

Learning path definition and usage in the context of learning analytics: literature review

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Abstract. *This paper reviews literature on learning paths (LP) within learning analytics, aiming to clarify LP definitions, contexts, and research methods. From 50 studies, 16 were analysed. Findings show that the term “learning path” is rarely precisely defined and usually refer to sequences of learning resources, activities, or challenges. Purposes of LPs usage range from guiding student learning, predicting outcomes to supporting adaptive interventions. Data sources are often learning management system logs, with statistical methods like logistic regression and discriminant analysis commonly applied. In the paper is highlighted the need for clearer conceptualization and further research into LP definitions and applications.*

Keywords. Learning path, learning analytics, definition

1 Introduction

Understanding and guiding student’s behaviour when acquiring knowledge and skills is an important aspect of teaching/learning process, oriented to effective achievement of learning outcomes.

Learning paths – LPs (also learning pathway, journey, roadmap, trajectory) is a term which may be defined by different elements, used in different contexts emphasizing different purposes.

For example, according to Wu (2025) „an effective learning path can guide students to master the necessary knowledge at an appropriate pace, thereby improving learning efficiency and outcomes.”

On the Digital Skills and Jobs Platform (n.d.) (learning) paths are defined, in the context of “the new feature designed to enrich the learning experience for users on the platform”, as “a set of learning content, training opportunities, skills resources or skills publications that correspond to a specific learning purpose and are structured in a guided way for the user to embark on a small learning journey”.

In the ECTS Users’ Guide (2015), the term learning pathway is used and defined as “a route taken by a learner allowing him/her to build knowledge progressively and acquire the desired set of

competences. The learning pathway may be ‘signposted’ through institution guidance and regulations (including the recognition of prior learning and experience) and different learning pathways may lead to the award of the same qualification. In essence the concept of a ‘learning pathway’ emphasises the choice of the student in reaching the desired educational goals.”

Reason to do scoping literature review on the topic of „learning path” was to clarify the key concept/definition and context of its use in the literature.

2 Research questions

Scoping literature review of studies/papers dealing with learning paths is based on the following research questions:

- RQ1: What are the approaches to definition of learning path(s) and context of its usage?
- RQ2: What are dominant research worldviews, types of research and research methods used in relevant research dealing with learning path(s)?

3 Methodology

In order to explore and systematize important aspect of defining learning path for area of education, learning and learning analytics, related scoping literature review has been done.

The following steps in scoping literature review have been followed:

- Identification of the research questions
- Identification of relevant studies
- Selection of studies to be included in the review
- Data extraction
- Summarizing and reporting the results

As a starting point, we precisely **defined the research questions**, which had been outlined in the previous section. The questions were defined to

provide the base of understanding the term learning path, needed to serve the goal of the project TRUELA dealing with the identification of learning patterns of more and less successful students.

Steps of **identification of relevant studies** and selection of studies to be included in the review are presented by the Fig. 1.

Identification of relevant studies was done in 19th of February, 2025 by retrieving records from the Web of Science (WoS) collection based on the query:

((((ALL=(learning path*)) OR ALL=(learning trajector*)) AND ALL=("learning analytics")) AND ALL=("education")) AND ALL=("student*"))

The query resulted in 50 records and all 50 articles/studies were downloaded and all relevant information were recorded.

The full set of 50 articles/studies found in WoS were published between years 2013 and 2025. 32 were published in journals, while 18 in conference proceedings

Selection of studies to be included in the review, i.e. eligibility check of the 50 articles/studies relevance to the topic of the literature review, has been done by 4 researchers in two rounds:

- firstly, based on the article abstract 26 articles were excluded, and
- then based on the full-text article insight additional 8 articles were excluded.

Eligibility check of 50 papers resulted in 16 papers to be analysed.

Analysis/**data extraction** was done by the same 4 researchers checking eligibility of the articles/studies.

Besides some common elements/information about articles to be included (such as the type of the article journal/conference, publication year,...), for each research question elements of analysis have been defined as follows:

- RQ1: What are the approaches to definition of learning path(s) and context of its usage?

To answer the first research question in each article/study, Definition(s) of learning path were checked as well as its (Definition) elements (as a sequence of *something* – for example activities, tasks...). Furthermore, Learning path usage context, Use/application of learning path, Data used, and Methods used were identified (listed in the Table 1).

