a range of international, national, and institutional actors reflecting the diverse ecosystem shaping Learning Analytics (LA) development. Key contributions came from **international organisations**, including **UNESCO (1)**, the **OECD (3)**, and the **World Bank (1)**, which provided global and comparative perspectives on data-driven education. Several **European and national bodies**, such as the **European Commission (1)** and **ministries or education authorities in partner countries (6)**, outlined policy directions and strategic frameworks guiding LA adoption in Europe or the partner countries. Additional materials were produced by **universities and national academic or research networks (8)**, offering both institutional strategies and insights from research-practice collaborations. Finally, works authored by **individual researchers and experts (12)** presented empirical findings, theoretical analyses, and professional perspectives. Together, these voices illustrate a balance between high-level policymaking, research-based evidence, and practitioner insight across the reviewed corpus.

Geographical contexts

The reviewed documents address LA across a range of geographical and contextual levels. Several sources adopt an **international or global perspective (5)**, focusing on overarching trends and comparative insights worldwide. A smaller number examine **European-level developments (3)**, often linking LA to EU policy priorities and cross-border collaboration. The majority, however, relate to the **national contexts of the partner countries (19)**, providing detailed accounts of strategies, implementation efforts, and institutional experiences at national scale. In addition, a few documents explore **other national settings (3)**, including the UK, France, and Brazil, offering useful external reference points. Finally, **case studies and small-scale investigations (5)** present context-specific examples of LA

practice at institutional or classroom level. Together, these materials illustrate the interaction between global initiatives, regional cooperation, and national and local implementation in shaping the evolving landscape of LA.

Educational levels covered

The reviewed documents span a wide range of educational levels, reflecting the broad applicability of LA across the educational continuum. Of the 35 documents, **12 focus on a single educational level**, while **23 address multiple levels**. Among these, **8 documents encompass all stages from early childhood to higher education**—notably, one of these also extends to **lifelong learning**, and another includes **vocational education**.

When considering the total educational levels represented (a cumulative frequency of 88, as some documents cover more than one level), the distribution illustrates strong attention to **primary (25, 28%)** and **secondary education (25, 28%)**, followed by significant representation of **higher education (20, 23%)**. **Early childhood education (9, 10%)** and **vocational education (7, 8%)** receive moderate focus, while **lifelong learning (2, 2%)** appears less frequently. This range indicates that LA research and practice tend to cluster around formal, compulsory, and tertiary education, with emerging but still limited emphasis on early years and adult learning contexts.

4.2 Purpose and objectives of LA use

Across the reviewed documents, the application of LA reflects a multifaceted effort to use data intelligently in support of teaching, learning, and educational management. Although the reviewed materials from Greece and Italy did not explicitly state the purpose of LA use, documents from the other partner countries convey a consistent set of objectives centred on **evidence-based improvement of educational processes and decision-making**.

A core function of **Learning Analytics (LA)** is to **monitor student learning and performance (13 references in total)**. The reviewed documents emphasise LA use to **track progress (2)**, **analyse learning behaviours (1)**, **understand student motivation (1)**, **detect learning difficulties (1)**, **identify students at risk of underperformance or disengagement (3)**, and **measure learning outcomes (1)**. Collectively, these practices enable educators and institutions to design proactive, evidence-based interventions grounded in real-time data rather than retrospective evaluation.

The most frequently cited goal is to **support teachers in their pedagogical work (24 references in total)**. For instance, LA helps teachers conduct **formative assessment (5)**, **detect at-risk students (6)**, and **empowers instructors with actionable insights (9)** for monitoring and adapting **timely, individualised instruction**. Additional aims include providing support for **course design (1)** and **understanding student performance (1)**—collectively reinforcing teachers' agency in data-informed practice.

In parallel, LA is applied to **support students directly (23 references in total)**. This includes efforts to **enhance optimal learning experiences (2)**, **foster personalised learning (5)**, and enable **timely intervention (5)**, thereby improving **learning outcomes (4)**. Several documents also highlight the role of LA in **promoting student reflection and self-regulated learning (4)** by providing **personalised feedback and recommendations (2)** that strengthen motivation and sustain academic progress.

Another major goal is to **support data-driven decision-making and overall educational improvement (20 references in total)**. LA is viewed as a means to generate **actionable insights** that guide **institutional and national strategies**, inform **policy development**, and strengthen **decision-making processes at all levels of education**.

At the institutional level, several reviewed documents show that LA contributes to **supporting schools and universities (11 references in total)** by providing **actionable data** for improvement. This includes uses such as

preventing school dropouts (1), aligning **strategic planning and resource allocation (1)** with actual data, **informing curriculum development (1)**, and contributing to **institutional quality processes (1)**.

Although mentioned less frequently, an additional objective is to **provide parents with real-time access to their children's learning progress (1)**. This approach extends the **transparency and inclusivity** of LA practices beyond the classroom, encouraging stronger home–school collaboration and enabling parents to actively support their children's learning pathways.

Overall, the purposes identified across the reviewed documents converge on a shared vision of LA as a tool to enhance educational quality by supporting **students, teachers, institutions**, and **policymakers** with accurate, timely, and ethically managed data. The aim is to strengthen both individual learning experiences and systemic educational improvement through informed, data-driven action.

4.3 Guiding Frameworks

The effective implementation of LA is often underpinned by guiding frameworks that link data use with pedagogical intent, ethical considerations, and institutional strategy. This section reviews the **policy, theoretical, pedagogical, and strategic frameworks** referenced in the examined literature, highlighting how they inform the adoption, interpretation, and responsible use of LA across different educational contexts.

The reviewed documents reference a range of frameworks that inform and contextualise the use of LA, spanning international policy agendas, national and institutional strategies, pedagogical models, and ethical principles. These frameworks collectively illustrate how LA is embedded within broader educational aspirations for digital transformation, evidence-based practice, and responsible data use.

International and intergovernmental frameworks (23 references, in documents reviewed by all countries except Finland and Italy) provide the most frequent overarching guidance. Prominent examples include policy initiatives and recommendations from the **EU** (18), such as the *Digital Education Action Plan 2021–2027* (8), **DigCompEdu** and **DigCompOrg** competence frameworks (1), reports on the digital transition and LA in education (2), and funding priorities (2). Additional alignment is found with frameworks developed by the **OECD** (3), including the *Future of Education and Skills 2030* framework (1) and *Digital Education Outlook* (1), as well as references to **UNESCO** frameworks for digital learning (1) and the **UN Sustainable Development Goals**, particularly *SDG 4 – Quality Education* and *SDG 9 – Industry, Innovation, Infrastructure* (1). These sources provide strategic direction that situates LA within global and regional efforts to improve the quality, equity, and sustainability of education.

National and institutional strategies and frameworks (22 references, in documents reviewed by Croatia, Finland, Greece, Italy, Lithuania, Portugal, and Slovenia) primarily address **digital education and transformation strategies** (16), **data-driven decision-making** across administrative levels, and initiatives aimed at **improving student outcomes** (5). One document also explicitly notes the importance of **ethical frameworks** that guide institutional adoption of LA (1), reinforcing the need for alignment between technological innovation and policy accountability.

More **specific frameworks for LA** (7 references, in documents reviewed by Portugal, Slovenia, and Spain) directly anchor practice within the principles and standards of the field. These include the work of the **Society for Learning Analytics Research (SoLAR)** (3) and the **Learning Analytics Community Exchange (LACE)** initiative (1). Institutional adoption is further guided by international models such as the **SHEILA guidelines** (2) and the **LALA Framework** (2), which integrate institutional, technical, ethical, and community dimensions. The framework proposed by **Gašević et al. (2022)** on *Analytics for Assessment* (1) is also referenced, illustrating how LA approaches can support **formative assessment** processes.

Several documents associate LA with **frameworks for monitoring learning outcomes** (8 references, in documents reviewed by Croatia, Cyprus, Finland, and Spain), encompassing **national assessments** (4), **international benchmarks** such as **PISA** and **TIMSS** (1), and principles of **formative assessment and continuous feedback** (3). These frameworks contribute to the development of measurement infrastructures that can be leveraged by LA to enhance the monitoring of educational progress.

Ethical frameworks (7 references, in documents reviewed by Bulgaria, Croatia, Lithuania, and Spain) address **transparency, consent, privacy, accountability**, and the **responsible use of data**, ensuring compliance with **EU regulations (e.g., GDPR)** and corresponding **national standards**. These principles are operationalised through mechanisms such as secure authentication and explicit user consent when personal data is accessed.

Pedagogical frameworks (14 references, in documents reviewed by Cyprus, Finland, Greece, Portugal, and Slovenia) highlight the integration of **ICT and digital tools** within teaching practice—not solely as delivery mechanisms but as **data sources** for continuous improvement (4). They emphasise **equity, inclusion, and digital competences** (1), as well as the connection between LA, **formative assessment**, **learner-centred approaches**, and **adaptive, personalised support** (3). Constructivist perspectives are also noted (2), reinforcing the importance of context, student-centre, active engagement, and feedback in learning processes.

Finally, a few documents reference **other related frameworks** (3), including those connected to **AI and digital transformation in education** (2) and models explaining the **acceptance and use of technology** (1). While less prevalent, these frameworks reflect emerging intersections between LA, AI, and broader digital innovation agendas.

Overall, the guiding frameworks identified across the literature demonstrate that LA implementation is deeply intertwined with international policy priorities, national and institutional strategies, pedagogical theory, and ethical responsibility—underscoring its multidimensional character as both a technological and educational innovation.

4.4 Implementation and Practical Use of LA

This section examines how **LA** has been implemented and utilised across educational contexts, focusing on its translation from conceptual frameworks into day-to-day practice. It summarises **who is involved** in applying LA, **how it is operationalised**, and the **technological and infrastructural, and methodological approaches** that enable its use. Attention is given to the **tools and platforms employed**, the **types and sources of data collected**, and the **analytical methods** used to generate actionable insights for teaching, learning, and institutional decision-making.

Stakeholders involved

Across the reviewed countries, the **implementation of LA** involves a wide spectrum of stakeholders spanning policy, practice, and technical domains. Common participants include **policymakers and education authorities** at national or regional levels (e.g., ministries, municipal bodies, institutional leaders), along with **teachers and students**, who consistently serve as the primary users and beneficiaries of LA systems. **Researchers and academic staff** play key roles in analysis, evaluation, and framework development, while **school leaders and administrators** support implementation and coordination within institutions. Several countries, including **Portugal, Slovenia, and Spain**, also emphasise the involvement of **technical teams, developers, and IT specialists** to ensure system interoperability and data integrity. In **Italy and Croatia**, **parents and caregivers** are noted as additional stakeholders, reflecting efforts to enhance home–school collaboration and transparency. Notably, **EU institutions** are identified among stakeholders in **Bulgaria**, and the **World Bank** is referenced in **Italy**, underscoring the engagement of international organisations in advancing LA initiatives. Overall, while stakeholder participation is broadly inclusive across contexts, the balance between policy leadership, pedagogical engagement, and technical support varies by country, with Finland, Greece, and Portugal presenting particularly integrated, multi-level collaboration models.

Infrastructure and technological requirements

Across the reviewed countries, the **infrastructure and technological requirements** for LA emphasise reliable connectivity, interoperable systems, and secure data environments enabling effective data collection and analysis. Most countries have developed or adapted **institutional infrastructures** supporting **dashboards, LMS platforms, and cloud-based or national data systems**. Countries such as **Bulgaria, Lithuania,** and **Spain** highlight the use of LA-specific technologies, including **learning record stores (LRS)** and **AI tools**. **Croatia, Lithuania,** and **Italy** underline the importance of **high-quality internet access, well-equipped classrooms, and digital public infrastructure** to sustain in-class analytics and nationwide implementation. **Greece, Slovenia,** and **Finland** focus on ensuring staff and student access to stable ICT environments, supported by local and national digital networks. Overall, countries share a commitment to strengthening digital and institutional foundations for LA, though levels of maturity vary—from advanced, cloud-based and interoperable ecosystems to more developing infrastructures centred on connectivity and classroom readiness.

Tools or platforms used

Across the reviewed countries, a wide range of **tools and platforms** support the practical application of LA, combining existing educational technologies with purpose-built analytics systems. Most countries rely on **learning management systems (LMS)** such as **Moodle**, **Blackboard**, or national platforms (**e-me**, **e-class**, **Open edX**) as core environments for data collection, learning delivery, and analytics integration. **Dashboards** are widely used across contexts (e.g., Bulgaria, Croatia, Greece, Lithuania, and Spain) to visualise learning progress, engagement, and institutional performance, often complemented by **predictive analytics**, **diagnostic tools** like SELFIE, and **custom analytics or data monitoring systems**. Several cases—particularly in **Spain** and **Lithuania**—demonstrate advanced technical integration through **learning record stores (LRS)**, **xAPI-SG standards**, and **recommender systems** supporting data interoperability and personalised feedback. **Bulgaria** and **Italy** extend this ecosystem with **AI-driven tools** and **intelligent tutoring systems (ITS)**, while **Finland** and **Cyprus** apply more focused tools for **assessment, observation, and structured feedback**. Overall, the integration of LA into digital learning environments follows a broadly consistent pattern centred on LMS-based ecosystems enhanced by analytics dashboards, predictive tools, and interoperable systems that translate learning data into actionable insights.

Types of data collected

Across the reviewed countries, the **types of data collected** for LA show a strong convergence around **student performance, engagement, and activity data** drawn from digital learning environments and institutional systems. Most countries—such as **Bulgaria, Croatia, Finland, Lithuania, Portugal,** and **Slovenia**—collect a combination of **achievement and assessment data** (e.g., grades, test scores, completion rates) and **activity logs** (e.g., logins, time on task, clicks, navigation behaviour, and interaction with learning materials). **Engagement indicators** like participation in discussions, forum activity, and tool usage are commonly analysed to gauge levels of involvement and motivation. Several contexts, including **Greece, Finland, Slovenia,** and **Spain**, emphasise **system-generated usage data** such as access frequency, session duration, or detailed interaction traces within specific digital platforms. Broader institutional or contextual indicators—covering **school performance, ICT adoption, digital maturity, demographic information, and socioeconomic factors**—appear in **Bulgaria, Croatia, Portugal, Slovenia,** and **Spain**, linking LA to systemic monitoring and policy evaluation. Some countries, such as **Lithuania, Slovenia,** and **Spain**, also incorporate **survey-based or behavioural data** (e.g., motivation questionnaires, gaze tracking) to complement automated logs with richer learner profiles. Overall, the datasets underpinning LA are multidimensional, combining academic results, digital traces, and behavioural signals to support nuanced insights into learning processes and institutional improvement.

