L2 - Learning Environments

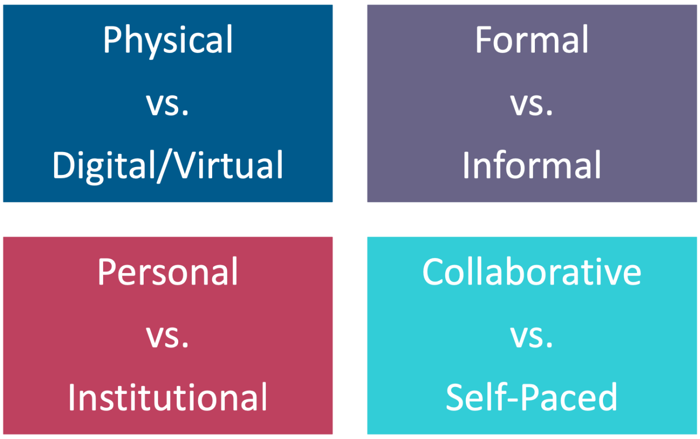
Lecture 2 - Learning Environments

Learning Goals

- Define what a learning environment is and describe its key components.
- Differentiate between various types of learning environments (LMS, VLE, PLE, SLE).
- Explain how technology supports and shapes modern learning environments.
- Identify core features and functions of Learning Management Systems (LMS).
- Describe the origins, structure, and challenges of Massive Open Online Courses (MOOCs).
- Discuss the concept and significance of Open Educational Resources (OER) and their licensing.
- Compare formal, informal, and personalized learning contexts.
- Evaluate advantages and limitations of digital learning environments for learners and educators.
- Apply the discussed concepts by designing a learning scenario integrating LMS, MOOCs, or OER.

Learning Environment

- **Abstract** term for anything you are learning in



- Components: **Learner characteristics**, **content**, **skills**, **assessments**, **ressources**, **learner support**

Learning Management Systems

- Software to “manage” institutional learning, includes learning **material**, **user-management, communication, analytics, assessments**
- Often comes with **video-based learning**

- Often allows a **flipped classroom** or **blended learning** approach
- Examples would be Moodle

VLE, PLE and SLE

- **Virtual Learning Environment:** Virtual space designed to **support learning** by replicating key functions virtually
  - All LMS are part of a VLE, but not all VLE are limited to LMS functionality
- **Personal Learning Environment:** System or collection of tools that individuals use to manage their own learning (e.g Youtube, OneNote, Discord;...)
- **Smart Learning Environment:** Uses adaptive, context aware, data driven, ai technology to enhance learning experience

Massive Open Online Courses

- History:
  - cMOOC (connectivist MOOC) 2008: networked learning, self-organize their participation
  - xMOOC (extension MOOC) 2011: every learner works on materials on their own, offer communication, but not focus
- “Year of MOOC 2012: Online Course for
  - thousands of users
  - open access and free
  - self scheduled learning and
  - community interaction (e.g. udemy, edX)
- MOOC hype according to gartner hype cycle 2012, from 2018 mainstream plateau
- **Challenges**:
  - Certification
  - Analytics
  - Plagiarism
  - Role of Teacher
  - Feedback
- **Trends**: Integration of MOOC in blended university courses, short, skill-based, analytics, multilingual, lifelong, professional learning, AI

Open Educational Resources (OER)

- **Any type of educational materials** with an open license, anyone can legally and freely copy, use, adapt and re-share them.
- Can be: Lecture Slides, Quizzes, Source Codes, Lecture Recordings
- Creating: Everything can be an OER, as long **ownership** is clear and **references** are proper
  - **Creative Commons**: “Some rights reserved” instead of “all rights reserved”
- **Platforms**: MIT OpenCourseWare., Filters in Google or Youtube

- **Challenges**:
    - No policies
    - hard to find
    - often low quality
    - uncertainty about licences
    - lack of sharing culture

L3 - Theoretical Foundations of Learning

Lecture 3 - Theoretical Foundations of Learning

Learning Goals

- define what learning is and differentiate between human and machine learning.
- explain the purpose of learning theories and how they help in designing learning environments.
- describe key principles and representatives of major learning theories:
  - Behaviorism (Pavlov, Thorndike, Skinner)
  - Cognitivism (Piaget, Bruner)
  - Constructivism and Constructionism (Piaget, Papert)
  - Connectivism (Siemens, Downes).
- compare how different theories conceptualize the learning process (stimulus–response, information processing, knowledge construction, connection-making).
- analyze how each theory influences instructional design and the role of the learner and teacher.
- identify strengths, limitations, and criticism of the connectivist perspective.
- apply theoretical insights to evaluate or design simple learning scenarios and digital learning environments.

Learning

- Gain knowledge, skill, or understanding of sth. by [study, instruction, or experience] ([...] increasing quality)
- **Human Learning: biological**, **cognitive** process, acquiring knowledge, skills, attitudes, or behaviors through **experience**, study, or teaching.
  - Characteristics: Active, cumulative, transformational (us), lifelong
- **Machine Learning:** computational process, systems learn patterns or rules from data without being explicitly programmed

Behaviorism

Focuses exclusively on observable behaviors resulting from external stimuli. It treats internal mental processes as an unobservable "black box." The learner is seen as a passive recipient whose behavior is shaped by reinforcement.

- **Classical Conditioning (Ivan Pavlov):** Learning through association, where a neutral stimulus (e.g., a bell) becomes associated with a meaningful one (e.g., food) to elicit a conditioned response (salivation).

- **Connectionism Theory (Edward Thorndike):** Learning occurs through trial-and-error, where connections between stimuli and responses are strengthened by reinforcement (Law of Effect).
- **Operant Conditioning (B.F. Skinner):** Behavior is controlled by its **consequences**, using positive/negative reinforcement to encourage behavior and positive/negative punishment to discourage it.
- **Application:** Programmed Instruction and Skinner's "Teaching Machine," which break down content into small, self-paced steps with immediate feedback, serve as precursors to modern computer-based training.

Cognitivism

Shifted focus from external behavior to internal mental processes, opening the "black box." It views the human mind as an information processor, analogous to a computer, which takes in, transforms, stores, and retrieves information.

- **Schema Theory (Jean Piaget):** Knowledge is organized into mental frameworks or "schemas" that learners use to interpret new information. Learning involves aligning new experiences with existing schemas (assimilation) or modifying schemas to fit new information (accommodation).
- **Scaffolding (Jerome Bruner):** A teaching method where structured support is provided to help learners accomplish tasks they cannot complete independently. This support is gradually removed as the learner's competence grows.
- **Application:** Cognitivism underpins learner-centered design, which considers learners' prior knowledge and cognitive processes. Teacher is more a facilitator. It also led to the development of Adaptive Learning (asking questions) which led to Intelligent Tutoring Systems (ITS).

