Annals of "Dunarea de Jos" University of Galati
Fascicle I. Economics and Applied Informatics
Years XXXI – nº3/2025
ISSN-L 1584-0409 ISSN-Online 2344-441X
www.eia.feaa.ugal.ro

DOI https://doi.org/10.35219/eai15840409552

Shareable Content Object Reference Model in the Era of Artificial Intelligence

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A R T I C L E I N F O

Article history:
Received December 02, 2025
Accepted December 18, 2025
Available online December 2025
JEL Classification
I21, I23, O31, O33

Keywords:
e-learning Standards, SCORM, xAPI, Learning Management System, AI, ITS, OER

A B S T R A C T

Technological progress has revolutionized classical educational processes, increasing adaptability and flexibility. From standardizing the delivery method of content to intelligent tutoring systems, it has been a long journey, but facilitated by recent advances in the field of artificial intelligence. This article aims to take a retrospective look at these standards, analyzing some examples of authoring tools, which offer support to teachers in their educational endeavors. A bibliometric analysis was also performed starting from the set exported from Scopus and processed in Biblioshiny/bibliometrix, for the 2010–2025 period.

1. Introduction

Learning outside the traditional classroom setting has gained popularity with the development of technologies and the spread of internet connection, but perhaps the COVID pandemic period has best demonstrated the importance of developing e-learning infrastructure. The most important components are Learning Management Systems (LMS), capable of managing all processes related to synchronous and asynchronous learning. With the first university platforms implemented, the need for compatibility and portability of e-learning products arose. In the late 1990s, the US Department of Defense together with the US presidential administration created a new organization, Advanced Distributed Learning (ADL), with the aim of standardizing and streamlining e-learning.

The ADL project, which was supposed to provide access to education "anytime, anywhere", was called the "Sharable Content Object Reference Model", being a set of specifications and technical standards that ensure the compatibility of educational content with different LMS platforms. In recent decades, this has been the standard for all e-learning products intended for online education, regardless of the software platform with which they were created.

Thus, SCORM establishes both data models and communication methods, which harmonize e-learning materials with learning management systems, while also providing a unified environment for developers. Over time, the standard has gone through several transformations, from version SCORM 1.1. to SCORM 2004 (also known as SCORM 1.3.), and currently, when Artificial intelligence is making its way into all fields, the question arises whether it is still relevant.

2. Literature review

The changes brought about by the unified standards have been debated in the specialized literature for a long time. As early as 2002, authors such as E.R. Jones, talk about the development of software systems for managing online courses, such as WEST, WebCT or Blackboard and about the use of internet standards for HTML, XML, CSS and multimedia content, which have triggered a real revolution in education. At first, the issue of streamlining educational costs was raised, by supporting online courses with a larger number of students, but the reduction was still not significant, because the costs associated with the development and maintenance of online resources, as well as those arising from copyright, were added.

The evolution of technologies and the improvement of Internet bandwidth occurred so rapidly that all online courses had to be significantly updated, at short intervals, to remain competitive. With each change in learning management systems there was a risk of losing large collections of e-learning content. In this context, the ADL initiative emerged, which, with the aim of consolidating e-learning specifications and unifying standards, proposed Sharable Content Object Reference Model.

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Materials conforming to this standard had to be reusable, accessible, interoperable and durable, and these properties were ensured thanks to the three components: Content packaging, Runtime communications, and Course metadata (Jones, 2002). The first component refers to the packaging of all the materials that make up the course/lesson, in a single zip archive, which must also contain an XML file (imsmanifest file), for the description of the content and the sequentiality of the navigation. Regarding the communication during the run, this must include the information about the students to and from the LMS and the individual metadata of the learners. The third component is important for finding the course in a SCORM material library and must specify the title, description and keywords.

Godwin-Jones (2004) talks about a variety of sources that contributed to the development of SCORM, an important contributor being the IMS (Instructional Management System) project, which established the set of meta-data used. Thus, Scorm uses the "Learning Object Meta-data" (LOM) specification, and packaging the content in the zip archive is also due to the IMS project. Regarding the communication mechanism with the LMS achieved through the API, this represents the contribution of the AICC - Aircraft Industry Computer Committee. If the SCORM 1.1 version established a concept that needed to be developed, the SCORM 1.2 version, released in 2001, clarifies the communication between the SCO and the LMS and completely standardizes the imsmanifest.xml file. Later, the 2004 version added a set of standard sequencing rules, providing support for new functionalities, such as remediation, pre- and post-assessments, or conditional branching.