- RQ2: What are dominant research worldviews, types of research and research methods used in relevant research dealing with learning path(s)?

To answer the second research question in each article/study, Research paradigm, Research approach, Research methodology, and Research methods were checked and identified (listed in the Table 2).

The steps of summarizing and reporting the results are incorporated in the following section of the paper.

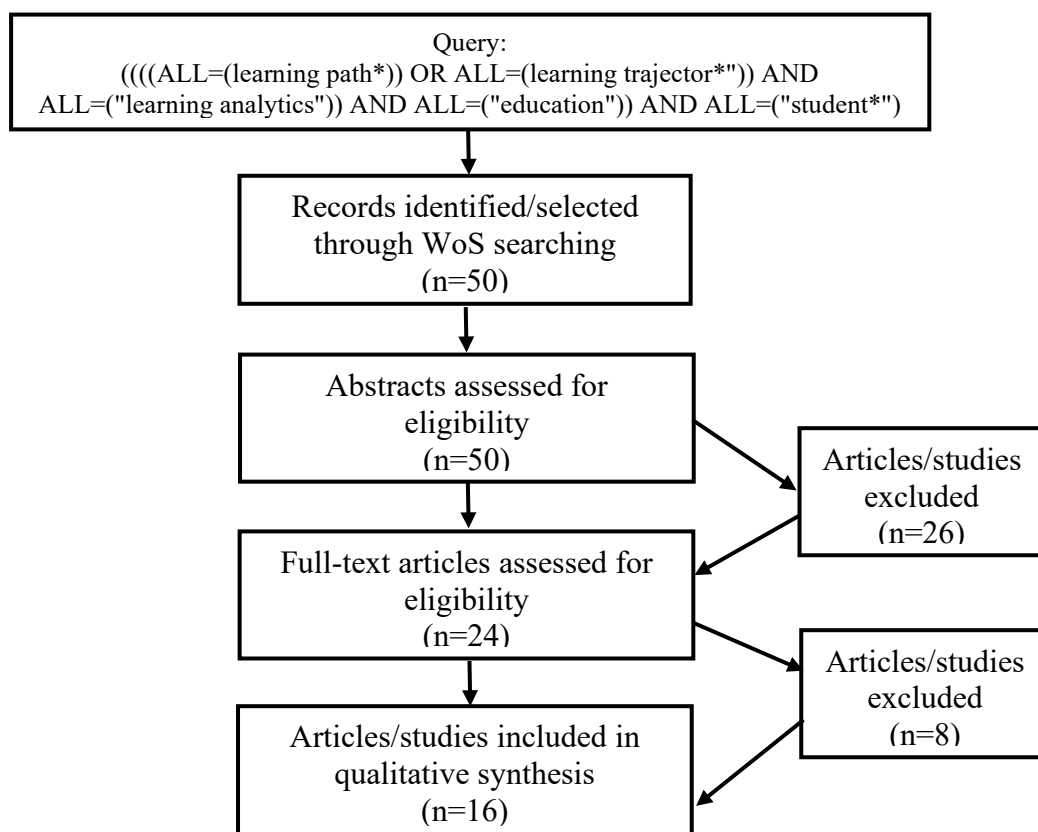


Figure 1. Flow diagram of the identification and selection of relevant studies to be included in the review

4 Results

After two rounds of eligibility checking, the set of 50 articles/studies was downsized to 16 published between years 2014 and 2025, 10 published in journals and 6 in conference proceedings.

Studies presented in the articles were done in 11 countries (Brazil, Bulgaria, Canada, Chile, China, India, South Korea, Spain, Turkey, UK, USA), mostly in higher education (1 primary and 1 in secondary education) and in the fields related to computer/ICT/STEM and engineering.

Students were the research participants in the analysed studies, with the exception of one case where both students and teachers were involved.

4.1 Results of the literature review to answer the first research question on approaches to definition of learning path(s) and context of its usage

To answer the first research question (RQ1 **What are the approaches to definition of learning path(s) and context of its usage?**), the sources of the definition of the term “learning path” were analysed.

Definition(s) of learning path:

In 2 articles/studies out of 16, author(s) definition (no quotation/citation/reference) was used. In 9 (out of 16) articles/studies implicit definitions could be concluded/recognized, while in 3 (out of 16) articles/studies there was no definition of the term “learning path” used.