Constructivism

Active process of constructing knowledge rather than passively acquiring it. Knowledge is seen as subjective and shaped by personal experiences and social interactions. There is no single objective reality; learners build their own unique understanding of the world.

- **Schema Development (Piaget)**: Learners use prior schemas (mental frameworks) to process and organize new knowledge.
- **Social Constructivism (Lev Vygotsky):** Emphasizes that learning is fundamentally a social process, occurring through interaction with others in a cultural context.
- **Role of the Teacher:** The teacher acts as a coach, facilitator, and designer of the learning environment, providing challenging, authentic, and situated problem contexts.
- **Application:** Situated learning, where knowledge is embedded in the context of its application; collaborative problem-solving; and project-based learning.

Constructionism

Is a derivative of constructivism that emphasizes that learners construct knowledge most effectively when they are engaged in building personally meaningful, shareable artifacts (products), a concept summarized as "learning by making."

- **Key Principles (Papert):** Learning through doing, collaboration, the use of technology as an enabler, and an iterative process where mistakes are part of learning.
- **Application:** Maker spaces, STEM programs, and tools like LEGO Mindstorms and the Scratch programming language.

Connectivism

Is framed as a learning theory for the digital age. It posits that knowledge is distributed across networks of people and technology, and learning is the process of creating, navigating, and maintaining these connections.

- **Core Idea (Siemens, Downes):** The ability to find and apply knowledge is more important than retaining it.
- **Application:** MOOCs, professional networks like LinkedIn, and personal learning journeys that leverage blogs, forums, and social media.
- **Criticism:** Connectivism has been criticized for lacking strong theoretical grounding, repackaging existing theories, overemphasis on technology.

Summary

Feature	Behaviorism	Cognitivism	Constructivism	Connectivism
View of Learning	Change in observable behavior	Information processing, change in mental structures	Active construction of subjective knowledge	Building and navigating networks of information
Learning Process	Stimulus-response, reinforcement	Encoding, storage, retrieval of information	Building on prior knowledge through experience and social interaction	Making connections between nodes (people, ideas, tech)

Role of Learner	Passive respondent to stimuli	Active processor of information	Active participant in knowledge construction	Active node in a learning network, knowledge creator
Role of Teacher	Dispenser of knowledge, controller of stimuli	Facilitator, structures information for processing	Coach, co-creator, designer of learning experiences	Facilitator, network guide
Key Proponents	Pavlov, Thorndike, Skinner	Piaget, Bruner	Piaget, Vygotsky	Siemens, Downes

L4-Introduction to Learning Analytics

Lecture 4 - Learning Analytics (LA)

Learning Goals

- define the term Learning Analytics (LA) and distinguish it from related fields.
- summarize the historical development and key milestones of the LA field (e.g., LAK, SoLAR, LASI) and identify its interdisciplinary roots.
- explain the main goals and perspectives of Learning Analytics (improving, learning, supporting teaching, enhancing decision-making, etc.).
- differentiate between the areas of Learning Analytics and illustrate their specific use cases.
- describe and interpret the steps of the Learning Analytics Process using reference model and LA cycle.
- identify and explain typical methods and techniques used in Learning Analytics.
- analyze the “What, Who, Why, and How” dimensions of the LA reference model and relate them to practical educational scenarios.
- evaluate current challenges of Learning Analytics (e.g., data quality, ethics, interpretability, organizational barriers, sustainability) and propose strategies to address them.
- reflect on the ethical and pedagogical implications of using analytics in educational contexts and formulate principles for responsible LA practice.

Definition of Learning Analytics

- **Learning Analytics (LA):** Is the **measurement**, **collection**, **analysis**, and **reporting** of data about learners and their contexts,
- **Purpose:** Understanding and optimizing learning and the environments in which it occurs.
  → Tries to **operationalize learning theories** by providing methods to answer key questions about the learning process.

History of LA

- Since ‘83: Workshops on intelligent **tutoring systems**
- 2008-2009: First conference, then first journal on **Educational Data Mining** (EDM)
- 2011: Society of Learning Analytics Research (SoLAR), organizing
  - 2011: First conference on Learning Analytics and Knowledge (LAK)
  - 2013: LA Summer institutes (LASI)
- 2014: Journal for LA
- 2024: LA in practice online events

Related Fields:

- Web analytics
- Business Intelligence/Analytics
- Recommender Systems
- Action Research
- Information Visualization

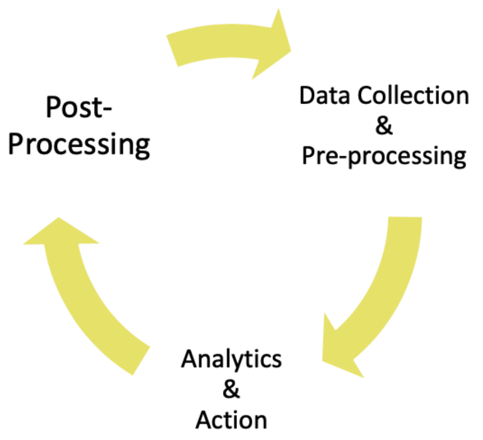
Goal of LA

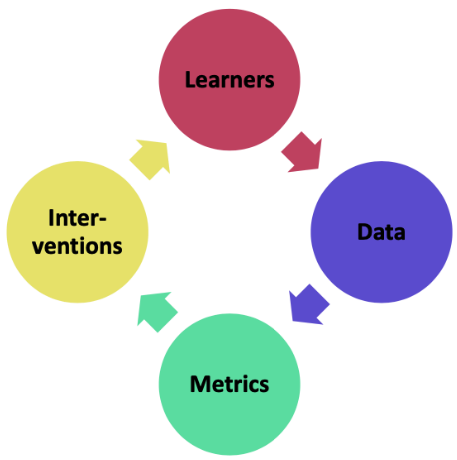
- Improve Learning outcome and make process more informed, effective, and personalized; depended on which perspective
  supporting student, teacher, institution, LE, research

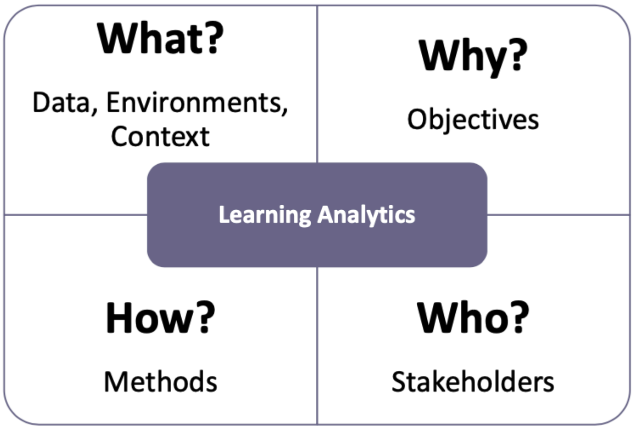
Areas of LA

- **Learning Analytics:** Focus on the learner and data which can be captured from him
- **Academic Analytics:** Application of business intelligence tools and practices in higher education
- **Teaching** Analytics: Focus on teacher and data which can be captured from him
- **Curriculum Analytics:** Focus on curriculum data and decision making
- **Game Learning Analytics:** Focussing on data from educational/serious games or game-based learning
- **Social Learning Analytics:** Focus on social dimensions of learning, particularly how learners interact, collaborate