Methods of data collection and analysis

Across the reviewed countries, **methods of data collection and analysis** for LA combine automated digital tracking with statistical and predictive techniques to derive actionable insights. Most countries rely on **automated collection**

of digital traces from learning management systems, online platforms, and assessment tools (e.g., Finland and Lithuania), supplemented in several cases by **surveys, self-assessments, or feedback instruments** (e.g., Bulgaria, Greece, Slovenia, Spain) to capture perceptions and contextual data. **Descriptive and diagnostic analytics**—including visualisations of grade distributions, engagement trends, and attendance patterns—form the foundation of analytical practice across most contexts. Many countries, such as **Bulgaria, Croatia, Lithuania,** and **Slovenia**, have advanced toward **predictive analytics** to identify at-risk students, personalise learning pathways, and support early intervention. Some, including **Bulgaria, Croatia, Portugal,** and **Spain**, additionally employ **benchmarking, trend analysis, and statistical modelling** to inform institutional improvement or policy decisions. More sophisticated analytical techniques are emerging, particularly in **Slovenia**, where **network analysis, sequence analysis, text mining, and multimodal analytics** are being explored to capture complex learning behaviours and emotional indicators. Overall, data collection and analysis methods across countries reveal a continuum—from foundational descriptive approaches toward more integrative, predictive, and explainable analytics—illustrating steady progress in technical and methodological maturity.

Overall, the implementation and practical use of LA reflect growing alignment among countries in building data-informed education systems. Common priorities include coordinated policy support, stakeholder collaboration, reliable digital infrastructure, and the integration of interoperable tools to support teaching and institutional improvement. Although maturity levels differ, all contexts move toward embedding analytics into everyday educational practice to enhance learning and decision-making.

4.5 Outcomes and Insights

This section examines the reported impacts of LA on teaching, learning, and educational policy across the reviewed countries. It highlights how LA initiatives have influenced classroom practice, institutional decision-making, and system-level strategies, while identifying key lessons and recommendations derived from implementation experiences. The section also considers the broader educational implications of LA, reflecting on how data-driven approaches are shaping pedagogical innovation, learner support, and evidence-based policy development.

Impacts of LA on teaching, learning, and policy

Across the reviewed countries, the effects and impacts of LA reveal significant progress toward more evidence-based, transparent, and learner-centred education systems. In **Bulgaria**, LA serves as both an ethical and operational cornerstone for modernising education through responsible and equitable data practices. **Croatia** demonstrates the most comprehensive systemic outcomes, with measurable gains in schools' digital maturity, improved feedback mechanisms, and stronger policy-level data use driving curricular reform and digital transformation. In **Cyprus**, the focus lies on understanding adoption factors, showing that support conditions strongly influence effective LA use. **Finland** reports positive student perceptions, increased self-direction, and reduced teacher workload through automation, while **Greece** underscores LA's strategic role in tracking digital engagement, promoting systematic monitoring of digital readiness, and informing national digital education policies. **Italy** and **Portugal** highlight broader systemic benefits—enhanced teacher effectiveness, personalised learning, and evidence-based policy development—but also identify gaps in advanced analytics adoption and governance. **Lithuania** and **Slovenia** showcase improved monitoring, early intervention, and self-regulated learning supported by analytics tools, with the latter also demonstrating LA's resilience in sustaining education during crises. Finally, **Spain** illustrates concrete motivational and learning gains resulting from adaptive and gamified analytics interventions, despite the absence of comprehensive supporting policies and the generally low level of institutional adoption. Collectively, these outcomes indicate that LA is not only improving teaching and learning practices but is also fostering a culture of informed decision-making and strategic innovation across European education systems.

Key Lessons Learned

Across Europe, education systems are increasingly using LA to improve teaching, personalize learning, and guide policy decisions. This section examines how several countries are implementing LA and what lessons emerge from their efforts. Together, these insights offer a comprehensive snapshot of how education can become more transparent, evidence-based, and equitable through the responsible use of data. All the countries reviewed share a common goal: to enhance learning outcomes and institutional effectiveness by turning data into actionable insight. While approaches and levels of maturity vary, a strong trend emerges: **LA is evolving from isolated experiments into a cornerstone of digital transformation in education.**

1. Ethical, transparent, and participatory adoption

Countries such as **Bulgaria** illustrate that trust is the foundation of any data-driven education system. They emphasise the importance of ethical principles, student consent, and transparent governance to protect privacy and ensure data is used responsibly. **Lithuania** and **Spain** also stress user-centred, co-design, and open communication between teachers, students, and system developers, helping institutions build a shared understanding of how analytics can serve learning rather than surveillance. For the broader European context, this shows that **public confidence in educational data use depends as much on ethics and participation as on technology or policy**.

2. Teacher training and data literacy as core drivers

Across the reviewed countries, the most consistent message is that **teachers are central to meaningful LA adoption**. Systems like those in **Cyprus, Greece**, and **Portugal** reveal that analytics become powerful tools only when educators know how to interpret and use the information they provide. Continuous professional learning, accessible digital tools, and clear pedagogical guidance are therefore essential. Equipping teachers with data literacy skills ensures analytics enhance rather than complicate teaching, making education more responsive to student needs.

3. Alignment of pedagogy, infrastructure, and policy

Several countries, most notably **Croatia** and **Slovenia**, show that technological progress must go hand-in-hand with pedagogical planning and policy coherence. Croatia's comprehensive digital maturity model and Slovenia's institutional monitoring systems demonstrate how data can bridge policy and practice. These experiences highlight the importance of **systemic alignment**: analytics thrive when educational goals, teacher practices, and technology infrastructures are designed to support one another.

4. Building institutional capacity and readiness

The lessons from **Italy** and **Portugal** underline that sustainable LA implementation depends on both physical infrastructure and organisational culture. Beyond purchasing technology, institutions need clear governance, stable data-management systems, and leadership committed to responsible data use. **Italy's caution** against technology-first strategies without proper testing underscores a critical point: success lies not in devices, but in how schools and universities use data to inform long-term improvement. In practice, data maturity requires time, collaboration, and policy consistency.

5. Data-informed policy and continuous improvement

Evidence from **Croatia**, **Greece**, and **Lithuania** shows how LA supports policy evaluation, strategic planning, and continuous reform. For example, Croatia's national frameworks connect data insights to curriculum design and digital education policy. Lithuania positions LA within broader digital and informatics literacy goals, viewing it as a mechanism to reduce inequalities and track learning progress at a system level. When data is used not just to monitor but to **inform and refine** educational practice, it becomes a tool for sustained progress rather than compliance.

6. Innovation, collaboration, and inclusivity

Spain's experience demonstrates LA's potential to drive innovation through adaptive, gamified, and motivational learning environments, while also revealing that true innovation requires strong systemic support and a culture prepared to embrace change. Across Europe, collaboration networks—such as national research groups and international consortia—are strengthening the links between data science, pedagogy, and education policy. A leading example is **Finland's EDUCA (Education for the Future) Flagship**, funded by the Research Council of Finland. Bringing together researchers from Finnish institutions and world-class universities, including Harvard, Yale, and Oxford, EDUCA operates within the Finnish national context and spans all levels of education. These partnerships promote inclusivity, scalability, and shared expertise, ensuring that LA benefits diverse learners and educational settings. Collectively, such collaboration is establishing LA as a unifying force for innovation and transformation across education sectors.

Overreaching Implications

Taken together, these lessons reveal that the future of LA in Europe depends on a balanced approach **combining ethical governance, skilled educators, and institutional commitment**. Effective use of analytics requires:

- Shared ethical frameworks to guarantee responsible and fair data use;
- Structured teacher training that embeds analytics into daily teaching practice;
- Investment in infrastructure and organizational capacity; and
- A shift in culture toward openness, collaboration, and continuous learning.

When these conditions are met, LA becomes not merely a technological tool but a **strategic engine of educational innovation**, enabling schools, universities, and ministries to make better decisions, support diverse learners, and align national education systems with European priorities for digital transformation and inclusion.

4.6 Ethical considerations

As LA becomes more deeply embedded in European education systems, **ethical considerations** have emerged as a defining dimension of its adoption. The responsible use of educational data requires careful attention to privacy, consent, transparency, and fairness, ensuring that learners' rights and trust remain protected. Across the reviewed countries, institutions are increasingly recognising that *the success of LA depends as much on ethical governance as on technological capability.*

1. Data Privacy, Protection, and Security

Data protection and compliance with the EU's General Data Protection Regulation (GDPR) underpin all national approaches to Learning Analytics. **Croatia**, **Greece**, **Portugal**, **Slovenia**, and **Spain** explicitly prioritise robust measures such as anonymisation, pseudonymisation, encryption, and controlled access to sensitive information. **Croatia's e-Schools** initiative integrates privacy safeguards through secure authentication, role-based data access, and depersonalised reporting. **Finland** exemplifies privacy-by-design principles by ensuring that student data is stored on encrypted servers, processed only within the EU, and never shared with third parties. Similarly, **Slovenia**, **Spain**, and **Portugal** reinforce data protection through anonymisation, informed consent, and—in Portugal's case—ethical oversight by regional or institutional review bodies. Together, these practices illustrate how legal compliance has evolved into a **culture of data stewardship**, where technological measures and ethical awareness operate hand in hand.

2. Informed Consent and Learner Agency

Transparent communication and active consent are widely recognised as critical to data ethics in education. **Finland**, **Lithuania**, **Slovenia**, and **Spain** provide notable examples where learners (and parents, for minors) must give informed consent before their data are used. Students are aware of what is collected, how it is processed, and for what purpose. **Croatia** and **Bulgaria** also require user permission for data access, while **Portugal** links consent processes to institutional ethics approvals. Beyond compliance, an emerging priority is **learner agency**—enabling students to understand and influence how their data informs teaching and assessment. This shift represents a move from passive consent toward **active participation and digital empowerment**.

3. Fairness, Algorithmic Bias, and Transparency

Many countries are confronting the ethical challenges of algorithmic decision-making in LA and AI-enabled education. **Italy** and **Portugal** highlight the risks of bias, stereotyping, and unequal assessment practices, calling for transparency in algorithms and inclusive data design. **Croatia**, **Lithuania**, and **Slovenia** identify the need for explainable analytics and continuous monitoring to prevent profiling, misinterpretation, or discrimination. Several national reports, especially **Slovenia's** and **Italy's**, stress that algorithmic tools must serve learning and inclusion, not surveillance or punitive evaluation. These insights point towards a shared European understanding that **ethical analytics means fair analytics**, requiring human oversight, interdisciplinary review, and accountability for automated decisions.

4. Governance, Accountability, and Institutional Ethics

Ethical LA depends on strong governance frameworks that define responsibilities, standards, and oversight mechanisms. **Portugal** outlines the importance of national or institutional ethics committees, data stewardship roles, and transparent accountability chains. **Bulgaria**, **Croatia**, and **Italy** link data governance to broader digital-rights frameworks, ensuring responsible use across schools and ministries. **Finland's** examples show how integrated procedures—such as research-ethics approval, pseudonymisation, and clear documentation—help maintain compliance while supporting innovation. This combination of legal, procedural, and cultural safeguards builds **systemic accountability** and protects both learners and institutions from misuse or unintended harm.

5. Trust, Capacity, and Ethical Awareness

Ethical implementation of LA depends on human as much as technical capacity. **Croatia** and **Lithuania** underscore the role of teacher training and ethical awareness in ensuring responsible data use. Across countries, ethics is becoming part of **digital and data literacy training**, enabling educators and administrators to interpret data responsibly and act as stewards of learners' rights. Building trust through open communication and shared understanding ensures that ethical commitments translate into everyday educational practice.

Together, these national experiences show that safeguarding privacy and data integrity is not only a matter of legal compliance but also a foundation for trust. By embedding security measures and ethical oversight into every stage of LA design and implementation, European education systems are ensuring that data use remains both lawful and learner-centred.

4.7 Sustainability and Scalability

LA initiatives evolve across Europe, and sustainability and scalability have become defining measures of long-term success. This section reviews national experiences in building durable frameworks and expanding pilot projects into systemic practice, guided by two central questions: current implementation status and potential for transferability to other contexts.

Long-term national strategies and stable infrastructures

Several countries have embedded LA within multi-year digitalisation or education strategies, ensuring institutional continuity and predictable funding. **Croatia** offers one of the most comprehensive examples: its e-Schools programme and SOZT, a long-term framework that is grounded in EU funding mechanisms (ESF, ERDF, Horizon 2020) and phased implementation cycles extending to 2028. CARNET's national platforms integrated digital identity systems, modular analytics tools, and large-scale teacher training to create a sustainable ecosystem that supports both iterative improvement and nationwide scalability. **Bulgaria's** 2021–2030 education strategy likewise sets out a structured implementation plan aligned with EU goals for the 2021–2027 period, indicating strong potential for national scaling and cross-border transferability.

Institutional integration and platform-based scalability

Several national cases highlight the importance of embedding analytics into widely used institutional systems. In **Slovenia**, the University of Maribor's integration of LA into its Moodle 4.1 platform and AIPS tools marks a transition from pilot to routine practice, supported by continuous platform development and standardised data formats that facilitate adaptation across other higher-education and vocational institutions. **Finland's** ViLLE learning platform, now implemented at scale nationwide, illustrates how sustained investment in a single technological infrastructure can underpin long-term sustainability. **Spain** similarly demonstrates the potential of open-source and standards-based approaches—ranging from xAPI-compliant learning games to low-cost and easy-to-use classroom tools—which enable scalability across schools and adaptability to new subject areas.

Emerging and pilot-stage initiatives

In other countries, LA remains at the pilot or early implementation phase but is supported by growing institutional or policy frameworks. **Greece** has concluded several pilot projects under its 2020–2025 strategy, laying foundations that could extend to higher education and nationwide evaluation systems. **Cyprus** reports early-stage development, where classroom-level or institutional pilots reveal strong potential if accompanied by systemic support—especially teacher professional development, national policy alignment, and investment in infrastructure. **Lithuania** presents more of a meta-analysis: while direct implementation is limited, regional studies highlight the scalability of informatics and analytics initiatives when connected to EU frameworks like the Digital Education Action Plan 2021–2027.

European and international enablers

Across cases, sustainability is reinforced by alignment with broader EU policies and global frameworks. **Italy** and partner initiatives advocate incremental interoperability, long-term policy coherence, and human-centred design—principles echoed in the UNESCO Recommendation on the Ethics of Artificial Intelligence and the Evolving Right to Education initiative. This international alignment supports transferability across borders and enhances the resilience of national systems against rapid technological change.