Some authors use **own definitions**, as follows:

- “A learning path is the linear list of LOs, organized based on their knowledge relation” (Raj & Renumol, 2024)
- “The results from the social network analysis provide the learning path during a course.” (Choi & Cho, 2020).

In two articles authors use/quote definition provided by other authors, from other sources:

- “Learning paths can be defined by various factors, such as their preferred learning styles (according Felder & Silverman 1988). Learning styles could be influenced by how students perceive information (sensing or intuitive), acquire information (visual or verbal), organize information (inductive or deductive), process information (active or reflective), and understand information (sequential or global)” (Govindarajan, Kumar & Kinshuk, 2016)
- “At course level, LPs are defined as “a sequence of learning tasks or activities which are designated to assist the student in improving their knowledge or skill in the particular subject” (according Yang, Li & Lau, 2010)” (Martínez-Carrascal, Munoz-Gama & Sancho-Vinuesa, 2023).

In 9 articles/studies **no explicit, just implicit definition** could be identified:

- Creating optimal learning path in order to achieve higher students’ motivation and thus learning outcomes and efficiency; based to different learning styles models identified by using dedicated psychological questionnaires, educational data mining (EDM) (Bayesian Networks (BN) and Case-Based Reasoning (CBR) (Kurilovas, 2019)
- “monitoring learners involves observing their interactions within the (*learning*) system, which can result in learning paths (Ramos et al., 2021). These paths can be analysed from multiple perspectives, and the success of learning strategies and tactics is influenced by several factors (Wang, 2021). According to López-Pernas et al. (2021), learning strategies are defined as any thoughts, behaviours, beliefs, or emotions that facilitate the acquisition, understanding, or subsequent transfer of new knowledge and skills. Closely related, learning tactics refer to cognitive routines-actions that learners take to achieve a learning goal or perform a task; in other words, they are the methods a learner uses to learn something. Data-driven analysis methods enable the identification of learning patterns and associations between digital traces (learning paths) and learning outcomes, which can be ‘mapped back’ to the planned learning activities. This contextualization highlights the need to develop new approaches for interpreting log data to understand better students’ learning interactions (Wang, 2021). (Real & Pimentel, 2025).
- Implied as a structured sequence of learning activities shaped by instructional design: "two learning paths to our students, traditional and novel, the second one with the aim of increasing the motivation and the engagement of the students and improving the learning results." (Sousa-Vieira et al., 2023)
- Implicitly, individualized sequence of strategies and activities based on behavioural analysis and prediction. (Ouyang et al., 2023)
- “As a result, the teacher’s assistance is critical in correcting his learning path, assisting him, directing him to the appropriate path, identifying and resolving learning hurdles for him, and encouraging him to continue on his learning path and **attain his intended goals**. "This investigation illuminates the value of learning analytics provided by the learning analytics dashboard in AEs (*adaptive environments*), how it aids educators in determining when to intervene with students to alter their learning paths" (Abouelenen, Selim & Aldosemani, 2025).
- "Students’ primary choice of learning activity were characterized as 3 learning paths: i) No use of video lectures (i.e., the course book readers) ii) Below average use of video lectures iii) Above

average use of video lectures." Reading the course book and mix of both (Angrave et al., 2020)

- "This work presents the study of **curricular trajectories** as processes (i.e., sequence of events) using process mining techniques. Specifically, the Backpack Process Model (BPPM) is defined as a novel model to unveil student trajectories, not by the courses that they take, but according to the courses that they have failed and have yet to pass" (Salazar-Fernandez et al., 2021).
- "Smart learning could mean customized learning that optimizes learning pathways, engages learners in positive interactions, and guides instruction in a goal-oriented fashion." (Kumar et al., 2014)
- No explicit definition given/used. In the context of Gamification and Digital Game-Based Learning (DGBL): "From learning perspective, challenges can be mapped to learning goals, levels to learning path, points and feedback to positive reinforcement, leaderboards to learning analytics." (Iliev, 2018, p. 10656).

There are no identified definitions used in 3 articles/studies ((Wu, Guo & Zhu, 2023), (Cooper, Ferguson & Wolff, 2016) (Baneres, 2016)).

More information on the elements/information collected are presented in the Table 1.