Learning Analytics Models







- **what**: data type (activity, context data, …)), data source (LMS, user-generated, …)
- **who**: Institutions, teacher, students, researcher
- **why**: Monitoring, prediction, adaption, reflection, assessment
- **how**: statistical analysis, data mining, process mining, visualization. network analysis

Challenges of LA

- Data Quality and Integration
- Privacy, Ethics, and Governance
- Interpretability and Actionability of Insights
- Scalability and Real-Time Processing, Maintenance
- Organizational and Cultural Barriers
- Validity, Reliability and Bias
- Sustainability and ROI

L5 - LA Methods

Lecture 5 - LA Methods

Learning Goals

- Differentiate between the four types of analytics (descriptive, diagnostic, predictive, prescriptive) used in learning analytics.
- Explain the purpose and typical questions addressed by each type of analytics.
- Identify appropriate analytical techniques for different learning scenarios.
- Apply simple descriptive and diagnostic methods (e.g., correlations, clustering) to example datasets.
- Evaluate how predictive and prescriptive approaches can inform educational decisions and interventions.
- Reflect on ethical and practical limitations of applying these methods in educational contexts.

The Four Tiers of Analytics

Analytics Type	Core Question	Description	Common Techniques
Descriptive	What happened?	Summarizes past data to provide an overview of learning behaviors, activity patterns, and outcomes.	Descriptive statistics, data visualization, clustering
Diagnostic	Why did it happen?	Looks for cause-and-effect relationships to explain observed trends, identify outliers, and uncover patterns.	Correlation analysis, comparative analysis (e.g., t-tests), Principal Component Analysis (PCA)
Predictive	What will happen?	Uses statistical models and machine learning to forecast potential future outcomes, such as performance or dropout risk.	Predictive modeling, ML, classification, regression

Prescriptive	What should be done?	Recommends specific actions or interventions based on predictions to achieve desired outcomes.	Rule-based systems, recommender systems, optimization algorithms, simulations

Examples in Education

- **Descriptive Example:** An instructor uses a dashboard to visualize student logins, quiz scores, and forum posts per week.
  Clustering algorithms identify distinct groups of learners: "High-Engagers" with frequent activity and high scores, and "Low-Engagers" with minimal activity and poor scores.
- **Diagnostic Example:** To understand why "High-Engagers" perform better, the instructor runs a correlation analysis and finds a strong positive correlation between time spent on the platform and final exam scores.
  A comparative analysis (t-test) shows that students who received weekly feedback performed significantly better than those who did not.
- **Predictive Example:** A university implements a system like Purdue's Course Signals. Using historical data on performance and current data on LMS engagement, a classification model predicts which students are "at-risk" of failing.
- **Prescriptive Example:** Based on a prediction that a student is struggling with a specific concept, a recommender system suggests remedial videos and practice quizzes.
  A rule-based system automatically assigns the student to a peer-tutoring group if their quiz scores remain below a certain threshold for two consecutive weeks.

L6 - LA Infrastructure and Data

Lecture 6 - LA Infrastructure and Data

Learning Goals

- explain the role of infrastructure in learning analytics, including why scalability, interoperability, and data governance matter.
- differentiate between key types of learning data (contextual, self-reported, activity, social, performance, physiological) and assess their strengths and limitations.
- distinguish data formats (CSV, JSON, XML, multimedia) from data models (xAPI, Caliper, CAM, LTI, SCORM) and describe their purposes.
- outline the components of typical LA architectures, including databases, data warehouses, ETL pipelines, and LRS systems.
- interpret the structure and function of xAPI statements and explain how LRSs enable cross-platform data collection.
- describe multimodal learning analytics and the main data fusion levels (data-, feature-, decision- level; hybrid) and identify typical challenges in multimodal data integration.

Why Infrastructure Matters

- **Scalability**: Support large institutions with a high number of users and vast amounts of data.
- **Interoperability**: Integration of multiple systems such as Learning Management Systems (LMS), Content Management Systems (CMS), and E-Assessment platforms.
- **Automation and Real-Time Analytics:** Creation of data streams and analysis pipelines, moving beyond retrospective reporting to real-time feedback.
- **Sustainability and Data Governance:** It provides a stable, manageable foundation for long-term LA initiatives and is critical for implementing and enforcing data governance policies

Evolution of LA Infrastructure

1. **Raw log data** and manuel reports, everything retrospective
2. **Institutionalization:** With business intelligence tools, Extract-Transform-Load (ETF) pipelines, institution-wide governance discussions
3. **Defining standards for interoperability:** Experience API (xAPI) *('language')*, Learning Record Stores (LRS) *('storage')*, federated data models
4. **Real time ecosystems:** Microservices, AI, ML, privacy-preserving infrastructure
5. Future: Edge computing, Learner-controlled data, federated learning

Data Sources

- **Contextual Data:** External Factors (e.g. demographics, socioeconomic status, prior academics), often used with other variables together
- **Self-Reported Data:** Directly provided from learner, typically through surveys and questionnaires.
- **Activity Data:** Created through learner's interaction with educational technology (e.g. Log-data)
- **Social Interaction Data:** Interactions between learners and other actors (e.g., teachers).
- **Performance Data:** Data that measures how well learners can apply what they have learned. Performance data != assessment data.
- **Physiological Data:** Physiological responses, captured to gain a more holistic understanding of learning experiences (e.g. eye-tracking, EEG (brain activity)).