Taken together, European experiences show that enduring sustainability depends on three interrelated factors: embedded policy commitment, stable funding and infrastructure, and continuous capacity-building. Scalability, in turn, is most successful when analytics tools are integrated into existing digital ecosystems, rely on open standards, and are supported by professional learning and ethical governance. While many initiatives remain in pilot or early stages, the emerging coherence across national and EU-level strategies points to a maturing ecosystem capable of long-term growth and cross-context transfer.

Co-funded by the European Union

5 Findings from semi-structured interviews

5.1 Background and Role

In total, **31 interviews** were conducted across the ten partner countries—Bulgaria (3), Croatia(3), Cyprus (2), Finland (3), Greece (3), Italy (3), Lithuania (5), Portugal (3), Slovenia (3), and Spain (3)—capturing diverse perspectives from teachers, researchers, policymakers, and education specialists engaged in LA and informatics education. The interviewees represented different educational levels and institutional contexts, from primary and secondary schools to universities and adult education. Their varied professional backgrounds illustrate how LA practices are evolving across Europe, highlighting common goals of enhancing teaching, supporting data-informed decision making, and connecting research, policy, and practice in digital education.

Bulgaria

Three Bulgarian interviewees reflect a broad spectrum of roles and experiences within informatics and digital education. Their backgrounds range from higher education and academic research to secondary schooling and regional policy coordination. The university researcher brings over a decade of experience in curriculum development and research on digital education. Her current work focuses on the integration of data-driven methods into higher education. The secondary school informatics teacher is deeply engaged in preparing students for national assessments and international programming competitions, directly influencing digital skills at the classroom level. Meanwhile, the regional policy advisor contributes to digital education policy, ensuring that local educational strategies align with EU digital transformation goals. Together, their combined experience highlights the interconnected roles of research, teaching, and policy in advancing digital education in Bulgaria.

Croatia

Three Croatian interviewees represent a diverse mix of leadership, academic, and practical expertise in higher education. One interviewee brings over twenty years of experience in education policy, contributing to national curriculum reforms and the alignment of Croatian higher education with EU frameworks. She has been introduced to LA integration into the curriculum through policy discussions and strategic meetings. The second interviewee leads professional services, drawing on her background in STEM education, including informatics, and experience across secondary and higher education to oversee student support, quality assurance, and institutional analytics. The third interviewee, originally from IT industry, now heads university's Data Science and AI studies, blending practical IT experience with a passion for teaching and curriculum development. Collectively, their profiles highlight strong connections between policy, practice, quality management, and industry engagement, reflecting a comprehensive perspective on the evolving landscape of digital education in Croatia.

Cyprus

The two Cypriot interviews illustrate how LA concepts are gradually transferring from research and teaching contexts into broader professional training and instructional design practice. Both participants work in higher and adult education environments shaped by EU-funded projects and entrepreneurship-focused learning. The first, a Marketing and Communication Associate, supports training activities by developing digital tools, quizzes, and communication materials, applying data analysis to measure participant engagement and evaluate project outcomes. The second, an instructional designer at the Academy of Entrepreneurship, creates interactive courses and integrates LA tools to track learner engagement and progress, using the insights collaboratively with instructors to refine teaching strategies. Together, their perspectives highlight a growing appreciation of LA as a means of improving educational effectiveness and learner experience, extending its role from formal education into professional and lifelong learning contexts in Cyprus.

Finland

Across all three Finnish interviews, participants described a tightly connected system linking research, technology, and classroom practice. They emphasised the use of LA as a practical tool for improving teaching and identifying student learning needs, reflecting a culture of data-driven decision-making and evidence-based education. The doctoral researcher is primarily engaged in data management and statistical modelling related to LA. The professor brings long-term expertise in psychometrics and educational assessment, connecting LA to national-level quality assurance. The STEM teacher applies LA directly in the classroom to monitor progress and adapt teaching and support to students. Together, these Finnish perspectives illustrate a well-established ecosystem in which research, policy, and classroom practice are closely aligned around the use of LA for continuous educational improvement.

Greece

Across the three Greek interviews, participants described an education system in transition, where teaching, research, and policy are increasingly connected to advance digital transformation and the use of LA. All emphasised the value of data-informed decisions, evidence-based practice, and collaboration between schools, universities, and authorities to align school initiatives with national and EU digital-education strategies. The teacher focuses on classroom implementation and supporting colleagues in using digital platforms. The researcher develops and evaluates digital learning environments and leads European projects on LA. The policymaker creates and manages regional and national strategies that expand infrastructure and enable large-scale adoption of LA. Together, these perspectives depict Greece as moving toward the systematic use of LA in support of a more integrated and data-driven educational ecosystem.

Italy

Across the three Italian interviews, participants illustrated a strong culture of reflective, evidence-oriented teaching in informatics, even where formal LA tools are not yet widespread. All value data-informed approaches—whether through classroom observation, simulator outputs, or aggregated performance data—to understand learning processes and refine instruction. The first teacher, with a physics and nanotechnology background, applies qualitative LA by monitoring student problem-solving behaviours and emotional responses. The second, a technically trained teacher, uses practical diagnostics from lab simulations to assess proficiency. The third, a mathematics graduate and regional STEM coordinator, employs LA on a broader scale to identify regional learning trends and training needs. Together, these perspectives show Italy's gradual move toward structured use of LA, starting from teacher-driven, informal practices that link classroom insight with broader educational improvement.

Lithuania

Across the five Lithuanian interviews, participants described a coherent and interconnected ecosystem linking educational policy, research, and classroom practice to advance IT education through LA. The group included a head of a municipal education department responsible for policy implementation and school quality, a senior official from an agency under the Ministry of Education working on national digital initiatives, a university researcher specialising in digital learning and LA, an expert secondary school IT teacher with nearly three decades of classroom experience, and two highly experienced primary school teachers recognised for their leadership in digital pedagogy. All emphasised that LA has become a crucial pedagogical tool rather than a mere technical aid, enabling continuous monitoring of students' learning process, progress, engagement, and learning strategies. They use a range of digital platforms—such as ViLLE, Nearpod, Liveworksheets, Wordwall, XLogo, and Bebro tasks—alongside tools like Excel and Power BI to monitor the progress of individual students and analyse the data to inform individualised instruction, risk detection, and strategic planning. Many also contribute to research and innovation projects, helping to develop or test new LA solutions. Collectively, these perspectives show Lithuania's strong, system-wide integration of LA, where policy, research, and practice converge to support personalised learning and sustained improvement in computer science education.

Portugal

Across three interviews, diverse perspectives highlight Portugal's nascent yet growing engagement with LA. The regional education policy officer overseeing the implementation of computational thinking and national digital policies emphasises LA's potential for system monitoring and targeted support, with pilot projects demonstrating how aggregated platform data can inform resource allocation and policy decisions to address structural inequalities. The university lecturer involved in teacher education highlights LA's pedagogical value, particularly in formative assessment and reflective practice; she advocates for embedding LA within teacher training programmes to develop future educators' data literacy. The secondary school teacher and pre-service teacher-trainer in digital pedagogy recognises the emerging significance of LA in supporting early identification of learning difficulties, though practical adoption remains limited, with teachers mostly using LMS logs and institutional diagnostics like SELFIE to complement traditional indicators. Overall, their perspectives illustrate that Portugal's landscape is characterised by active policy experimentation, teacher training initiatives, and growing awareness of LA's potential to enhance teaching and learning, even as full-scale integration remains a future goal.

Slovenia

Across the three Slovenian interviews, participants reflected a close link between teaching practice, research, and policy in advancing digital and data-informed education. All three highlighted the significance of LA as a valuable but evolving tool for improving teaching and learning in informatics and related subjects. The ICT coordinator and teacher, with a strong background in computer science, uses Moodle's LA functions and Excel analysis both in his classes and in training colleagues to adopt analytics. The university researcher, an assistant professor in technology didactics, has developed and evaluated an intelligent tutoring system and supervises AI-supported LA research, while acknowledging the limitations and ethical challenges of data-intensive approaches. The policymaker and assistant professor in business informatics, active in curriculum design and teacher training, applies LA for formative assessment and feedback through digital platforms such as Moodle, Mahara, and MS Teams. Together, their perspectives portray Slovenia as fostering integration between classroom innovation, academic research, and educational policy, where LA is seen as a valuable element of quality improvement—used with technical skill, pedagogical care, and increasing ethical awareness.

Spain

Across all three Spanish interviews, there is a growing awareness and gradual integration of LA across diverse educational contexts, from secondary and vocational to higher education. All participants acknowledge LA's growing importance for understanding learning processes, personalising instruction, and supporting early detection of difficulties. The secondary school teacher, specialising in languages and educational innovation, applies LA indirectly through formative assessment and interprets digital platform data to guide feedback, also contributing to teacher training and publications on the topic. The vocational education teacher, specialising in informatics education with a background in software development, applies LA in programming and systems courses to identify at-risk students and tailor learning experiences. The university professor, active in educational informatics and European projects, uses Moodle reports and tools like Learning Locker to inform teaching practice and curriculum design, seeing LA as a strategic resource for educational personalisation. Together, their perspectives illustrate Spain's steadily expanding use of LA across educational levels, driven by innovation-minded educators who translate data into pedagogical insight and student support.

Cross-Country Summary

Overall, the interviewees represent a rich cross-section of professional profiles spanning education, research, policy, and industry. Their combined experience reflects the depth and diversity of expertise in the development and use of LA as well as informatics education across Europe. From classroom teachers and instructional designers to university researchers, policy advisers, and institutional leaders, each provides complementary insights grounded in practical experience, research, and strategic vision. Collectively, their profiles illustrate how the advancement of

digital and data-informed education relies on the active collaboration of experts operating at different levels of the educational ecosystem.

5.2 Use of LA in Informatics

This section examines how LA is currently used in informatics education across EU countries, focusing on practices, purposes, tools, and consent procedures. It reveals a range of approaches, from systemic integration to experimental use in classrooms, with applications including student monitoring, formative assessment, and curriculum improvement. These insights provide a comparative overview of the evolving landscape of data-informed teaching in informatics across different national contexts in the EU.

Bulgaria

In Bulgaria, LA is used at multiple levels, from classroom practice to policy development. Teachers employ analytics features in Moodle, Shkolo.bg, AdminPlus.bg (Bulgarian digital school management systems), Google Classroom, and MS Teams to monitor attendance, assignment submissions, test results, and student engagement. These insights help identify learners needing extra support and guide the adaptation of teaching materials to individual needs. In higher education, LMS-based dashboards and custom scripts are used to track coding tasks and online activity, providing early alerts on student progress while ensuring GDPR compliance through consent procedures. At the policy level, LA mainly supports system monitoring, with aggregated data on achievement and participation to inform strategic decisions. Though informatics-specific analytics are still emerging, there is growing interest in integrating metrics on coding, problem-solving, and STEM engagement into national platforms. Overall, Bulgaria shows a developing, multi-layered use of LA, linking classroom application, university innovation, and policy interest in data-informed improvement.

Croatia

In Croatia, LA is in gradual development, combining early policy initiatives with emerging institutional and classroom practices. At the system level, LA remains largely conceptual, as school data are mostly administrative—covering demographics, grades, and attendance—without structured pedagogical use. During the national curriculum reform led by Minister Blaženka Divjak (2017–2020), the idea of digital student dashboards was proposed to consolidate learning data and support personalised instruction, but the project did not progress beyond pilots due to political and resource constraints. At the university level, LA is gaining practical application. One interviewee uses analytics in both teaching and institutional management, analysing performance trends, enrolments, dropouts, and survey results through tools such as Excel, Infoeduka, Tableau, and Power BI. These dashboards aid in identifying at-risk students and improving support services. From a teaching perspective, another interviewee applies continuous and adaptive assessment to not only track learning progress but also identify conceptual gaps. He experiments with AI-driven testing systems that detect missing knowledge areas and automatically generate personalised learning tasks, aiming to move beyond purely quantitative measures toward diagnostic and formative analytics. Overall, Croatia's experience with LA reflects a transitional phase—bridging policy vision, emerging institutional analytics, and innovative classroom practices, while highlighting the need for systematic integration and deeper pedagogical application.

Cyprus

In Cyprus, LA is applied primarily within digital learning platforms rather than through national or institutional frameworks. The interviewee reported using LearnWorlds, a learning management system with built-in analytics that tracks metrics such as time spent on the platform, units completed, assessment scores, course start and completion dates, and certificate acquisition. These data are used to monitor learners' progress, identify at-risk students, and trigger targeted interventions such as reminders or activity prompts. The analytics also inform teaching and curriculum development as well as support institutional reporting. Data collection complies with privacy regulations through a consent form introduced at the start of each course. While broader systemic use of LA is still

emerging, tools like LearnWorlds demonstrate how digital platforms are supporting the data-informed development of teaching and learning in Cyprus.

Finland

In Finland, LA plays an increasingly significant role in linking research, teaching, and system-level monitoring, supported by well-developed digital infrastructure and ethical frameworks. ViLLE, digital learning platform developed by the Turku Research Institute for Learning Analytics at the University of Turku, is widely used to track code submissions, task performance, time on task, repeated attempts, and progress, providing both teachers and students with detailed insights and real-time feedback. Across institutional, research, and classroom contexts, LA supports evidence-based decision-making, enabling educators to monitor progress, identify at-risk learners, and reduce subjective bias in assessment. It also serves diagnostic and psychometric purposes, generating valid and comprehensive measures of knowledge, skills, and attitudes that inform instructional design and educational policy. Finnish teachers use LA to understand individual learning trajectories and to act promptly on identified difficulties—data impossible to gather through observation alone. Assessment tools such as FUNA (numeracy fluency), MUREA (reading fluency), and mathematics assessments complement ViLLE's interactive analytics, while platforms like Teams offer partial monitoring capabilities. Data governance operates through multi-level consent structures, typically managed by municipalities or subject to ethical board approval, ensuring compliance with research and privacy regulations. Overall, LA in Finland demonstrates a mature, research-driven ecosystem where analytics are increasingly embedded in instructional design and educational decision-making, though practical uptake across all schools continues to evolve.

Greece

In Greece, LA is gradually expanding, particularly during the COVID-19 pandemic, across policy, research, and classroom contexts driven by national digital platforms and EU-funded initiatives. At the school level, teachers use systems such as the Ministry's e-class system, Moodle, e-class, and e-me to monitor student participation, assignment submission, quiz results, and engagement patterns, particularly in coding and programming activities. These analytics are primarily used formatively to identify learning gaps, adapt instruction, and provide evidence of progress to parents. In higher education, LA plays an increasingly important role in research, where LMSs like Moodle, and Open edX, and code submission environments generate datasets used to model learning behaviours, predict performance, and refine instructional design. Despite this, use in everyday teaching remains limited and largely research-driven. At the policy level, national data infrastructures such as MySchool collect extensive participation and performance statistics, supporting system-level reporting and evaluation rather than direct pedagogical feedback. Multiple EU-funded initiatives have focused on design, test, and evaluate LA dashboards, particularly in the context of programming education. While the use of LA in informatics teaching is still in its early stages, growing awareness of its potential points towards its future application in addressing equity gaps, supporting personalised learning, and informing curriculum development.