4.2 Results of the literature review to answer the second research question on dominant research worldviews, types of research and research methods used in relevant research dealing with learning path(s)

The second goal in the focus of the research and literature review is to answer the question formulated as types of research and research methods used in relevant research dealing with learning path(s).

With regard to research paradigms, the most common are post-positivist in 6 out of 16 (37.50%) and pragmatic - in 5 out of 16 (31.25%) articles/studies.

Dominant research approach is quantitative – in 9 out of 16 (56.25%) articles/studies, followed by mixed - in 5 out of 16 (31.25%) articles/studies and qualitative – in 1 out of 16 (6.25%) articles/studies reviewed.

The most used research methodologies are case study research – in 6 out of 16 (37.50%) and experimental research – in 5 out of 16 (31.25%) articles/studies. Research methodologies of quasi-experiment research, empirical study, action research, systematic literature review and design research are used in one article each – in 1 out of 16 (6.25%) articles/studies reviewed.

Research methods are diverse and presented in the last column of Table 2, which contains the results of the literature review related to RQ2.

5 Conclusions with future research

Based on the review of the literature results, the following conclusions can be drawn:

- Definitions of the term "learning path" are rarely exactly given or clarified or clearly indicated in the articles /studies.
- Different elements are used and/or emphasized when defining the term: as a sequence of objects/resources, learning tasks or activities, and as challenges in blended learning environment (gamification in situated learning).
- Definition and/or term "learning path" are used in the context of: a course, a part of the study program (set of courses) and/or in a particular field/group of courses, and task.
- Use/application/purpose of the "learning path" varies from to guide student learning and to predict learning success/failure, to compare the critical learning paths of two groups of students (students with or without disabilities), to construct a method of data tracking and recording in interactive learning environment, to propose a learning path recommendation approach (model) focused on knowledge building and learning performance analysis, to illuminate the value of learning analytics in AEs (adaptive environments) and how it aids educators in determining when to intervene with students to alter their learning paths.
- Data used are mostly collected from dashboard, video, LMS, task or multimodal logs, learning objects (meta)data, psychological or preference questionnaires.
- Methods used to analyse data differ from clustering, behavioral analytics, statistical comparisons, prediction models, Bayesian networks, Case-Based Reasoning, educational data mining (EDM), process mining, etc.
- Regarding research on the topic, dominant research paradigms are post-positivist and pragmatic, research approach is quantitative, research methodologies are case study research and experimental research, encompassing diverse research methods.

Based on the results, it is evident that the related field would benefit from a clearer conceptualization of the term "learning path," particularly in light of its varied and often ambiguous usage across studies. Despite the increasing relevance of learning paths in the context of learning analytics and instructional design, the absence of consistent definitions and theoretical grounding limits comparability among studies.

Table 1. RQ1 related results of the literature review

	Definition(s) of learning path:	Learning path as a sequence of:	Learning path used in the context of:	Use/application	Data used	Methods used
(Abouelenen, Selim & Aldosemani, 2025)	implicit	activities influenced by adaptive interventions	science teacher education (pre-service teachers)	analyze how interventions change self-regulation behavior	dashboard logs, self-regulation indicators	clustering, learning analytics, questionnaires
(Angrave et al., 2020) -	implicit	video segments accessed by learners	system programming course	analyze how learning paths affect learning outcomes and engagement	video logs, search events, student grades	behavioral analytics, statistical comparisons
(Baneres, 2016) -	no definition	learning tasks and exercises	course in digital systems design	adaptive support based on predicted success	performance data from tutoring systems	prediction models, intelligent tutoring systems
(Choi & Cho, 2020)	own	learning tasks and interactions	Educational psychometrics, statistics courses	diagnose learning progression and provide feedback	task logs, social network structures	SNA, Bayesian networks, ECD framework
(Cooper, Ferguson & Wolff, 2016)	no definition	learning activities	programs or courses for disabled students	compare the critical learning paths of disabled students and nondisabled students and to identify barriers to accessibility	completion rates, LMS data, accessibility indicators	comparative analysis
(Govindarajan, Kumar & Kinshuk, 2016)	quoted	learning activities	Programming course	predict optimal paths based on competence and meta-competence	competence scores, learning object data	clustering, learning analytics
(Iliev, 2018)	implicit	challenges and learning tasks	challenges and learning tasks	dynamic adaptation of tasks, gamification, and instructor support	multimodal logs (gesture, text, audio, video)	real-time tracking, dynamic assessment
(Kumar et al., 2014)	implicit	learning tasks	programming course	personalized feedback, competence analysis	trace data from coding activities	competence analytics

Table 1. RQ1 related results of the literature review (cont.)