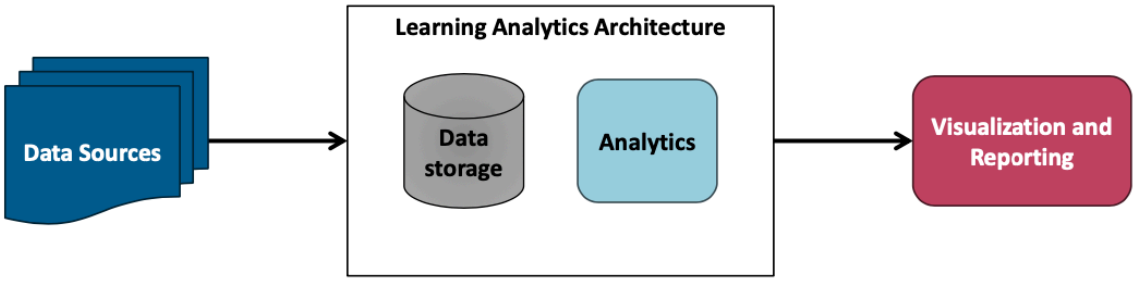
Data Formats and Models

	Data Format	**Data Model**
Focus	Physical representation	Logical structure and relationships
Scope	Serialization, transmission, storage	Design, organization, semantics
Examples	JSON, XML, CSV	Relational, Document, Graph
Use case	Interchange between systems	Database design, querying

Data Models for for LA

- **Contextualized Attention Metadata (CAM):** Model representing Action/Event based interaction with LE
- **Learning Context Data Model (LCDM):** Builds on CAM, more user-centric
- **Experience API (xAPI):** Specialized data format for tracking learning experiences; “subject - verb - object” statements
- **Learning Tools Interoperability (LTI)**
- **Sharable Content Object Reference Model (SCORM)**

Architectures for LA



Database vs. Data Warehouse

Feature	Database	Data Warehouse
Primary Function	Optimized for real-time transactional operations (CRUD).	A centralized repository that aggregates data from different sources for analysis.
Processing Type	Online Transaction Processing (OLTP) *("day to day")*	Online Analytical Processing (OLAP)
Centralization		Combines Data from different systems (ERP, databases, …)
Optimization	Supports many simultaneous users and quick access to individual records.	Optimized for read-heavy, complex analytical queries and aggregations for f.i. governance and reporting
Orientation	Tool oriented (System A, …)	Subject oriented (sales, …)
Data Structure	Typically normalized to ensure data integrity.	Often denormalized to improve query performance.

Time Variant	Stores current data.	Stores historical data over long periods to analyze trends.
Volatility	Data is frequently updated.	Data is non-volatile; once entered, it is rarely changed.

ETL-Pipeline

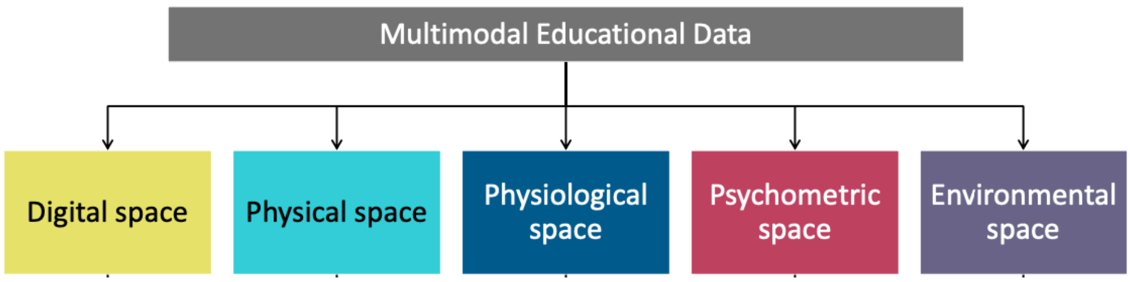
1. **Extract:** Data is collected from sources like LMS logs, assessment systems, APIs (xAPI, LTI), surveys, and sensors; dealing with varied formats, incomplete data, and differing timestamps.
2. **Transform:** Raw data is cleaned, standardized, and integrated to then map it to a standard data model (e.g., xAPI).
3. **Load:** The transformed data is loaded into its destination, which could be a data warehouse, LRS, or a data lake (for unstructured data).

LRS

- Server responsible for receiving, storing and providing access to Learning Records (Stores xAPI statements) (some analytics included, but not focus)

Multimodal Data and Data Fusion

- **Multimodal Learning Analytics (MLA):** Capturing, integrating, and analyzing different sources of educational data which together provide a holistic understanding of the learning process



e.g. User Logs Gestures Eye-tracking Surveys temperature

- **Data Fusion (DF) for LA:** Integrating data from multiple sources to produce more accurate output.
- Techniques of Data Fusion
    - **Data-level (Low-level) Fusion:** Combining raw data streams directly.
    - **Feature-level (Early) Fusion:** Features are extracted separately, then concatenated into a single feature vector before being fed into a classifier.
    - **Decision-level (Late) Fusion:** Each data source processed by own classifier, results then merged to produce a final, fused decision.
    - **Hybrid Fusion**: A combination of feature-level and decision-level fusion.

Challenges

- **Heterogeneity** in:
    - System (mainframe, flatfile, …)
    - Logic (schema, format, …)
    - Syntax (encoding, …)
    - Quality
    - Availability (synchronization, permanent/periodically)
    - Law
- **Complexity**

L7 - Information Visualization

Lecture 7 - Information Visualization

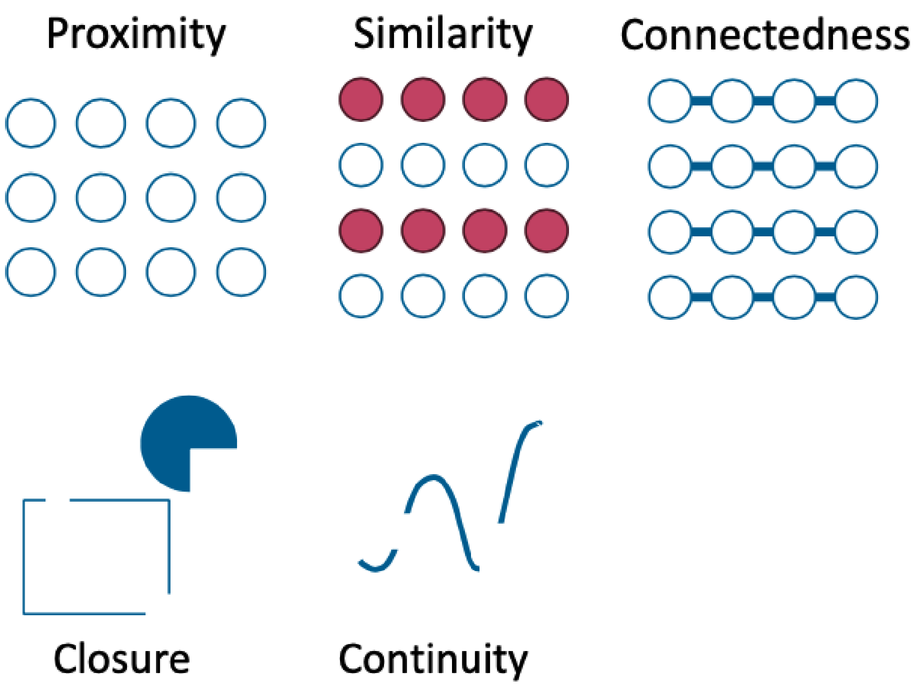
Learning goals

- Explain the fundamental role and objectives of information visualization in making data understandable and actionable
- Apply human perception principles to create visuals that reduce cognitive load and improve clarity
- Select and justify suitable visualization techniques based on data characteristics and communication goals
- Transform raw or complex datasets into visual representations that reveal patterns, trends, and insights
- Critically evaluate and design learning analytics dashboards that support reflection, decision-making, and user needs