Italy

In Italy, LA remains largely informal and locally developed, with few instances of systematic or nationwide implementation. Most educators rely on teacher observation, classroom reflections, and simple digital traces rather than dedicated analytics platforms. In schools, LA is often understood as a process of diagnosing conceptual difficulties—for example, identifying persistent misunderstandings in topics such as recursion, data structures, or network configuration—and using this insight to adjust teaching strategies and provide targeted scaffolding. Teachers occasionally make use of logs from simulation tools like *Packet Tracer* to analyse patterns of error and time spent on tasks, though such practices are primarily diagnostic rather than data-driven in a formal sense. At a broader level, regional projects employ basic statistical analysis and Excel-based monitoring of anonymised data from programming or contest platforms to inform teacher training and curricular support. Consent and ethical considerations are managed either implicitly through approved school systems or centrally by data-collecting

organisations. Overall, Italy's current use of LA in informatics is fragmented and formative, characterised by isolated innovation and reflective classroom practice rather than systematic digital analytics infrastructures.

Lithuania

In Lithuania, LA is applied across multiple levels of the education system, from classroom practice to national initiatives. Teachers routinely monitor student progress using digital environments such as TAMO, Moodle, Google Classroom, Keltas, Matific, Egzaminatorius.LT, and specialised tools like LearnLab, Eduten Playground, ViLLE, Nearpod, Liveworksheets, and Wordwall, collecting data on test results, assignment completion, attendance, and online engagement. More advanced implementations analyse log data, code submissions, reflection texts, and self-assessment results, supporting formative evaluation and differentiation of instruction. Teachers use these insights to identify conceptual gaps, adjust materials, and provide targeted support for both struggling and advanced learners. National projects, including *Artificial Intelligence in Schools*, have furthered the development of AI-driven and gamified LA tools, exploring how system-wide analytics can enhance personalisation and creativity in IT education. At the policy level, aggregated student data are analysed through the Education Management Information System (EMIS) to inform educational planning and quality improvement. Data governance follows GDPR standards, with consent typically obtained from students and their guardians during school admission and additional authorisation required for research projects. Overall, LA in Lithuania is becoming increasingly systematic, combining local classroom practices with national efforts to modernise education through data-informed and ethical uses of analytics.

Portugal

In Portugal, the adoption of LA remains patchy, with most schools primarily using platform data for administrative monitoring, such as login activities, submission records, and grades. A few teachers access insights dashboards to detect low engagement, but there is no widespread, systematic use of LA integrated into classroom pedagogy. Data collected includes LMS interaction logs, assessment scores, self-reports, and artefacts from programming tasks where applicable. The purposes of LA focus on early detection of at-risk students, informing formative feedback, and supporting school-level reporting and evaluation. Tools such as Microsoft 365, Moodle, and Forms are common, with varying practices around obtaining student or parent consent—some include data-use clauses during enrolment, while others treat analytics as part of routine educational administration. At the university level, LA is mainly used for institutional evaluation and research, informing programme improvements and pedagogical studies through diagnostics like SELFIE and LMS data, often with explicit consent and transparency. Regionally, LA usage is mostly aggregated to monitor policy implementation, with efforts to ensure GDPR compliance through anonymisation and consent procedures, though practices vary across institutions. Overall, Portugal demonstrates an evolving but still limited landscape of LA integration, predominantly at organisational and research levels.

Slovenia

In Slovenia, the use of LA in informatics education varies between schools and higher education institutions and remains largely dependent on individual initiative rather than national policy. At the school level, unified Moodle classrooms are widely used to track student progress, analyse quiz results, monitor task completion, and identify learners who may be falling behind. Teachers employ features such as activity tracking, restricted access, rubrics, and gradebook reports to support formative assessment, occasionally exporting data to Excel for detailed quantitative analysis. In higher and vocational education, Moodle, MS Teams, and institutional systems such as AIPS (Academic Information Subsystem of the University of Maribor) provide basic analytics, but their integration and use are inconsistent. Data is primarily gathered for progress tracking, teaching improvement, and institutional reporting, with limited application for predicting or supporting at-risk students. Although educators recognise the potential of LA to foster self-regulated learning and inform adaptive teaching, its current implementation is hindered by fragmented data collection, insufficient training, and a lack of advanced analytical tools. Ethical practice is generally observed, with data used only for educational purposes and consent procedures aligned with legal frameworks,

although knowledge of GDPR and awareness of data rights vary among institutions. Overall, LA in Slovenia remains at an early, exploratory stage, focused more on monitoring and reporting than on systematic, pedagogically driven data use.

Spain

In Spain, the use of LA in informatics education is uneven but gradually expanding, largely driven by institutional initiatives and EU projects. Most institutions employ Moodle or Canvas as their main learning management systems, using embedded dashboards and complementary tools such as OpenLAP, Quizizz, Google Forms, and Edpuzzle to collect and visualise data on student interaction, assessment performance, time-on-task, and participation. LA serves multiple purposes, including identifying students at risk of disengagement or dropout, enhancing formative assessment, improving teaching quality, and informing institutional decision-making. Some educators also use analytics reflectively to redesign instruction and activate prior knowledge, aiming for deeper mastery of concepts. Data management follows institutional protocols aligned with national and EU privacy regulations, with student consent typically obtained through enrolment processes or parental approval for school accounts. Overall, Spain demonstrates a growing but still heterogeneous uptake of LA, marked by active experimentation within individual institutions and supported by European collaboration projects that foster more systematic use and capacity building.

Cross-Country Summary

Across the participating countries, a common pattern emerges of evolving but uneven implementation of LA. In Finland and Lithuania, LA is well-developed and systematically integrated across institutional, research, and classroom levels. These ecosystems leverage mature digital infrastructures and strong ethical frameworks, enabling detailed monitoring of student progress, diagnostic assessment, and data-driven instructional design. Teachers and policymakers use LA insights to identify at-risk learners, tailor support, and inform system-level decisions, with GDPR compliance and transparent consent procedures in place. This advanced integration exemplifies a research-driven and policy-supported approach to data-informed education.

Conversely, in Bulgaria, Croatia, Cyprus, Greece, and Portugal, LA practice is developing gradually, often limited to specific tools, pilot projects, or individual teacher initiatives. Bulgaria and Greece have started integrating LA at multiple levels—classroom, institutional, and policy—with growing recognition of its pedagogical potential. Portugal's use remains patchy, mainly involving administrative data for early detection of at-risk students and institutional reporting. Croatia and Cyprus are in transitional phases—Croatia applying dashboards for performance tracking and adaptive assessment within universities, and Cyprus focusing on platform-based learner monitoring with analytics embedded in specific LMSs. These countries face ongoing challenges related to awareness and infrastructure but share a trajectory toward broader adoption and pedagogical integration.

Finally, countries like Italy, Slovenia, and Spain show more fragmented or informal LA practices. In Italy, LA is largely teacher-driven, based on classroom observation and simple digital traces without widespread systematic platforms. Slovenia exhibits variability across institutions, with some use of LMS features for formative assessment, but limited integration and a focus on monitoring rather than deep analytics. Spain is experiencing growth driven by EU initiatives, with institutions experimenting with LMS dashboards and supplementary tools for formative and diagnostic purposes. Overall, these countries underscore the ongoing transition from anecdotal or pilot LA use towards more structured, policy-backed, and pedagogically embedded data practices, albeit with significant variation in readiness and maturity.

5.3 Guiding Frameworks

This section explores the policy, theoretical, and pedagogical frameworks that shape the implementation and evolution of LA across the participating countries. The interview question focused on whether such frameworks

exist, how they influence LA practices, and in what ways they guide decision-making, ethical considerations, and pedagogical integration. However, there has been no response from Bulgaria on this topic. The insights reveal diverse levels of formal guidance, from national policies and research-informed principles to classroom-level pedagogical approaches, shaping how LA is adopted and developed within different educational contexts.

Croatia

Croatian interviewees link LA to broader educational aims such as learning outcomes and student-centred, constructivist pedagogies. One participant views LA as a support tool for outcome-based education, emphasising the importance of balancing measurable results with the value of unquantifiable learning aspects. Another primary guiding framework for LA is GDPR, ensuring data protection and informed consent, with additional policies in data management and information security at higher education institutions. However, there is no dedicated national policy or institutional framework explicitly encouraging or regulating LA at the systemic level. Overall, Croatia's approach reflects a focus on data privacy and security, with application driven by individual initiatives and pedagogical considerations rather than formal policy frameworks.

Cyprus

From a policy perspective, Cyprus's frameworks focus on ensuring that data is collected and used responsibly, with an emphasis on respecting privacy and ethical standards. Theoretical and pedagogical frameworks highlight how data should be interpreted in relation to learner behaviour, offering pathways to improve engagement and personalise learning activities to meet individual needs. Overall, Cyprus's approach underscores the importance of ethical data use and learner-focused analytics to support meaningful educational improvements.

Finland

Finnish experiences with LA reflect a blend of formal policy, theoretical principles, and local practice. One interviewee emphasised the student-centred purpose of LA within ViLLE, focusing on assessing current performance and supporting real-time learning. Another highlighted national legislation that requires schools and regions to evaluate student and school performance, supported by tools like DigiArvi, which align with theoretical frameworks such as the national core curriculum and models of learning progression, especially for lower-achieving students. Conversely, a third interviewee noted that at the school level, LA use is largely guided by local practice and teacher experience rather than formal policies or pedagogical frameworks, with LA applications often relying on informal agreements with municipalities. Overall, LA development in Finland is shaped by a mixture of policy directives, pedagogical theories, and professional judgement, creating a flexible landscape for its use.

Greece

Greece currently does not have a dedicated national pedagogical framework guiding the use of LA. Teachers reported that existing platforms like e-class and Moodle offer reporting functions but are not connected to a broader strategic or pedagogical approach; teachers rely mainly on their judgment for data interpretation. At the higher education level, research and development teams apply various theoretical models, such as learning design, self-regulated learning, and constructivist pedagogy, but these are locally driven and lack systemic policy support. The policymaker pointed out that broader digital education policies, including Greece's Digital School and Digital Transformation strategies, guide LA use more generally; GDPR provides the essential legal framework for data privacy. Currently, analytics functionalities are primarily designed for accountability and reporting rather than pedagogical purposes, and there is a recognition that developing formal pedagogical guidelines for LA would be a valuable next step.

Italy

In Italy, LA practices are guided by well-established pedagogical frameworks. One educator highlighted the central role of constructivist learning theories, supplemented by Bloom's Taxonomy and the SOLO taxonomy, which shape

the design of learning tasks aimed at fostering cognitive development and assessing deep understanding. These frameworks represent a pedagogically grounded approach that informs the development and application of LA in classroom settings, emphasising the importance of aligning data use with sound pedagogical principles.

Lithuania

Lithuania's approach to LA is guided by a combination of national policies, ethical principles, and pedagogical considerations. The application of LA aligns with the Lithuanian National Education Strategy, the Code of Ethics, the General Guidelines for Education, and assessment principles outlined in the General Programs. Core principles include data minimisation, transparency, and compliance with personal data protection legislation, with a focus on responsible use that avoids increasing social exclusion. International guidelines, such as the Learning Analytics Code of Practice (JISC), and theories of personalised and self-directed learning also inform practice. Pedagogically, LA is seen as a tool for motivating students, fostering autonomy, and promoting active engagement, making it a vital component of pedagogical strategies aimed at student success and personal development.

Portugal

Portugal's LA practices are guided by a combination of national frameworks, such as the Digital Transition and PADDE initiatives, and EU guidelines like DigCompEdu. Diagnostic tools like SELFIE are employed to assess digital readiness, but there remains a lack of operational guidance on how schools should translate diagnostic outputs into classroom LA workflows. Pedagogically, there is a strong emphasis on connecting LA to formative assessment theory and constructivist pedagogy, with advocates highlighting the importance of framing LA as a tool to support meaningful, ethically grounded, and student-centred learning rather than reducing learning to mere metrics. Overall, Portugal shows an interest in developing practical guidance to help schools implement LA pedagogically and ethically.

Slovenia

In Slovenia, there are no specific national guidelines or overarching pedagogical frameworks guiding LA use. The interviewee relies on general ethical codes and pedagogical principles that prioritise collecting only data necessary for pedagogical purposes, emphasising transparency and creating "safe zones" for student learning—spaces where students can study without feeling scrutinised. He warns against measures solely based on LA that might lead to over-standardisation, premature conclusions, or privacy breaches. His approach is "pedagogy first," with minimal data collection and a focus on ethical standards, professional judgement, and student dialogue. Overall, Slovenia's use of LA remains informal and ethically cautious, with no systematic framework linking LA to formal pedagogical or formative assessment guidelines.

Spain

In Spain, there is currently no specific national framework guiding the use of LA. Teachers generally have limited knowledge of the concept, and practices are often informal. Pedagogically, the emphasis is on personalisation and adaptive learning, with some guidance derived from European digital education strategies and national digitalisation policies. While no formal or dedicated framework exists for LA, the national and institutional strategies stress the importance of digital transformation and the responsible management of student data. Overall, Spain's approach to LA is characterised by active experimentation within institutions and reliance on broader digital policies to guide responsible and adaptive use.

Cross-Country Summary

Across the participating countries, two broad patterns emerge regarding the guiding frameworks for LA. **In countries like Finland and Lithuania**, approaches are relatively well-established, grounded in formal policy, national legislation, and pedagogically motivated principles that primarily inform the implementation and evolution of LA.

Finland's development is shaped by a combination of formal policy, legislation, and classroom practice, with a strong emphasis on student-centred assessment and real-time support, guided by pedagogical models and professional judgment. Lithuania's efforts are guided by national strategies, aligned with international guidelines such as the JISC Code of Practice, and are underpinned by core ethical principles and commitments to responsible data management—collectively ensuring LA supports active engagement and fosters personal development.