	Definition(s) of learning path:	Learning path as a sequence of:	Learning path used in the context of:	Use/application	Data used	Methods
(Kurilovas, 2019)	implicit	learning activities and content tailored to learning styles	learning paths in courses, adapted for individuals	increase motivation and learning outcomes by matching LPs to learning styles	Psychological questionnaires, learning styles inventories	Bayesian networks, Case-Based Reasoning, educational data mining (EDM)
(Martínez-Carrascal, Muñoz-Gama & Sancho-Vinuesa, 2023)	quoted	learning activities	mathematics course	assess effectiveness of recommended LPs through process mining	LMS logs	Process mining, log skeletons
(Ouyang et al., 2023)	implicit	learning resources and tasks	engineering courses	predict at-risk students and establish personalized learning pathways	Student interaction data, collaborative learning data	deep learning, learning analytics
(Raj & Renumol, 2024)	own	learning objects	computer science and engineering courses	recommend adaptive LPs based on learner profiles and real-time performance	learner logs, knowledge graphs, LO metadata	ontology, real-time analytics
(Real & Pimentel, 2025)	implicit	learning tasks	course	identify patterns, adjust course design	LMS logs	process mining
(Salazar-Fernandez et al., 2021)	implicit	courses, with special focus on failed and retaken courses	curricular analytics at the engineering study program level	inform curricular changes	student enrolment and grade data	process mining, directly-follows graphs
(Sousa-Vieira et al., 2023)	implicit	learning tasks	ICT course	compare traditional and gamified approaches, analyze impact on engagement and outcomes, predict learning success/failure	LMS logs, forum participation, task completion	descriptive statistics, correlation analysis
(Wu, Guo & Zhu, 2023)	no definition	micro-operations within 3D design software	3D design course	Evaluate spatial thinking and design skills	xAPI logs from GeekCAD	learning analytics, xAPI tracking

Table 2. RQ2 related results of the literature review

	Research paradigm	Research approach	Research methodology	Research methods
(Abouelenein, Selim & Aldosemani, 2025)	pragmatic	quantitative	experimental research	descriptive-longitudinal method
(Angrave at al., 2020)	positivist	quantitative	experimental research	log analysis, statistical tests (a Mann-Whitney U test)
(Baneres, 2016)	post-positivist	quantitative	case study	predictive modelling
(Choi & Cho, 2020)	post-positivist	quantitative	empirical study	data mining method using social network analysis, an analytic method using a Bayesian network
(Cooper, Ferguson & Wolff, 2016)	pragmatic	mixed	case study	(survey and historical module) data analysis, comparative analysis, statistical method (odds ratios)
(Govindarajan, Kumar & Kinshuk, 2016)	positivist	quantitative	experimental research	simulation, cluster analysis/clustering
(Iliev, 2018)	constructivist	mixed	action research	questionnaire
(Kumar at al., 2014)	post-positivist	quantitative	case study	descriptive statistics methods (visualization)
(Kurilovas, 2019)	pragmatic	qualitative	systematic literature review	literature review
(Martínez-Carrascal, Munoz-Gama & Sancho-Vinuesa, 2023)	constructivist	quantitative	experimental research	process mining
(Ouyang at al., 2023)	pragmatic	mixed	quasi-experiment research	predictive modelling, social network analysis (SNA), quantitative content analysis (QCA), thematic analysis method,
(Raj & Renumol, 2024)	post-positivist	mixed	experimental research	ontology-based method (of/for modelling), simulation (of data)
(Real & Pimentel, 2025)	positivist	quantitative	design research	educational process mining (EPM),
(Salazar-Fernandez at al., 2021)	post-positivist	quantitative	case study	process mining
(Sousa-Vieira at al., 2023)	post-positivist	mixed	case study	social network analysis (SNA), machine learning/deep learning (ML/DL)
(Wu, Guo & Zhu, 2023)	pragmatic	quantitative	case study	validation

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