Visualization

- Transforms the symbolic into the **geometric**, offers a method for **seeing the unseen**
- **Objectives**: Cognitive amplification, Insight generation, Communication & decision support

Human Perception Principles



Visualization Types

Textual Representations

- default format of data
- **Strengths:** precise, detail
- **Weaknesses:** low scanability, no pre-attentive processing, slow pattern recognition
- → Text informs, visualization reveals
- **Tables:** Structured text supporting exact lookup

Charts

- Maps data onto symbols, such as points, lines, or bars, enables understanding and to show relationships
- Examples:
    - Line Chart
    - Bar Chart
    - Box-Whisker Plot
    - Scatter Plot
    - Heat Map
    - Parallel Coordinate Plot
    - Sankey Diagram

LA Dashboards (LAD)

- Visual displays that integrate different **indicators on learning activities**, **aggregates** different **visualizations of learner data**
- **Objectives** for Stakeholders:
    - **Students**: Self-regulated learning
    - **Teachers**: Decision-making & timely interventions
    - **Institutions**: institutional monitoring & optimization
- **Characteristics**: Many synonyms, different target user (see above), 7-10 indicators, personalized view
- **Data Sources:** Log data, learner artifacts, questionnaires, sensor data, institutional database. external APIs

LAD Design Recommendations

- Designed as **pedagogical tools** that enhance awareness and reflection
- Concepts from **learning sciences** should be used to motivate design decisions
- Determine which **group of learners benefit** most; not all users experience same effect

- Seamlessly **integrated** in an online learning environment

Checklist for LAD Development

1. Planning
    - Why needed?; Who needs?; How to best match the needs?
2. Design
    - Theoretical foundation?; Which technology?; Who should be involved in the design?; Which data?
3. Implementation
    - How moving from prototype to large-scale implementation?
4. Evaluating
    - How evaluate Impact?; How long is evaluation?; Which focus?

L8 - LA Techniques

Lecture 8 - LA Techniques

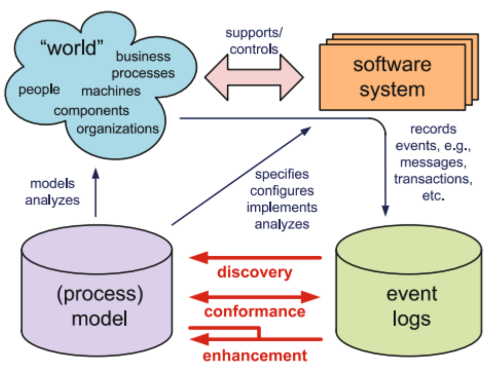
Learning Goals

- Explain the core concepts and objectives of Educational Process Mining, Social Network Analysis, Discourse Analysis, and Sentiment Analysis.
- Differentiate between key LA techniques by comparing their data requirements, analytical outputs, and use cases.
- Apply basic discovery and analysis steps (e.g., event-log abstraction, SNA metric interpretation, sentiment classification pipeline) to sample datasets.
- Analyze learner interaction data by interpreting process models, network structures and text-based indicators.
- Evaluate the quality, limitations, and risks of LA techniques with respect to data quality, ethics, and methodological constraints.
- Interpret analytical results to derive actionable insights for improving learning processes, collaboration structures, or course design.

Educational Process Mining (EPM)

- **Motivation**: Treats education as a process. Learners follow sequences of actions, interactions, and decisions.
- **Reveals**:
  - Effective or ineffective learning strategies.
  - Common bottlenecks or points of confusion.
  - Differences in behavior between successful and struggling students

The Process Mining Model



- **The "World"**: Represents the entire context (learners, teachers, …)
- **Software Systems:** Digital platforms like LMS, CMS, and MOOCs
- **Event Logs**: The primary data source for EPM; event is a recorded action with three attributes: Activity (e.g., 'Watch Video'), Time, and Case (entity, e.g., 'User 1')
- **Process Models:** Formal, graphical representations of a process (e.g. Business Process Model and Notation (BPMN) or Petri Nets)

Process Mining Tasks

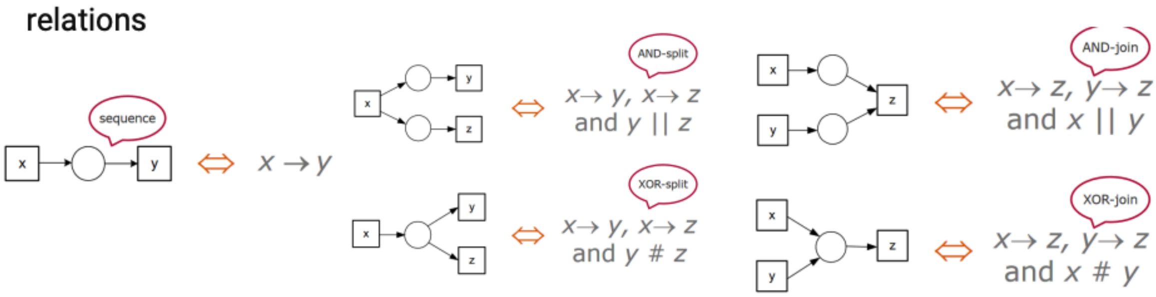
Task	Inputs	Process	Outputs
Process Discovery	Event Log	Discovery	Model
Conformance Checking	Event Log, Model	Conformance Checking	Diagnostics
Enhancement	Event Log, Model	Enhancement	New Model

The Alpha Miner Algorithm

Process discovery that generates a Petri net from an event log, by first identifying the ordering relations between every pair of activities in the log:

- **Direct Successor** (a > b): Activity b directly follows a in at least one trace.
- **Causality** (a → b): a > b is true, but b > a is not.
- **Concurrency** (a || b): Both a > b and b > a are true.
- **Exclusiveness** (a # b): Neither a > b nor b > a is true.