The remaining countries—such as Portugal, Slovenia, Spain, Greece, Croatia, and Cyprus— display more emergent frameworks where broad policy and international guidelines underpin the informal or developing implementation of LA. Key pedagogical principles—such as constructivist learning, personalised learning, and formative assessment—along with national and EU digital education policies like DigCompEdu, often drive the adoption of LA. In these contexts, data privacy governed by GDPR and fundamental ethical considerations around responsible data use shape how LA is developed and employed. However, in many cases, there is a lack of explicit pedagogical or national frameworks to guide the interpretation and use of LA data; instead, teachers frequently rely on their own professional judgment and contextual expertise.

Overall, these patterns reveal a landscape where most countries operate in a dynamic space—balancing formal policies, ethical standards, and pedagogical theories. The level of systemic support, operational guidance, and pedagogical integration varies widely, influencing how LA is developed, adopted, and embedded within educational practices across different contexts.

5.4 Stakeholder Engagement

This section examines the roles and involvement of various stakeholders—teachers, students, researchers, policymakers, and others—in the design, implementation, and interpretation of LA. It considers the extent of their participation, the nature of their contributions, and the support and training available to empower them in leveraging LA effectively and ethically within educational settings. It should be noted that there has been no response from Bulgaria and Italy on this topic.

Croatia

During the curricular reform period, Croatia identified CARNet as a potential technical supporter for LA; however, one interviewee notes that CARNet lacks a guiding vision and has mainly followed ministerial directives without proactive development or strategic direction. While some stakeholders—including teachers, the British Council, and OECD experts—were engaged in training and consultation, systemic continuity and sustained support for LA have been largely absent. The potential motivation among teachers to use LA exists, as it could enhance their ability to demonstrate effectiveness and reduce frustration, but without long-term policy backing, such engagement remains fragmented and isolated.

At the institutional level, LA is used primarily for internal management and support at one higher education institution, where teachers mainly encounter data through reports and dashboards rather than conducting in-depth analyses. Although no formal or systematic training opportunities are available for teachers, discussions around pass rates and performance metrics tend to raise awareness and motivate teachers' interest. Some teachers pursue LA initiatives driven by individual interest, often outside formal mandates; this bottom-up approach is hindered by rigid rules in primary and secondary education that limit the ability to adapt lessons dynamically. Overall, stakeholder engagement around LA remains informal and individual-driven, with a clear need for broader systemic support and strategic frameworks to foster more integrated and sustainable use.

Cyprus

In Cyprus, teachers actively use LA to adapt their teaching methods and identify student needs, supported by feedback from student progress reports. Researchers focus on evaluating the impact of LA on learning outcomes, while policymakers establish regulations aimed at ensuring ethical data use and safeguarding privacy. Other stakeholders, including instructional designers, utilise LA to improve curriculum development and collaborate with course instructors to enhance learner engagement and overall educational experience. Platforms like LearnWorlds provide ongoing support through online tutorials, webinars, and user guides, promoting continuous professional development and supporting effective use of LA tools. Overall, stakeholder engagement in Cyprus is multifaceted, with practical use across teaching, research, policy, and curriculum design, supported by accessible training resources.

Finland

In Finland, stakeholder involvement in LA unfolds across multiple levels, with developers, teachers, researchers, and municipal directors contributing to system development through ongoing feedback. Teachers play a central role as active participants in classroom data interpretation, with students primarily serving as data sources, while researchers provide expertise in data analysis and interpretation to inform both local and national educational policies. Engagement tends to be driven by professional expertise and institutional mandates, with less emphasis on co-design or shared decision-making among stakeholders.

Support structures for teachers include formal remote training sessions and dedicated customer support for platforms like ViLLE. Some tools are designed for ease of use, requiring minimal instruction, while others have more superficial teacher training—typically limited to a few hours—focused on operational use rather than pedagogical understanding and benefits of LA. As a result, effective application of LA relies heavily on teachers' initiative, prior knowledge, and ongoing self-directed learning, highlighting the need for more comprehensive professional development in data interpretation and pedagogical integration across the system.

Greece

In Greece, at the school level, teachers are the main LA users, with data shared with parents to support performance discussions. Student engagement with dashboards is limited, as most outputs target teachers. Due to limited formal training, teachers mainly develop skills through self-learning and peer exchange, with younger teachers being more receptive. Engagement with policymakers and researchers is minimal, and there are no formal mechanisms for teacher input into LA system design.

In higher education, stakeholder involvement is typically limited to specific projects, with faculty, IT staff, and students collaborating on pilot initiatives. Broader dissemination of insights remains scarce, and research findings are seldom integrated into mainstream practice. Policymakers show interest in EU-funded results, but national strategy integration remains weak. Teacher training opportunities are limited and usually tied to research projects, underscoring the need for targeted professional development to improve teachers' ability to interpret and effectively apply LA data.

Overall, stakeholder engagement remains limited. Policymakers and administrators mainly use aggregate data, while students and parents are generally disconnected. Stronger links between researchers, teachers, and policymakers are needed to promote more widespread and meaningful LA use.

Lithuania

In Lithuania, various stakeholders—including teachers, students, researchers, and policymakers—are actively involved in the development, application, and interpretation of LA. Teachers are the primary users, monitoring student progress, analysing data to inform pedagogical decisions, and engaging in professional development

through seminars, courses, and participation in national and international projects. Additionally, digital resources such as emokykla.lt guide understanding and implementing LA. Students reflect on their achievements using LA tools, receive personalised recommendations, and independently plan their learning pace. Parents are involved by receiving achievement updates reported by teachers and collaborating to support educational outcomes.

Researchers develop analytics models, perform data analysis, and evaluate LA's impact, often working closely with teachers. Policymakers contribute by shaping strategic initiatives like TŪM and EdTech, analysing national data, and producing reports to support education modernisation efforts. Teachers benefit from training organised by municipal education centres and the National Education Agency (NŠA), which offers qualification seminars, courses, and involvement in pilot projects like 'smart classrooms' and LMS with integrated analytics. Digital platforms such as emokykla.lt provide teaching materials and tools that help teachers understand and apply LA principles effectively. Together, these groups form a collaborative ecosystem that advances data-driven education in Lithuania.

Portugal

In Portugal, teachers are the main interpreters of LA, with students primarily serving as data sources, though they may be engaged through reflective activities. Researchers and external trainers, such as CFAE and Education Networks, support pilot projects, while policymakers set broad priorities and funding strategies. Involvement across stakeholder groups tends to be uneven and often top-down. Support for teachers is offered through regional training centres, national digital competence measures, and project-based continuous professional development such as Erasmus initiatives and local networks. However, many teachers lack sustained support and training to interpret LA outputs pedagogically.

In university settings, the involvement of stakeholders in LA design is actively encouraged—co-design activities involving pre-service teachers and research partnerships with school teachers are promoted, with a focus on participatory approaches to defining relevant indicators. There is scope for more comprehensive training modules on data literacy, ethics, and interpretation, but the need to cascade this training into in-service programmes and wider CPD is urgent.

The digital policy environment seeks to coordinate efforts across schools, teacher training centres, and universities, but scaling up data-literacy training remains limited by constraints on time and budgets. Blended approaches combining online modules with school-based coaching are increasingly being promoted to overcome these challenges. There is also a recognised need for clearer channels for teacher feedback and for greater involvement of practitioners in the co-design of LA tools.

Slovenia

At Slovenian institutions, students, guided by teachers, define success criteria in line with formative assessment principles, which are implemented within Moodle activities. Students always see their own learning outcomes. Teacher training on LA is mainly indirect, delivered as part of general Moodle and MS Teams training, supplemented by resources from Moodle's extensive open-source community. However, this training does not foster a conscious understanding of LA's role and importance in teaching and learning, and ICT coordinators provide individual support to staff wishing to utilise Moodle's LA functions, often on an ad hoc basis.

Data use involves all staff working with personal data, including professors and student office personnel, mainly in aggregated and anonymised forms that are accessible to staff and occasionally to the public. Discussions about LA at departmental levels are informal and sporadic, with some colleagues sharing insights on specific student challenges. For students with special needs, responsibility for sharing relevant information often lies with the students themselves, leading to delays. There is a recognised need for greater transparency, stronger student involvement in data practices, and clearer institutional regulation. However, LA implementation remains inconsistent: no dedicated training is provided, and regulations tend to be followed formally without targeted,

practical support. Stakeholder engagement in LA development, use, or interpretation is rare unless driven by personal interest, and long-standing development projects have largely remained unimplemented.

Spain

In Spain, the use of LA among teachers remains limited, with most practitioners engaging mainly through reflective discussions rather than formal, institutionalised training. Teachers primarily use LA to monitor student learning process, progress, and outcomes, while students are generally passive recipients of analytics insights, with some involved in feedback sessions. There are no dedicated institutional training programmes specifically focused on LA, only some courses, publications, and seminars led by experts like Santiago and Amo. Support is usually provided via workshops, refresher courses, and pilot projects designed by researchers, with participation remaining voluntary and uneven. Policymakers tend to focus on aggregated indicators, offering support through programmes and funding, but engagement at the classroom level remains limited. Overall, professional development opportunities in LA are scarce, and staff engagement varies widely.

Cross-Country Summary

Across the participating countries, stakeholder involvement in LA varies widely, reflecting different levels of maturity, and systemic support. **In countries like Cyprus, Finland, and Lithuania, stakeholder engagement is more multi-layered and systemic**. Teachers, researchers, policymakers, and students participate actively—teachers interpret data to inform pedagogy, researchers develop models and analyse impact, policymakers shape strategic initiatives, and students reflect and self-regulate with LA tools. Formal support systems—professional training, co-design activities, and participatory approaches—are more established, fostering a collaborative ecosystem where stakeholders work together to embed LA into everyday practice.

Conversely, with some exceptions, **many countries, such as Portugal, Slovenia, Greece, and Spain exhibit more informal, limited, or fragmented stakeholder engagement.** Teachers often operate as the primary users, with support provided through ad hoc training, pilot projects, or digital resources, often on a voluntary basis. Student engagement tends to be limited, and involvement of policymakers and researchers remains mostly project-driven rather than embedded in ongoing, systemic processes. In these contexts, professional development opportunities are scarce, and stakeholder feedback rarely influences LA design or broader strategic planning—highlighting a need for stronger, more inclusive engagement mechanisms and clearer pathways for collaboration.

Overall, the landscape suggests a spectrum from well-established, collaborative ecosystems to more isolated, pilot-driven efforts. Countries where stakeholders—especially teachers and students—are involved in co-design, interpretation, and ongoing feedback tend to embed LA more deeply, whereas where engagement remains superficial, sporadic, or top-down, LA adoption remains limited and peripheral to routine educational practice. Building systematic, participatory, and sustained stakeholder engagement remains critical to realising the full potential of LA for supporting teaching and learning.

5.5 LA in Institutional and National Contexts

This section examines how policies, strategies, funding programmes, and national initiatives promote or hinder the integration of LA into educational practice, exploring the specific mechanisms through which these influences operate and how they impact implementation at institutional and national levels. It should be noted that there has been no response from Cyprus.

Bulgaria

At the university level, LA is increasingly recognised as a priority, but systemic support remains limited. National strategies, such as the Strategic Framework for Education (2021–2030) and the upcoming Action Plan (2025–2027),

emphasise the importance of digital tools and evidence-based teaching; however, targeted funding specifically for LA in informatics is scarce.

At the school level, the Ministry of Education advocates for digitalisation through broader strategies like the Digital Transformation of Education, which supports e-learning platforms—yet, the implementation of LA remains inconsistent, primarily because the development of a systematic framework is still underway. Bulgaria aligns with the EU Digital Education Action Plan (2021–2027), aiming to strengthen data use in education, including in informatics, but concrete support for LA implementation at the national and institutional levels is still emerging.

Croatia

In Croatia, scepticism about political commitment to educational reform persists, with long-term improvements often lacking prioritisation. EU processes and funding mechanisms, such as the ESF, ERDF, and National Reform Programmes, act as external drivers, but institutional support remains limited. CARNet (Croatian Academic and Research Network) is seen as politically dependent with limited staff, whereas SRCE (Computing Centre at the University of Zagreb) has greater independence and capacity. Although CARNet and SRCE help develop ICT systems, embed analytics in educational tools, and disseminate practices through conferences, concrete developments in LA are scarce.

On a national level, data use in policy is exemplified by AZVO (Agency for Science and Higher Education), which issues annual enrolment recommendations based on labour market needs. Although a portal provides labour market statistics, transparency and accessibility remain hindered by bureaucracy. Initiatives like the "School for Life" reforms envisioned dashboards, but these tools were never implemented. Overall, LA remains peripheral, with support fragile and largely unexecuted.

Finland

The development and maintenance of ViLLE, a digital learning platform with integrated LA, are primarily supported by the University of Turku and external project grants like Erasmus+ awarded to the Turku Research Institute for Learning Analytics—funding that was largely not allocated specifically for LA. Despite its widespread use across various educational levels in Finland, there is limited awareness of dedicated national or institutional policies, strategies, or funding programmes explicitly supporting LA in education or informatics. One researcher noted that, while there are various project names and funding initiatives in related areas, he is not familiar with the details or guiding frameworks, as his work primarily focuses on data analysis. Similarly, a professor observed that Finland currently lacks explicit national policies or dedicated funding streams for LA, with ongoing work in assessment tools and digital education contributing indirectly.

From the classroom perspective, there are no targeted policies, training opportunities, or national projects that support LA, and acknowledged limited visibility of initiatives promoting or resourcing LA use in day-to-day teaching. Overall, while related development occurs within broader education and technology projects, there is no formalised national or institutional structure or dedicated funding particularly supporting the promotion or integration of LA in education at present.

Greece

Greece benefits from an extensive digital infrastructure, with nationwide platforms such as e-class, e-me, and MySchool providing foundational support for LA across schools. These systems are widely adopted and supported by the Ministry of Education, ensuring universal access. However, the pedagogical use of LA remains limited; reports generated are often basic and not fully aligned with classroom needs. Participation in these platforms is mandatory.

In higher education, Greek universities use LA tools mainly in pilot or experimental phases, often based on open-source LMS platforms such as Moodle integrated with analytics plugins. While the digital transformation agenda fosters a favourable environment for LA, there is no dedicated national framework for LA in higher education or informatics. All research activities rigorously follow GDPR protocols, ensuring informed consent and dataset anonymisation—a process that can sometimes hinder rapid innovation but is essential for building trust. Despite the availability of infrastructure and EU collaborations, full integration of LA into national practice remains limited, with most initiatives remaining at the pilot stage.