Based on these derived relations, the algorithm constructs Petri net fragments



- **Limitations:** Requires Completeness, Cannot rediscover short loops, Not robust against noise
- **Other Algorithms:** Heuristic Miner, Inductive Miner
- **Quality Metrics:** Fitness (how well it fits), Precision (does it allow more than data?), Simplicity

Visualizations in Process Mining

- Dotted Charts
- Bubble Charts
- Process Discovery (Petri Model, BPMN)
- Spagetti Process Model

Social Learning Analytics

- Focuses on understanding and supporting the social dimensions of learning, particularly how learners interact, collaborate, and influence each other
- **Data source**: Collaboration platforms, network data, content data

Social Network Analysis (SNA):

- Quantitative Study of a social network; learners are nodes, their interaction a edge
- **Objectives:** Find disconnected learners, information broker, learning communities, group structure and dynamics
- **Network Metrics:**
    - Degree centrality
    - Weighted Degree
    - Betweenness centrality
    - Closeness Centrality
    - Reciprocity

Discourse Analysis

- Shifts focus from who interacts (SNA) to how they interact and what is being constructed through dialogue

Sentiment Analysis

- Identifies emotional signals in forums, feedback forms, reflections; mostly text classification task
- Aggregated sentiment trends over time (course weeks, project phases)

L9 - ELSI_LA_adoption

Lecture 9 - ELSI and LA adoption

Learning Goals

- Differentiate between ethical, legal, and social implications (ELSI/ELSA) in the context of learning analytics.
- Identify and explain key ethical issues in LA, including privacy, transparency, labelling/autonomy, data ownership, and algorithmic fairness.
- Evaluate the DELICATE checklist and apply it to assess responsible LA implementations.
- Analyse trade-offs between institutional data needs and learner rights (e.g., consent, opt-out, data minimisation).
- Assess institutional challenges in LA adoption and map them to strategic, operational, and contextual factors.
- Critically appraise policy frameworks relevant to LA (e.g., GDPR alignment, institutional readiness, SHEILA).
- Judge the risks and benefits of LA interventions for different stakeholders and argue for ethically sound design choices.

Ethical, Legal, and Social Implications (ELSI)

- Originated with the Human Genome Project (HGP), address the societal impact of genetic research
- Today Responsible Research and Innovation (RRI)
- Characteristics:
    - **Proximity**: Embeddedness within scientific programs.
    - Early Anticipation: Proactively identifying potential issues and responsible parties.
    - **Interactivity**: Engaging stakeholders and the public in co-designing research agendas.
    - **Interdisciplinarity**: Bridging boundaries between different research communities.

Ethics

- Systematization of correct and incorrect behavior: duty- or rule-based, Consequentialist, Virtue

Inherent Contradictions in Learning Analytics Ethics

- Contradiction 1: Data Maximization vs. Data Minimization
- Contradiction 2: Learner Rights vs. Institutional Obligations
- Contradiction 3: Technology vs. Regulation

Ethical Issue	Core Guideline & Description
Privacy	Involves cooperation among all stakeholders regarding data collection and analysis. It is a human's right to define access to their data to protect their identity from abuse.
Openness and Transparency	Requires clarity, data control, and accountability. Learners must be able to make a well-informed choice to opt-in or opt-out.
Labelling (Autonomy)	Dictates that data will not be used to negatively stereotype learners. It addresses the risk of reducing student potential based on predictive models.
Data Ownership	Mandates that school data must not be sold. It addresses the complex legal and moral questions of who owns raw data, processed data, and analytical models.
Algorithmic Fairness	Focuses on avoiding biases in data interpretation. It recognizes that while algorithms are neutral, human decisions in their design and application can introduce bias.
The Obligation to Act	Establishes that learners have the right to know about their progress. Institutions have an ethical responsibility to use LA results to support learners.

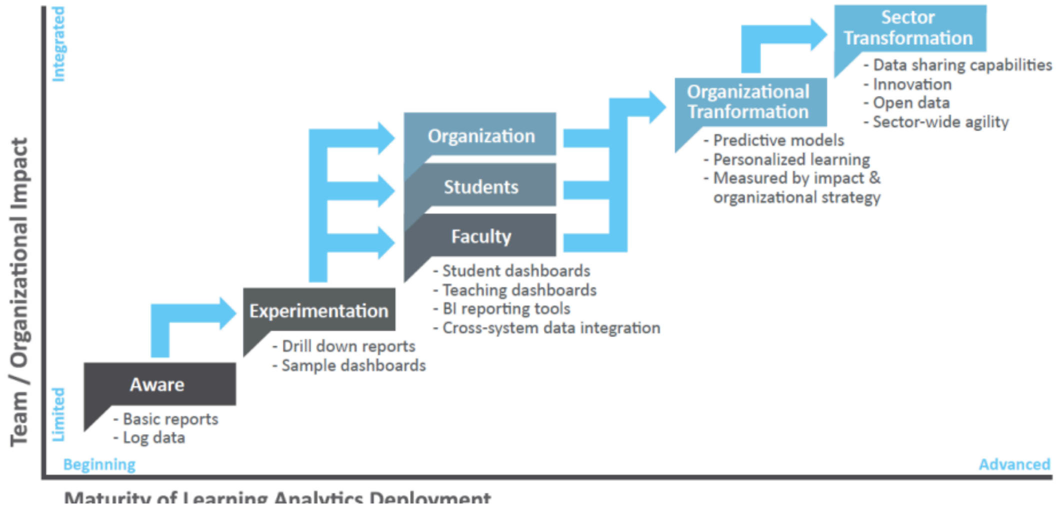
Its a DELICATE issue

- Concerns of LA impact on individuals, their identity and integrity
- **Roles**: Ethics, Privacy, Legal Frameworks

Acronym	Principle	Guiding Questions & Actions
D	**DETERMINATION**	**Why do you want to apply Learning Analytics?**
E	**EXPLAIN**	**Be open about your intentions and objectives.**
L	**LEGITIMATE**	**Why are you allowed to have the data?**
I	**INVOLVE**	**Involve all stakeholders and the data subjects.**
C	**CONSENT**	**Make a contract with the data subjects.**
A	**ANONYMISE**	**Make the individual not retrievable.**
T	**TECHNICAL**	**Implement procedures to guarantee privacy.**
E	**EXTERNAL**	**Manage work with external providers.** • Ensure providers comply with national and organizational rules.

Institutional Adoption of Learning Analytics

- Institution-wide strategy needed
- Need to build analytics mindsets, capabilities, and capacity for LA
- LA policy alignment with national and international legislative frameworks



- **Challenges for institutional LA deployment**:
  - Stakeholder engagement and buy-in
  - Weak pedagogical grounding
  - Resource demand
  - Ethics and privacy
- **Factors for Institutionalization (Institutional readiness):**
  - **Macro:** Policy, funding, values, politics, capital constrains
  - **Meso:** faculty, culture, GPDR, operations
  - **Micro:** data, needs, support, false positives

    —-------------
  - **People**

SHEILA

Addresses specific challenges in LA adoption, particularly those related to organizational culture and stakeholder management:

- Policy Development: It guides institutions in creating LA policies that align with legislative frameworks (such as GDPR),.
- Stakeholder Inclusivity: SHEILA emphasizes the importance of inclusivity in the adoption process; balance the unequal distribution of power between the institution and its primary stakeholders (students and teachers).
- Overcoming Resistance: It helps institutions address resistance to change, which often stems from a mix of political, social, cultural, and technical norms,.