Italy

Despite the existence of the Italian Piano Nazionale Scuola Digitale (National Digital School Plan), which promotes data-informed teaching, it offers limited guidance and resources for implementing LA specifically in informatics education. As a result, there are no significant national policies, strategies, or funding programmes directly supporting LA in secondary informatics classrooms. Related initiatives are mostly confined to experimental efforts by research institutes like INDIRE and CISPI, which rarely reach mainstream secondary education. The national plan endorses data use in principle but lacks concrete policies or dedicated funding for LA. The only consistent support often comes from modest regional budgets allocated to local STEM networks, which serve as the most notable local initiatives. The network's findings are regularly presented to regional Education Authorities to advocate for curriculum updates and increased funding, providing rare direct access to policy discussions. Formal LA training remains virtually non-existent; therefore, practitioners like this educator must design and deliver the only available data literacy training for their peers.

Lithuania

In Lithuania, the application of LA, including in IT education, is actively supported by several national strategies and programs. Key initiatives—such as the Digital Education Transformation (EdTech LT) and the Millennium Schools (TŪM) Programme—aim to modernise infrastructure, improve educational quality, and foster innovative solutions, including LA development through EU support mechanisms. While there are no programs exclusively targeting IT teachers, their involvement in LA projects often correlates with higher digital competence.

At the policy level, clear rules outline responsible LA use, aligned with data protection, ethics, and transparency standards. Platforms like LearnLab and Eduten Playground have been nationally implemented for real-time monitoring and tailored teaching, tested through pilot projects with partners like UNESCO and Norwegian institutions. Lithuania also hosts projects such as "Artificial Intelligence in Schools" and "Learning Record Repository," which develop scenarios for AI integration and centralised data collection to enhance teaching. Supported by the National Education Agency and research foundations like the Lithuanian Science Council, these initiatives combine strategic policy, teacher training, and innovative technologies for advancing educational technologies.

Portugal

At the national level, the Digital Transition programme and PADDEs create structural incentives for digital data collection but do not specifically mandate LA. Some institutions are running pilot initiatives, though overall funding and technical capacity limit wider scale-up. Notable projects include SELFIE diagnostics, LED kits distribution, and Erasmus+ pilots exploring digital pedagogy. Universities play a central role in incubating LA practices and developing ethical frameworks, with calls for stronger links between university research and school practice to ensure that pilot projects scale responsibly and sustainably.

Slovenia

Slovenia currently lacks any active national or institutional policies, strategies, or funding programmes explicitly dedicated to LA in any subject area. One interviewee suggests that if funding is provided, it should be aligned with

clear pedagogical goals, ethical standards, and measurable learning outcomes. While there have been past policies supporting LA, these are no longer active, and current efforts are limited to informal, individual, or project-based activities.

The national provider ARNES offers MOOCs on basic Moodle use, with only brief coverage of LA, and provides advanced Moodle workshops for small groups—yet requests for LA support are rare, and none are specifically for informatics education. The eŠola digital learning platform, which aims to incorporate LA, is not widely adopted due to its commercial nature. There are no notable national projects or initiatives focused on LA, and at the institutional level, no active projects are systematically developing or implementing LA. Monitoring student progress remains the responsibility of individual professors, with practices varying widely across classrooms.

Spain

In Spain, there are no known policies explicitly dedicated to LA. One interviewee suggests that if such policies exist, they should be closer to teachers and integrated into broader digital competence programmes rather than addressed separately. He is not aware of any national projects specifically focused on LA.

However, digital transformation initiatives at both university and national levels support the integration of LA, with Spain participating in European projects such as SHEILA and Horizon Europe that include significant LA components. The SNOLA initiative is noted as a key national effort in the context of digital education. Additionally, some Erasmus+ projects are exploring the integration of analytics into innovation practices, but overall, there are no major national projects or policy exclusively dedicated to LA.

Cross-Country Summary

Across the examined countries, the landscape of LA support varies significantly, often reflecting differing levels of systemic commitment, policy clarity, and resource allocation. **In the Nordic and Baltic regions—Finland and Lithuania—there is a tendency towards widespread adoption of LA platforms supported by university-led initiatives, strategic programs, and EU funding.** Finland benefits from a strong research and digital infrastructure, though it lacks a formal national policy dedicated specifically to LA. Lithuania, while backed by strategic programmes like EdTech LT and TŪM, does not have a formalised institutional structure or targeted funding directives for LA.

Southern and Mediterranean countries—including Bulgaria, Greece, Italy, Spain, and Portugal—show more fragmented or emerging efforts. Bulgaria benefits from Ministry support and national strategies emphasising digital tools and evidence-based teaching, but tangible support for LA remains limited. Greece boasts extensive digital infrastructure, yet pedagogical adoption of LA is still in its infancy; policies are not specifically dedicated, and most initiatives are pilot or experimental. Italy relies heavily on the National Digital School Plan, regional support, and experimental projects, but lacks significant national policies, strategies, or dedicated funding. Moreover, LA training and resources for informatics education remain scarce. Spain, despite the absence of specific policies for LA, actively participates in EU projects such as SHEILA and Horizon Europe, with some national initiatives promoting digital education. Portugal's efforts stem from broader digital transformation programmes and small-scale pilots, with universities playing a key role in fostering LA practices.

Eastern European countries, including Croatia and Slovenia, exhibit even more limited systemic support for LA. Croatia's LA initiatives are peripheral, hampered by political and institutional constraints, with past reform efforts like "School for Life" falling short of expectations. Slovenia shows no active institutional or national policies, funding programmes, or large-scale projects in LA; monitoring remains largely the responsibility of individual educators, often based on informal or project-driven activities. Both countries highlight the urgent need for clear policy frameworks, strategic funding, and institutional support to transition LA from pilot or informal activities to mainstream practice.

Overall, while some countries are making progress through EU funding, regional initiatives, and university-led incubations, the widespread absence of dedicated policies and sustainable support mechanisms continues to hinder the deep integration of LA in national education systems. Achieving meaningful progress will require strategic planning, clear policy directives, and resource commitments aligned with pedagogical goals and stakeholder involvement.

5.6 SWOT Analysis

This section provides a comprehensive assessment of the current landscape of LA in informatics education, drawing on interviewee insights about its strengths, weaknesses, opportunities, and threats. It explores the internal factors (strengths and weaknesses) and external factors (opportunities and threats) influencing LA development and implementation. The analysis aims to identify key areas for growth and highlight risks that could impede the responsible and effective use of LA in educational settings.

Bulgaria

In Bulgaria, the landscape of LA benefits from the increasing availability of LMS data, motivated faculty, and alignment with EU digital policies supporting broader digital transformation. Teachers' willingness to experiment and students' digital skills further bolster the potential for LA adoption. The country also benefits from strong policy backing and expanding digital infrastructure, creating a conducive environment for integration.

However, significant challenges remain, including a lack of technical and pedagogical training for teachers, insufficient institutional investment, and limited expertise in LA among decision-makers. Fragmented data systems and inconsistent access to advanced LA tools hinder cohesive implementation and scaling efforts.

Opportunities for growth include EU funding programmes and collaborations between universities and schools, as well as the development of national LA guidelines. Existing Ministry-supported platforms such as Shkolo.bg and e-School, along with EU funding for pilot projects and the potential for best practice sharing, can facilitate wider adoption.

Despite this promising outlook, threats such as data privacy concerns and GDPR compliance issues, uneven digital infrastructure across institutions, resistance from teachers, and inequalities between urban and rural schools continue to pose barriers. Additionally, bureaucratic delays and political changes could slow or complicate progress in the adoption of LA.

Croatia

In Croatia, LA holds strong potential to enhance both teaching and learning. It can boost teacher motivation by providing evidence of positive outcomes, identify areas for improvement, and support adaptive pedagogical approaches. LA also enables more individualised learning paths, helps prevent dropout through predictive insights, and supports curriculum development aligned with student feedback and labour market needs. Growing access to structured quantitative data and user-friendly tools such as Power BI and Tableau further increases its practicality, while smart systems can ease administrative workloads by automating reports and feedback.

However, Croatia currently lacks a systemic approach to LA. Limited expertise, insufficient teacher training, and varying levels of motivation and openness to innovation restrict adoption. Existing data are often underused, with a risk of focusing too narrowly on measurable indicators while overlooking socio-emotional and contextual dimensions of learning. Over-reliance on quantitative metrics may also lead to data overload and frustration among teachers.

Opportunities lie in piloting LA in adult or higher education, where measurable outcomes and standardised curricula facilitate experimentation, with the potential to scale effective practices to other levels. EU funding programmes, the European Semester, and partnerships among schools, universities, and software providers can support LA development and implementation. Engaging teacher training and peer learning can spread good practice, while AI-driven tools can strengthen data use and enable adaptive, personalised assessments. LA can also enrich informatics education through practical, career-oriented tasks such as Excel-based projects.

Yet several threats could impede progress. Student digital distractions, weak self-regulated learning skills, and teacher burnout may limit LA impact. Ethical and data protection concerns, risks of misuse, financial constraints, and bureaucratic barriers remain significant challenges. Moreover, political inertia, rigid school policies, and the risk of treating LA as an administrative exercise rather than a pedagogical aid could further hinder progress.

Cyprus

In Cyprus, LA has strong potential to enhance informatics education through real-time feedback and continuous monitoring of learner engagement and progress. It helps identify learning patterns and challenges, enabling timely adjustments in teaching methods and materials. Interactive tools—such as quizzes, surveys, and discussion features on platforms like LearnWorlds—offer valuable insights beyond traditional grading, providing a more comprehensive understanding of student learning behaviour and performance. Integrating conventional assessment with digital feedback mechanisms supports more personalised and adaptive learning experiences.

However, several weaknesses constrain the wider adoption of LA. Data privacy concerns can limit information sharing, while many teachers and instructional designers lack the digital and analytical skills needed to interpret and apply insights effectively. Institutions often rely on basic platforms without advanced analytics or visual dashboards, restricting meaningful data use.

Opportunities arise from the rapid development of AI and intelligent systems capable of automating data interpretation and personalising learning. The emergence of more user-friendly tools, stronger policy support, enhanced cross-institutional collaboration, and improved teacher training can further promote broad and effective implementation of LA.

Yet, LA progress faces threats from ethical and privacy challenges, strict data protection regulations, limited financial and time resources, and potential changes in national or institutional policy that could hinder long-term sustainability.

Finland

In Finland, LA strengthens teaching and learning by enabling continuous monitoring and data-driven insight into student learning processes and outcomes. Unlike traditional assessments or teacher observation, LA provides real-time, detailed information on each student, supporting responsive instruction in informatics and beyond. Digital traces, including performance and rich behavioural data, help teachers identify learning challenges and refine instructional design. Integrating analytics into assessment and feedback improves reliability, reduces subjectivity, and motivates learners, while technology-enhanced tasks such as coding exercises promote active engagement.

However, several factors limit LA's full potential. Teacher engagement remains uneven across municipalities, with some educators adhering to traditional practices or lacking data-interpretation skills. Turning analytics into timely action still requires effort, judgment, and support. Legacy platforms like ViLLE also lack flexibility for integrating adaptive testing or AI-based analytics without significant investment.

Opportunities lie in using existing and emerging data to develop adaptive, teacher-supportive systems that personalise learning. Student-level data can help predict learning needs, freeing teachers from routine evaluation and enabling more targeted instruction. Advances in AI, machine learning, and tools such as eye tracking can provide immediate insights for personalised feedback, engagement, and instruction. These technologies can complement rather than replace teachers, while optimising current systems can already enhance outcomes. Growing demand for flexible and distance learning further reinforces LA's relevance.

Yet technical constraints, limited infrastructure, funding shortages, and data protection or ethical concerns—especially around AI and potential misuse—may impede progress. Strict privacy regulations and tensions between research and data governance can also hinder the advancement of knowledge essential for LA development and use. Teachers may feel pressured by automated recommendations, leading to resistance, though the greater risk lies in underusing LA. With responsible design, transparency, and strong professional oversight, these challenges can be mitigated, enabling LA to realise its full educational potential in Finland.

Greece

In Greece, LA benefits from strong national infrastructure and policy support for digital transformation. Platforms such as e-class, e-me, and MySchool ensure wide coverage and equitable access. LA provides objective evidence of student engagement and performance, helping teachers identify learning difficulties early—an approach readily applicable to informatics education, including coding. Universities show strong research capacity and a culture of experimentation, while active participation in EU-funded projects aligns national initiatives with broader European innovation and funding frameworks.

Despite these strengths, several weaknesses limit LA's impact. Dashboards remain basic and provide few actionable insights relevant to classroom practice. Fragmentation of tools and the absence of a unified pedagogical or policy framework hinder systematic adoption. Teachers often lack training in interpreting analytics, and available data are largely used for reporting rather than instructional improvement. Students themselves rarely engage with LA to support self-regulation, and research findings are not consistently translated into practice or policymaking, limiting their wider influence.

Opportunities exist to expand national dashboards with more pedagogically meaningful metrics and to integrate LA into informatics-specific and coding environments. AI-driven analytics offer potential for greater personalisation and adaptive learning. Strengthening teacher professional development and fostering collaboration among schools, universities, and the Ministry of Education could support the design of more effective LA systems. Ongoing national digital transformation strategies and participation in EU projects provide both frameworks and resources to embed LA sustainably across education.

However, several threats may constrain progress. Privacy and ethical concerns, especially regarding data monitoring, can provoke resistance from teachers, students, and parents who fear surveillance or misuse. Teacher unions may oppose additional workload if support is inadequate. Budget constraints, shifting political priorities, and reliance on time-limited EU funding threaten continuity, while research outcomes risk remaining isolated from classroom practice and policy implementation.

Italy

Italy benefits from a teaching workforce that is technologically adept, open to innovation, and supported by strong observational and relational skills, providing valuable qualitative insights. The country's humanistic educational tradition promotes ethical, student-centred approaches to data use. Network-based learning systems generate rich and objective log data, enabling precise performance analysis. In addition, regional funding supports teacher networks that develop national benchmarks and foster the exchange of effective practices, strengthening collective expertise in LA.

Despite these strengths, Italy's digital infrastructure remains uneven, with schools often relying on external platforms that produce unstable, fragmented data. Metrics are typically siloed, anonymous, and aggregated, making it difficult to support individual learners. Teachers receive limited training in data literacy and educational analytics, and institutional frameworks to guide LA integration are largely absent, leaving implementation dependent on individual initiative and external systems.

Italy could leverage existing diagnostic outputs from widely used simulation platforms to create a cost-effective, "zero-cost" LA framework. Participation in international and EU initiatives such as DIGITAL FIRST offers prospects for developing lightweight, pedagogically sound LA models suited to schools with limited infrastructure. These avenues can promote shared standards, teacher training, and collaboration between policymakers, educators, and technology providers, creating an integrated, scalable analytics ecosystem.

Public concerns about data privacy and fears of surveillance could limit acceptance of LA, while an overemphasis on quantitative metrics risks undermining its educational value without clear ethical guidelines. Fragmented data and possible misinterpretation by policymakers may distort decision-making. Pedagogical oversimplification—reducing complex competencies to narrow indicators—and data fatigue among teachers pose further risks. Rapid obsolescence of digital tools and the potential loss of regional funding threaten continuity, potentially ending systematic LA initiatives and halting progress toward evidence-based innovation.

Lithuania

In Lithuania, LA provides deep insights into teaching and learning by analysing interaction logs, reflections, and code submissions, revealing entire learning processes rather than just final outcomes. It enables individualised and differentiated instruction by helping teachers identify both fast and struggling learners and adapt content accordingly, while also fostering student motivation, self-reflection, and responsibility. Continuous LA inform pedagogical and strategic decisions from classroom to national level, strengthening formative assessment, feedback, and evidence-based policymaking. A well-developed digital ecosystem—including platforms such as TAMO, Google Classroom, Eduten Playground, LearnLab, ViLLE, and Moodle—supports real-time monitoring of student learning activities and progress, complemented by analytics innovation using tools like Jupyter and Python. Continuous teacher training under the National Education Agency (NŠA), together with initiatives like the Millennium Schools program, the EdTech LT strategy, and international collaborations with UNESCO and partners from Finland and Norway, ensures innovation transfer into practice. These combined strengths demonstrate Lithuania's robust infrastructure, institutional support, and collaborative culture, positioning LA as a key element of the country's digital education transformation.

LA in Lithuania faces uneven implementation across schools, largely dependent on teachers' digital competences, initiative, and resources. Many schools rely only on basic data such as grades and attendance, lacking taking advantage of in-depth analytics, while IT teachers receive limited targeted support. Access to advanced platforms and technical assistance is inconsistent, and fragmented systems hinder data integration across tools. Teachers' ability to interpret analytics varies, as professional training focuses more on general digital skills than pedagogical use of LA. Data protection and consent practices are inconsistent, with GDPR compliance sometimes treated formally rather than ethically. Moreover, LA development depends heavily on short-term, project-based funding, risking limited sustainability, while collected data are not yet fully exploited to shape education policy or long-term strategic planning.

Lithuania has strong opportunities to expand and systematise LA across education. A centralised data environment linking platforms such as TAMO, Eduten, LearnLab, and Google Classroom could ensure consistent analysis through unified standards and generate automated, visualised insights with personalised recommendations. Strengthening teacher competencies through targeted training, teacher networks, and classroom-based project labs would enhance practical skills in using LA across the country. Students could benefit from tailored feedback, gamified tools,

and reflective activities like e-portfolios, promoting self-regulated learning and motivation. Broader partnerships with universities, EdTech developers, and international collaborators such as Finland, Norway, and UNESCO would foster innovation transfer and localised adaptation. Embedding LA within national digital transformation strategies and securing long-term funding would ensure continuity, extend support for LA implementation, and establish a sustainable, data-driven learning ecosystem.

LA in Lithuania faces several external and systemic threats that may hinder its sustainable development. Uneven implementation across schools and reliance on short-term, project-based funding create disparities and uncertainty in continuity. Fragmented platforms, limited integration, and insufficient technical support complicate data use, while dependence on specific technology providers increases long-term cost and accessibility risks. Unequal teacher competences and occasional resistance to change can slow adoption, especially where confidence in interpreting data is low or workloads are a concern. Inconsistent consent procedures and formalised GDPR compliance pose ethical and legal risks, alongside potential data misuse without clear transparency mechanisms. At the strategic level, data are not always fully utilised in policymaking, and an excessive focus on quantitative metrics such as test scores can overlook broader educational values. Shifting policies, tightening privacy regulations, stakeholder scepticism, and funding cuts could undermine LA integration and its impact on educational improvement.

Portugal

Portugal has wide access to platforms with built-in analytics and a strong research base in higher education that supports theoretical knowledge of LA. LA is well aligned with national digital priorities and diagnostic frameworks, supported by dedicated funding streams that encourage innovation. Established ethical review processes ensure data use remains transparent, responsible, and student-centred, building trust among stakeholders and enabling policy coherence.

Despite progress, teacher readiness and school capacity for LA remain uneven, with few pedagogical models explicitly integrating analytics. Infrastructure limitations persist, especially outside major centres, and the gap between university-led pilots and classroom-level adoption prevents systematic scaling. Many teachers lack the time and support needed to use LA effectively.

LA can be integrated into PADDE monitoring to guide investment, track impact, and inform digital transformation policies. It can support personalised learning, embedding data-driven feedback into everyday teaching. Teacher-education curricula can mainstream LA competences, while research-practice partnerships can link schools, universities, and policymakers to test, evaluate, and refine scalable approaches.

GDPR and ethical concerns may result in cautious or inconsistent implementation, while public sensitivity to data use could foster mistrust if LA is associated with surveillance. Excessive focus on quantitative indicators risks overlooking qualitative dimensions such as collaboration. Misalignment between policy metrics and classroom realities may weaken teachers' engagement, and without sustained funding for scale-up may hinder LA implementation across Portugal.

Slovenia

Slovenia applies a pedagogy-first approach, viewing LA as a supportive tool enriched by qualitative insights and contextual understanding. LA helps teachers refine assessment criteria and gain a clear overview of student progress. Rubric-based grading, peer assessment, and proven tools such as LMS/MS Teams and the TECH8 tutoring system demonstrate practical success. Drawing on international models and prioritising transparency, Slovenia emphasises minimal data collection and student access to their own analytics through platforms such as AIPS, reinforcing trust and student agency.

Teachers remain insufficiently familiar with Moodle's LA functions and their pedagogical benefits, with limited training and institutional guidance. Effective LA use demands significant initial time investment and varies widely across institutions. Awareness of GDPR and consent procedures is inconsistent, often relying on generic consent and creating administrative barriers. This lack of systematic, school-level integration limits coherence and reduces the visibility of meaningful LA applications in practice.

Students can increasingly use their own LA data to strengthen self-regulated learning. Integrating AI-supported, explainable tools offers timely, personalised feedback while retaining transparency. Teacher collaboration and targeted teacher-training in metrics interpretation, ethics, and GDPR compliance could promote best practice. National strategies and guidelines would encourage wider adoption and standardisation. Centrally managed Moodle platforms could be further developed to widely promote LA. Clear standardised procedure establishment, privacy-by-design dashboards, and pilot projects can support shared good practices and further R&D into innovative, scalable LA models.

Legal and ethical risks—such as excessive data collection or weak consent—could undermine trust. Broader LA adoption may face resistance from parents wary of surveillance or data misuse. There is a danger of teachers over-relying on quantitative data at the expense of personal interaction, leading to over-standardisation and premature conclusions. Pressure to adopt "tech-first" administrative uses of analytics could distort pedagogical goals. In addition, AI algorithms remain unreliable and their use in grading is legally restricted, posing further challenges to responsible LA integration.

Spain

Spain benefits from strong digital infrastructure, with widespread use of Moodle and Canvas, providing solid foundations for LA. Faculty interest in LA is increasing, supported by motivated teachers eager to apply data in teaching. A collaborative community led by Dr. Amo has advanced classroom LA practices and shared knowledge through publications. Experience gained from European projects positions Spain well for continued innovation in evidence-based education.

LA integration into everyday teaching remains limited, with uneven adoption and occasional resistance to change among staff. Data quality issues and the perception of LA as distant hinder teacher engagement. Teachers need deeper digital and pedagogical competence (TPACK model) to interpret analytics effectively and balance data with contextual judgment. Insufficient training opportunities mean many rely on surface-level app feedback rather than analytical insight, reducing the potential pedagogical impact of LA.

Stronger collaboration among teachers can demonstrate the tangible benefits of LA and normalise its use across disciplines. AI can help interpret complex learning data, with Canvas offering tools for automated, deeper analysis. European initiatives supporting digital transformation and create a favourable environment for LA. Building networks between institutions can accelerate best-practice sharing, research partnerships, and sustainable, large-scale innovation in LA.

Privacy and surveillance concerns among students and parents could erode trust and hinder LA adoption. Educational technology may be applied superficially rather than to genuinely enhance learning. New practices might be viewed as extra workload or demand steep learning curves, while overly technical or isolated implementations risk reducing classroom impact. Potential funding cuts could disrupt ongoing projects and slow LA integration into mainstream practice.

Cross-Country Summary

Table 1 summarises the common strengths, weaknesses, opportunities, and threats (SWOT) shared by partner countries in implementing LA. It highlights recurring factors across national contexts and reveals collective trends in

pedagogical, technical, ethical, and policy dimensions of LA integration. This shared analysis supports joint priority setting, possible collaboration, and coordinated advancement of evidence-based educational practice.

Table 1: Shared Learning Analytics (LA) SWOT Analysis among Partner Countries

Strengths	Weaknesses
1. **Improved learning support**: LA supports formative assessment, immediate feedback, personalised and self-regulated learning, and timely support. 2. **Evidence-based decision-making**: LA enables continuous monitoring of learning, supporting data-driven decisions at classroom, institutional, and policy levels. 3. **Developed digital infrastructure**: Broad access to LMSs (e.g., Moodle, Canvas, Google Classroom) provides a solid foundation for efficient learning data collection and analysis. 4. **Motivated and skilled educators**: Teachers equipped with relevant competencies show openness to innovation and willingness to use data to enhance teaching and learning. 5. **Active research and collaboration networks**: Universities and professional networks engage in pilots and projects, sharing expertise and good practices that advance LA across Europe. 6. **Policy and institutional support**: National strategies, EU programmes, and alignment with European frameworks promote coherent and scalable LA implementation. 7. **Ethical awareness and transparency**: Many systems prioritise minimal and secure data collection, responsible use, and student access to their own analytics. 8. **Innovative use in informatics education** – LA enhances engagement through interactive, technology-driven tasks such as coding and algorithm exercises.	1. **Lack of systemic implementation:** Data are siloed across platforms, with no baseline use of LA, uneven access, and limited guidelines, reducing coherence and integration into practice. 2. **Limited digital infrastructure**: Dashboards offer few actionable insights, and legacy platforms lack flexibility to integrate adaptive testing and AI-based analytics, hindering LA advancement without major investment. 3. **Underuse and limited usability of data**: Many rely on basic data like grades and attendance, using analytics mainly for reporting, while anonymous, aggregated data hinder individual support and meaningful decision-making. 4. **Limited LA competence and training**: Many stakeholders, including teachers, policymakers, and developers, lack the technical, analytical, and pedagogical skills for effective LA implementation. 5. **Limited engagement and capacity:** Adoption depends on individual motivation and openness to change, while significant time and workload demands reduce teachers' confidence and consistent use of LA. 6. **Research-practice gap** – Limited dissemination of research outcomes and weak links between academic pilots and classroom practice hinder widespread LA adoption. 7. **Insufficient support**: Weak policy frameworks, scarce investment, and short-term project funding reduce sustainability and scalability of LA. 8. **Inconsistent data governance**: GDPR compliance, consent management, and ethical data practices vary widely, undermining trust and transparency.
Opportunities	**Threats**
1. **Centralised and user-friendly platforms:** Expanding national dashboards and existing LMSs such as Moodle with meaningful indicators enhances accessibility and impact. 2. **AI-driven personalisation:** Emerging AI and machine-learning tools enable adaptive feedback, automated data interpretation, and personalised learning pathways.	1. **Uneven infrastructure and access**: Disparities between urban and rural schools, fragmented digital systems, and differing resource levels hinder equitable LA implementation. 2. **Technological and AI reliability issues**: Rapid obsolescence of tools, technical limitations, and unreliable algorithms, especially in grading, pose challenges to responsible use.

3. **Evidence-based policy and monitoring:** Integrating LA into institutional and national strategies improves policy evaluation, investment decisions, and continuous improvement. 4. **Student empowerment:** Student access to their own data supports motivation, reflection, self-regulated learning, and ownership of learning progress. 5. **Professional development:** Targeted training and peer learning can build LA competences in data-informed teaching and decision-making. 6. **Cross-sector collaboration:** Partnerships among schools, universities, research institutions, ministries, EdTech providers, and international partners strengthen research-practice links and facilitate knowledge transfer. 7. **Scalable pilot projects:** Pilot initiatives enable controlled testing of approaches that can later be adapted across contexts to build sustainable LA ecosystems. 8. **Supportive policies and guidelines:** Policies, strategies, and frameworks encourage wider, equitable, and sustainable adoption and standardisation across education sectors. 9. **EU and international funding support:** European initiatives, structural funds, and programmes such as Erasmus+ and DIGITAL EU reinforce innovation, pilot projects, and large-scale LA implementation. 10. **Integration into informatics education:** Embedding LA in coding and career-oriented tasks, such as Excel-based projects, can meaningfully enhance informatics learning.	3. **Over-reliance and misinterpretation of data** – Excessive focus on quantitative metrics and limited data literacy or governance can distort policymaking and overlook qualitative, socio-emotional aspects of learning. 4. **Teacher resistance and burnout**: Heavy workload, digital fatigue, limited support, and competing demands can reduce teacher motivation to adopt LA and weaken its classroom impact. 5. **Fragmented research-practice link**: Weak translation of academic findings into classroom application diminishes evidence-based innovation and sustained improvement. 6. **Policy and bureaucratic barriers**: Rigid administrative structures, political changes, and policy misalignment with classroom realities can delay or disrupt implementation. 7. **Financial instability and short-term funding**: Dependence on project-based or EU funding and potential budget cuts threaten continuity and scalability. 8. **Privacy and ethical risks**: Strict data protection regulations, GDPR compliance issues, and fears of surveillance and data misuse may erode trust among teachers, students, and parents.

Overall, the cross-country SWOT analysis shows that partner countries share a solid foundation for advancing LA through established digital systems, motivated educators, and supportive policies. Yet common challenges—limited training, uneven adoption, and ethical or data protection issues—call for coordinated action. Harnessing shared opportunities in AI-driven personalisation, collaboration, and evidence-based policymaking can help address these gaps. By strengthening transparency, capacity building, and sustainable integration, partner countries can enhance LA's role in supporting equitable, data-informed, and learner-centred education across Europe.

5.7 Future Directions

This section gathers interviewee perspectives on what is needed to advance the use of LA in informatics education over the next five years. It examines the key actions, policies, resources, and cultural shifts required to embed LA more deeply and effectively within educational practice, providing recommendations for stakeholders at all levels.