L10 - Serious Games and Gamification

Lecture 10 - Serious Games and Gamification

Learning Goals

- Define and distinguish between game-based learning, serious games, and non-serious games, citing key characteristics and examples.
- Explain the educational purpose of serious games and identify contexts in which they can be applied effectively.
- Analyze game design elements (goals, rules, feedback, voluntary participation) and discuss how they contribute to learning outcomes.
- Identify genres and application areas of serious games, including edugames, exergames, and advergames.
- Evaluate platforms and examples of educational games, linking their mechanics to learner engagement and motivation.
- Describe the role of feedback, flow, and intrinsic motivation in games and gamified learning environments.
- Discuss gamification concepts, including common game elements (points, badges, leaderboards) and how they can enhance learning experiences.
- Assess the benefits and limitations of serious games and gamification in educational settings, including measurability, ROI, and engagement.
- Describe how Game Learning Analytics (GLA) can be implemented to assess and validate serious games through the analysis of in game data.
- Discuss the SIMVA infrastructure and highlight current achievements in GLA as well as the outlook to future trends and research directions

Game-based Learning

- Learning by playing games

Games

- Artificial conflict, defined by rules, resulting in quantifiable outcome
- Features for games:
    - Specific goal
    - Rules
    - Feedback system
    - Voluntary Participation
- Purpose for Gaming:
    - Intrinsic motivation trigger
    - Goal oriented & feedback loop
    - Safe failure environments

      For Tetris

    - Strong Feedback, Flow, Entertainment (Spannung, Rollenerfahrung)

Serious Games

- It's a game in which the education (in all forms) is the primary goal, not the entertainment
- You can see every game as serious (according to game developer)

- **Non-Serious Games:** All other games where entertainment is the primary goal.
  → However, these games can be used for serious purposes.
- **Serious Gaming:** The practice of using games for serious purposes. This can involve:
    - **Purpose-Shifted Games:** Using commercial off-the-shelf (COTS) games like *Minecraft*, *SimCity*, or *Portal 2* in educational contexts without modification.
    - **Mods:** Modifying existing commercial games to suit a specific educational need.

Serious Games Community

- **Growing market**; three major roles:
    - Gaming industry
    - Scientific community
    - Educational community

Serious Games Application Areas

- 3D training and simulation environments, e.g. for pilots, firefighters
- visualization and construction tools, e.g. for architects
- research tools for human perception
- support learners and teachers in educational settings
- motivate for a healthy, active life,
- raise awareness, e.g. for politics, security
- assess human behavior

Genres

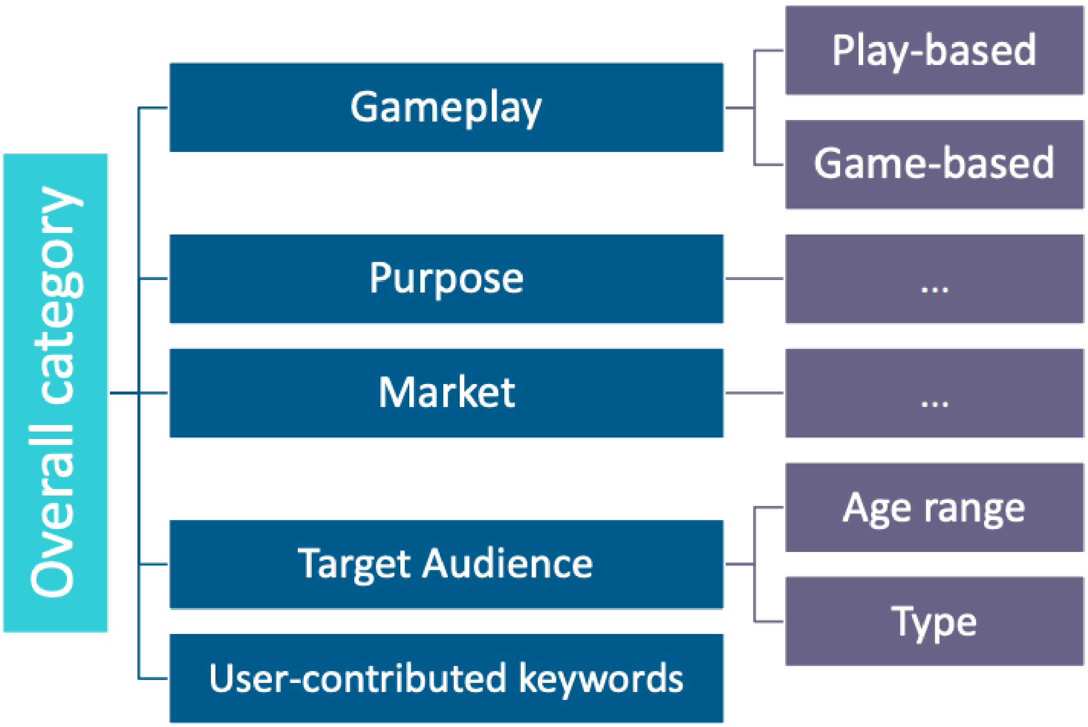
- Action game
- Adventure game
- Fighting game
- Role-play game
- Sports game
- Strategy game

Subcategories

- **Advergame:** Broadcasts a marketing message.
- **Newsgame:** Broadcasts an informative message.
- **Edugame:** Broadcasts an educative message.
- **Exergame:** A physical or cognitive training game.
- **Edumarketgame:** Combines marketing with an educational or informative message.

Classification of Serious Games

- Complex problem, as no single, universal system exists; often outdated
- **Approach**: Use the power of the crowd, and multiple criteria:



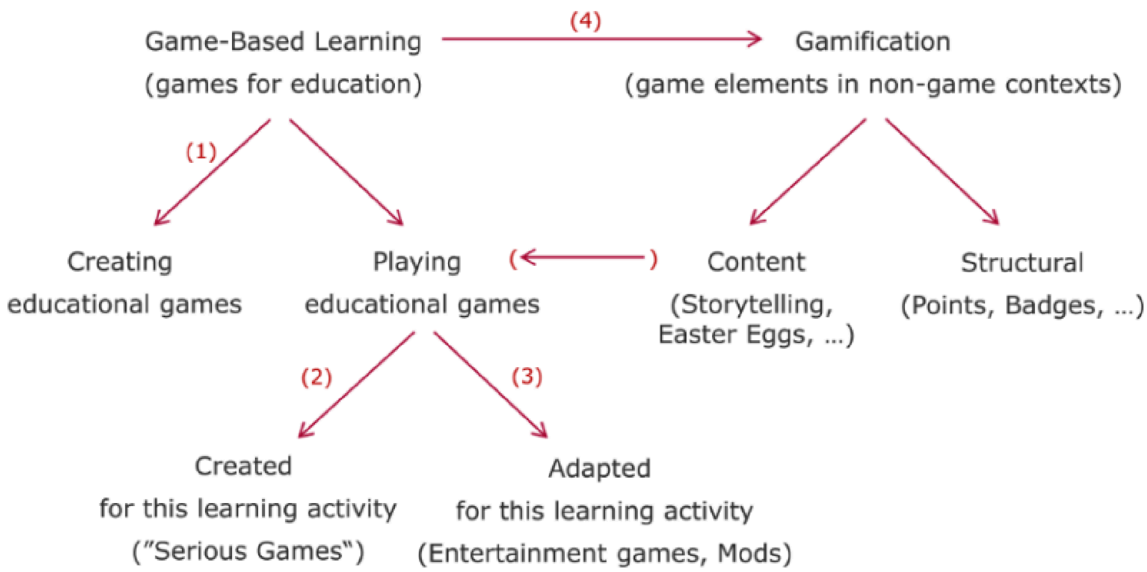
play-based=no goals, game based=stated goals