Bulgaria

Both interviewees emphasised the urgent need for Bulgaria to develop comprehensive national guidelines and frameworks to ensure the consistent, ethical, and responsible use of LA in informatics. They called for the establishment of interoperable data systems and the implementation of pilot projects to test scalable models. Over the next five years, Bulgaria should focus on integrating LA into teacher training programmes and strengthening the connection between school-level data and policy-level decision-making to promote more effective and responsible adoption of LA practices.

Croatia

All interviewees agree that expanding LA in Croatia requires stronger policy support, better teacher training, and a change of teacher mindset across education levels. LA should not only improve efficiency but also help teachers personalise learning to meet diverse student needs. Higher education and adult learning, with greater institutional autonomy, offer significant potential, while secondary schools, especially gymnasiums, are more immediately accessible due to curriculum standardisation. Developing AI-supported systems that reduce administrative workload and meaningful data interpretation to enhance pedagogical insights is a key goal. Greater cooperation among the state, schools, teachers, and parents, along with increased transparency of national data, is essential to build trust and encourage broader adoption. Ultimately, LA should support lifelong learning by fostering teacher mindset shifts and engaging professional development that motivates educators to innovate.

Cyprus

In Cyprus, fostering greater cooperation between schools, projects, and technology providers is seen as essential for making LA practical and widely adopted. However, without supportive policies from global regulators, LA's potential will remain limited. Sustainable progress requires continuous investment in infrastructure and the development of user-friendly tools tailored to educators' needs. Additionally, ongoing training and professional development for teachers and instructional designers are crucial to enhance their knowledge and skills for LA development and implementation. Strengthening these areas will help embed LA into everyday practice and support its long-term integration within education.

Finland

Interviewees are optimistic about LA's future, noting that technological barriers are largely overcome. Key challenges now include ensuring data access, developing a strong theoretical foundation, and supporting sustainable investment. Progress depends not only on innovation but also on establishing ethical, infrastructural, and conceptual frameworks to enable responsible and scalable LA use. One interviewee stressed that broader, ethical data access and expertise are essential for research and innovation, while another predicted that AI and personalised pathways will dominate the next five years—pending sustained funding and clearer educational models, as informatics is still in its early stages. A third noted that the necessary infrastructure exists, but resource constraints, partly due to Finland's small market, limit large-scale development. Overall, the system is ready for growth but needs better governance, theoretical clarity, and investment to achieve equitable, meaningful LA integration.

Greece

Greece's strategic focus should include developing a national framework to support pedagogical LA, investing in teacher training, and fostering stronger cross-sector cooperation among policymakers, researchers, and schools to embed LA into daily practice. While infrastructure and digital policies are in place, realising the full potential of LA depends on providing user-friendly dashboards that offer actionable insights, as well as ongoing professional development to help teachers leverage LA pedagogically. Future efforts should integrate LA more closely with programming tools and strengthen the connection between classroom LA and system-level data, ensuring national data informs everyday teaching. Despite Greece's strong research and innovation capacity, there remains a gap

between pilot projects and large-scale implementation. Priority areas include establishing a coherent strategy to bridge research and practice, as well as creating infrastructure for data sharing that respects privacy. Embedding AI and emerging technologies into classroom practice, beyond pilots, is vital to support meaningful and active classroom use of LA.

Italy

To advance LA over the next five years, efforts should focus on validating and supporting diverse, teacher-led forms of LA, such as observation, as valuable pedagogical tools. Strengthening data literacy among teachers is paramount, enabling them to effectively use learning evidence to foster students' critical thinking and problem-solving skills. The goal should be to develop simple, ethical, and context-sensitive frameworks that empower teachers to act on evidence without the need for expensive tools or deep technical expertise; projects like DIGITAL FIRST offer promising models for future implementation. Further, efforts should aim to standardise and centralise existing technical data from lab and simulation tools into easy-to-use dashboards that provide actionable pedagogical insights—such as understanding why students struggle based on specific error patterns. Emphasis must shift from reliance on costly new tools to maximising the diagnostic potential of data already generated. The immediate priority is to expand basic data literacy training for teachers nationwide, ensuring LA supports curriculum validation and student learning outcomes, rather than merely measuring failure rates.

Lithuania

Lithuania's vision for advancing LA focuses on comprehensive policy, technological integration, teacher training, stakeholder involvement, and ethical and privacy measures. Expanding the National LA Strategy to include computer science, the country aims to establish sustainable funding and develop an integrated platform that pools data across all educational levels for use by schools, researchers, and policymakers.

Technologically, Lithuania plans to connect existing systems—such as TAMO, Google Classroom, Eduten, and Moodle—into a unified data ecosystem, supported by advanced analytics tools that offer automatic personalised recommendations and visualisations. Standardising data collection will ensure quality and comparability across all schools.

Teacher training will focus on developing skills in data interpretation and pedagogical decision-making, supported by ongoing mentoring and practical labs. For students, LA will promote self-management, with personalised recommendations, gamification and visualization tools to motivate and foster reflection and self-assessment. International partnerships with countries with advanced experience in AI, like Finland, Norway, and Estonia, are also a priority, alongside collaborations with EdTech developers and universities for joint research.

Finally, Lithuania underscores the importance of ethics and privacy: establishing a clear consent system, strengthening ethical guidelines, and actively involving communities to build trust and ensure responsible, socially equitable LA use.

Portugal

Portugal's forward-looking strategy emphasises embedding LA, data literacy, and ethical training into teacher certification and continuous professional development to build capacity across the teaching workforce. Developing simple, teacher-centred dashboards that translate analytics into actionable pedagogical steps at the classroom, school, and municipality levels is a key priority. Pilot projects in programming and informatics classes—particularly code-trace analytics—aim to be implemented with strong ethical safeguards and clear consent procedures as well as operational guidance provided to schools on responsible LA use. Collaboration between schools and universities is encouraged to evaluate tools and co-design participatory LA solutions involving teachers and learners.

Slovenia

A top priority for the next five years starts with broad debate and awareness-raising regarding LA among teachers and stakeholders. The next steps involve adopting policies, strategies, and guidelines, followed by establishing technical standards for data collection and processing. Teacher training in didactics and meaningful LA use is also essential throughout this process. LA should support, not replace, pedagogy. Progress begins with clear pedagogical goals and well-defined metrics, as well as policies on data retention, consent, and transparency, for instance, student dashboards allowing access and opt-out options. Small-scale pilots combining quantitative data with surveys and reflections should be overseen by an ethics committee to ensure ethical standards and data protection, with boundaries set to prevent misuse. Only after demonstrating meaningful, ethical results should LA expand across more courses, with open reporting on outcomes. All activities should follow a "small data" approach, focused on clear purposes and student choice. The expert views this as.

Spain

Advancing LA requires a fundamental rethinking of assessment, viewing analytics as tools for support, improvement, and early detection. This shift necessitates developing accredited digital competences and embedding LA within daily classroom practice, grounded in reflection and pedagogical purpose. Key priorities include comprehensive teacher training and curricular integration of analytics, alongside clear policies on ethics and privacy. Making LA more accessible to students—allowing them to benefit directly from their data—should also be a focus. Only through sustained effort in training, policy clarity, and pedagogical alignment can LA realise its full potential in Spain.

Cross-Country Summary

Across the countries, advancing LA relies on strategic policy, strong infrastructure, teacher training, and stakeholder collaboration. Many stress the need for clear policies and frameworks—national or institutional—to support responsible, ethical, and scalable LA. Developing simple, user-friendly dashboards for teachers is crucial, enabling pedagogical use beyond mere monitoring.

Teacher training is a key focus, with calls for comprehensive courses in data literacy, pedagogy, and ethics. Embedding LA into curricula, professional development, and initial teacher training is vital for sustainability. Several countries also highlight the importance of cross-sector collaboration—between schools, universities, research bodies, and tech developers—to co-design solutions aligned with pedagogical goals.

Most strategies emphasise ethics, privacy, transparent consent, and community involvement to build trust. Progress in Finland and Lithuania shows movement toward integrated platforms and national strategies, while Greece and Slovenia stress the need for policies and pilot projects before wider adoption. Ultimately, success depends on aligning innovation with governance, stakeholder engagement, and maintaining equity and ethics as LA becomes more embedded.

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6 Conclusion

This deliverable has provided a comprehensive overview of the current state of LA theories, policies, and practices for informatics across participating European partner countries. By bringing together evidence from literature, policy documents, project reports, and institutional initiatives, it offers an integrated picture of how LA is evolving within the national education systems and how ethical, technical, and organisational factors interact in shaping its adoption. By combining insights from the grey literature review and interviews with teachers, institution leaders, researchers, and policymakers, this report provides a multi-layered understanding of how LA is currently understood and used across Europe.

One of the most significant findings from the grey literature review is the growing convergence around a shared vision of Learning Analytics as an enabler of educational quality and system-wide improvement. Across Europe, LA is increasingly viewed not merely as a technological tool but as a strategic mechanism that helps students, teachers, institutions, and policymakers act on accurate and ethically managed data. The reviewed frameworks reveal deep alignment with international and national education priorities, linking analytics to pedagogical theory, digital transformation, and data ethics. Common trends include coordinated policy support, capacity building, and the integration of interoperable, open-standard tools within secure infrastructures. Although levels of maturity vary, the collective direction is clear: European education systems are moving from fragmented pilots toward sustained, data-informed practice—establishing LA as both a driver of innovation and a foundation for transparent, equitable, and evidence-based education.

At the same time, interviews with experts reveal an evolving but uneven landscape of LA implementation across Europe. While some countries have established mature, research-driven ecosystems with strong ethical and technical frameworks, others remain in pilot or early adoption stages, often limited by fragmented policies and variable infrastructure. Across contexts, success depends on coherent strategies, sustainable support, and the meaningful engagement of teachers, researchers, and students in using data to inform learning and decision-making. Experts consistently highlight the need for teacher training, data literacy, and clear ethical governance as foundations for responsible practice. Overall, the interviews depict systems transitioning from experimentation toward structured integration, where collaboration, capacity-building, and transparent policy frameworks will be critical to realising LA's potential for equitable, evidence-based, and learner-centred education across Europe.

Together, these findings underline the central role of Work Package 7 within the *Digital First* project. They confirm that achieving meaningful and ethical adoption of LA requires an approach that is simultaneously technologically sound, pedagogically aligned, and institutionally sustainable.

Looking ahead, the insights presented in this deliverable lay a strong foundation for the next stages of WP7. They will inform Deliverables 7.2–7.4, guiding the development of a practical, evidence-based guidebook to help teachers, schools, and education authorities introduce and scale Learning Analytics for informatics education in ways that are secure, ethical, and future-ready.

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8 Annexes

8.1 Annex 1 – Grey Literature Review Guidelines

Identify at least three documents. For each selected document, please provide a structured summary (approximately 1–2 pages per reviewed document) addressing the following key aspects:

1. **Background Information**
    - Title of the document
    - Author(s) or institution
    - National and regional context
    - Educational level(s) involved (e.g., primary, lower secondary, upper secondary, vocational, higher education)

2. **Purpose of Using Learning Analytics (LA)**
    - The main objectives or goals for applying LA in the context described

3. **Guiding Frameworks**
    - Relevant policy, theoretical, pedagogical, or strategic frameworks informing the use of LA (if available)

4. **Implementation and Use**
    - How LA was applied in practice
    - Stakeholders involved (e.g., teachers, students, researchers, policymakers)
    - Infrastructure and technological requirements
    - Tools or platforms used (e.g., dashboards, learning management systems, custom analytics tools)
    - Types of data collected (e.g., performance data, activity logs, feedback systems, predictive analytics)
    - Methods of data collection and analysis

5. **Outcomes and Insights**
    - Reported effects or impacts of LA on teaching, learning, or policy
    - Key lessons learned or recommendations
    - Broader educational or institutional implications

6. **Ethical Considerations**
    - Any identified ethical issues (e.g., data privacy, consent, algorithmic bias)

7. **Sustainability and Scalability**
    - Current status (e.g., pilot, scaled implementation, discontinued)
    - Potential for transferability or scaling to other contexts

8. **Documentation**
    - A working link to the reviewed document (if publicly available)

8.2 Annex 2 – Interview Questions

Background and Role

1. Could you briefly describe your current role and responsibilities?
    - What is your professional background?
    - How long have you worked in this role?

2. How does your work relate to informatics education?
    - Are you involved in curriculum design, teaching, training, assessment, or research?
    - What age group or educational level do you primarily work with (e.g. primary, lower secondary, upper secondary, vocational, higher education)

3. What experience do you have with learning analytics (LA)?
    - Have you worked directly with learning analytics tools, data, or systems?
    - Are you involved in designing, implementing, interpreting, or evaluating LA in any way?

4. In your opinion, how important is learning analytics in informatics education? Has this changed over time?

Use of Learning Analytics in Informatics

5. How is LA currently used in informatics education at your institution or in your country?
    - Have you observed or been involved in the use of LA in teaching or program development?
    - What types of data are typically collected (e.g., learning management system (LMS) interaction data, assessments, code submissions, attendance, self-reports)?

6. What are the main purposes for using LA in your context?
    - Is it used to monitor student progress or identify at-risk students?
    - Is it aimed at improving teaching quality, curriculum development, or supporting institutional reporting?

7. What tools or platforms are used for LA, and how is student consent for data use handled?
    - Can you name specific tools or systems used (e.g. LMS features, dashboards, custom tools)?
    - Is student consent collected (e.g., for all data, only for specific projects, or not at all)?

Guiding Frameworks

8. Are there policy, theoretical or pedagogical frameworks guiding the use of LA? How?

Stakeholder Engagement

9. How are teachers, students, researchers, policymakers and other stakeholders involved in designing, using, or interpreting LA?

10. What kind of training or support is available for teachers using LA tools?

Institutional/National Context

11. Are there any national or institutional policies, strategies, or funding programmes that support LA in informatics?

12. Are there notable national projects or initiatives related to this area?

SWOT Analysis

13. Strengths

- What are the key strengths of how LA is currently being used in informatics education in your context?
- Are there any practices, resources, or partnerships that are working particularly well?

14. Weaknesses

- What are the current limitations or shortcomings in the use of LA for informatics education?
- Are there gaps in data, tools, skills, or teacher readiness?

15. Opportunities

- What opportunities do you see for improving or expanding the use of learning LA in informatics education (e.g. policy support, technology trends, collaboration)?
- Are there emerging practices or innovations you find promising?

16. Threats

- What risks or barriers might hinder the effective use of LA in informatics education (e.g. ethical concerns, lack of buy-in, data privacy regulations)?
- Are there external pressures (e.g. ethics, privacy, stakeholder resistance, policy changes, funding cuts) that could affect LA implementation?

Future Directions

17. In your view, what is needed to advance the use of LA in informatics education in the next 5 years?

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