- **Purpose** for classification:
  - **Transparency** for stakeholder
  - **Operations** (f.i. faster search)
  - **Research** (f.i hypotheses support)

Gamification

- Using **game** design **elements in non-game context** (critics: intrinsic vs. extrinsic motivation)

- Export the design components from game components people like in games and import in serious non game context
- F.i. Badges, Points, Levels
- **Why gamification:**
    - Motivation, collaboration, communication
- **Gamification in education:**
    - Participation, engagement, motivation, team, communication



Game Learning Analytics (GLA)

- Collecting, analyzing, and interpreting data generated from educational/serious games or game-based learning environments
- **Objectives**: evidence-based assessment, Inform and optimize, integrating games into teaching, adaptive and personalized learning
- Core purposes:
    - **Assessment** (formative + summative in-game),
    - **Adaptation** (dynamic difficulty, scaffolding, feedback),
    - **Design optimization** (data-informed iteration of game mechanics and learning design)
- **Outlook**:
    - Multimodal learning analytics
    - Real-time learning analytics
    - XR, spatial and immersive analytics
    - Interoperability and standardization

SIMVA Infrastructure

- SIMVA = SIMple VAlidator

- Designed to validate serious games and operationalize GLA; Connects in-game data with pre/post test survey data
- Platform Clients:
  - **Game Client:** Collects player interaction data during gameplay.
  - **Simva Frontend:** Manages studies, surveys, and users (teachers, researchers).
  - **Dashboard (T-Mon):** Visualizes analytics for monitoring and decision support.
- Platform Backend:
  - **Simva-backend (Core):** Central orchestration service.
  - **Trace Storage (MINIO):** Stores interaction data.
  - **Trace Processor (Kafka Connect):** Handles real-time data streaming.
  - **LimeSurvey:** Manages pre/post-game questionnaires.

L11 - AI in Education

Lecture 11 - AI in Education

Learning Goals

- Define AIED and distinguish it from AI education and alternative trends
- Characterize the AIED system landscape including its layers
- Explain how AI can be applied to different areas/aspects of education
- Define and explain the concept of Intelligent Tutoring Systems
- Describe the core architecture of ITS
- Explain different implementation variants and in particular Cognitive Tutors
- Describe the Core Shift toward GenAI in Education
- Discuss different use cases and associated risks of GenAI in education
- Describe the Architectural Perspective of GenAI in EdTech
- Discuss GenAIs impact on Assessment and Academic Integrity and Outline Trends of GenAI in EdTech

AI in Education (AIED)

- Use AI to support and enhance teaching, learning, and administration
- Promises:
  - Personalization
  - Faster feedback
  - Early intervention
- History of AIED

Period	Paradigm	Key Developments
1970s–1980s	Expert Systems	Early rule-based Intelligent Tutoring Systems (ITS9
1990s–2000s	Data-Driven Shift	The emergence of Machine Learning led to the development of Cognitive Tutors (CTs), which use student models for adaptive instruction.
2010s	Learning Analytics (LA)	AI was integrated with LA for prediction and personalization within platforms like Learning Management Systems (LMS) and MOOCs.

2020s	Generative AI (GenAI) Era	The advent of Large Language Models (LLMs) like ChatGPT enabled scalable chatbots, content generation, and automated feedback, leading to widespread adoption.

- **System Landscape**; AIED is not a single technology rather an ecosystem
    - **Data Layer:** Collects information from learning activities, system logs, sensors, text, and assessments.
    - **Model Layer:** The reasoning core, Machine Learning (ML), Natural Language Processing (NLP), recommender systems, and LLMs process data to generate insights.
    - **Application Layer:** The user-facing interface, which includes tools for tutoring, feedback, analytics, content authoring, and assessment.
    - **Governance Layer:** The regulatory framework that controls the system, addressing critical issues such as privacy, fairness, transparency, and regulation.
- **Application Areas:**
    - Instruction and support
    - Assessment and feedback
    - Self-regulated and collaborative learning
    - Educational management and design

Intelligent Tutoring Systems (ITS)

- Gives Instruction and feedback to students like human tutors by replicating 1 o. 1 environment on a lager scale
- Includes:
    - **Interface Model**: Communication
    - **Learner (Student) Model**: Replicates learners knowledge
    - **Pedagogical Model (Teacher)**: Strategies for learning
    - **Domain Model**: Subject knowledge
- Can be: Rule based, NN, LLM,...

Cognitive Tutors

- Subclass of ITS; Has cognitive model to provide feedback to students as they are working through problems; feedback comes immediately, informing students of the correctness, or incorrectness, of their actions in the tutor interface; ability to provide context-sensitive hints and instruction to guide students towards reasonable next steps.

GenAI - Core Shift in AIED

- From domain specific, pedagogical, deterministic ITS/Cognitive Tutors to
- broader, emergent (you don't know what they doing), probabilistic GenAI/LLM

Use Cases of GenAI in EdTech

- **Learner Facing:** Rephrasing, translation
  Risks: Hallucinations, over-trust
- **Teacher Facing:** Quiz generation, planning
  Risks: Quality, didactic misalignment
- **Institution Facing:** Chatbots, analytics
  Risks: Data leakage, compliance

Architecture Perspective

- **Standalone tools:** ChatGPT, high risk, **low governance**
- **Embedded services**: LMS plugins, **moderate governance**
- **Hybrid AIED systems**: GenAI + LA + Rule based, **human-in-the-loop control**

Impact on Integrity and Assesment

- Traditional homework more uninteresting, process oriented task gain relevance
- Oral, in class assessments increase
  → Assessment design kex strategic governance issue, not technical one

Trends of GenAI in EdTech

- Multimodal tutoring
- Copilots in LMS
- Feedback at scale