Papazoglakis (2013) considered version 1.1. only a trial implementation, which did not achieve the goal of interoperability. It was not until the launch of version 1.2. that this goal was achieved, thus being widely used for two decades by most LMSs. If previous versions allowed a relatively linear structure, SCORM 2004 (having 4 editions from 2002 to 2009), by introducing objectives, conditioning/branching, (Sequencing and Navigation), allows a certain degree of adaptability for SCO. Thus, SCORM 2004 goes further and defines dynamic or pre-established ways for a learner to follow the process, adapting to their own abilities or potentials or to an activity-centered order.

B. Miller, T. Rutherford, A. Pack, A. Johnson (2021) provide an interesting analysis of the evolution of these standards. They compare the period preceding the ADL project, when training moved from locally stored content to online, web-based training, materialized through the SCORM standardization, with the current period, which is facing equally drastic changes. The authors believe that SCORM is not sufficiently extensible to support new technologies nor does it provide adequate governance for data capture. Thus, the Department of Defense has made efforts to adequately update, the Experience Application Programming Interface (xAPI), this being the superior model for tracking learning processes. However, the move from SCORM to xAPI was a major evolutionary leap, although, when e-learning processes require minimal LMS oversight, SCORM is still relevant and widely used by content providers. Large libraries of learning content still rely on this standardization because it ensures compatibility with most systems.

Released in 2013, the Experience Application Programming Interface (xAPI) technical specification is an open-source data and interface standard developed by the Institute of Electrical and Electronics Engineers (IEEE). xAPI enables software applications to capture and share data about both student learning experiences and performance, and to facilitate comparative analysis of these data. The new specification aims to increase interoperability between platforms and services that produce, collect, store, and analyze learning data. (Miller, Rutherford, Pack, Johnson, 2021)

According to scorm.com, xAPI removes content from the LMS and allows it to send actor-action-object declarations to a Learning Record Store (LRS). These declarations establish the format for specific learning activities, and the LRS stores the declarations and defines the communication method for sending and receiving data.

In 2016, cmi5, a complementary specification to xAPI, was released, which establishes a set of rules for interoperability in a traditional LMS environment and uses xAPI as the communication protocol and for the data format. The new specification structurally defines the course that will be packaged and imported into the LMS. According to xapi.com, cmi5 introduces the concept of a learning session and has specific rules for capturing a basic set of data for learning experiences. It also defines the rules for interoperability between the LMS and learning activities enabled through xAPI.

3. Some authoring tools for creating SCORM content

In the article "Choosing Authoring Tools" (2016), an official resource of the ADL Initiative, Peter Berking defines authoring tools as "software applications used to develop e-learning products". These tools allow the creation, editing, configuration and testing of e-learning products. They can be advanced software platforms, applications or simple utility programs capable of transforming Powerpoint presentations into web pages. The major advantage of these tools is the accessibility of the interface, which allows users without technical knowledge to use them. Therefore, authoring tools reduce the requirements for programming skills in the process of obtaining e-learning products.

Most applications automate time-consuming tasks, optimize workflows, and offer simplified and more efficient approaches to the sometimes cumbersome creation process. Creators have a wide variety of applications at their disposal, from freeware or even open source to commercial products. With the widespread adoption of the SCORM standard, authoring tools have experienced exponential growth, becoming essential skills for educators using various learning management systems. They have also allowed the creation of large libraries of educational content, which have thus become Open Educational Resources, easy to reuse, distribute, or integrate across different platforms.

According to techsciresearch.com, the Global E-Learning Authoring Tools Software Market was estimated at USD 6.16 Billion in 2024, and is growing steadily. This trend is driven by the increasing demand for personalized learning experiences that meet the particular needs of learners and the significant global shift towards distance education, which requires the digitization of learning processes. Rapid technological advancement is also a determining factor, especially the integration of artificial intelligence. The report also discusses the challenges faced by this market, including the complexity of more advanced platforms, which can discourage creators without specialized technical skills.

Given that in recent years, many educational institutions, especially in the context of the pandemic, have used virtual environments, both for synchronous and asynchronous learning, the demand for interactive and attractive digital content has continuously increased. Educators have had to adapt quickly to this requirement, without having time to improve their technical skills. This gap had to be solved through tools with intuitive and easy-to-use interfaces, but which lead to attractive results, from multimedia lessons to interactive exercises to consolidate knowledge. The aforementioned study presents the example of Coursera, to demonstrate the appetite for online learning, which for the third quarter of 2024, added over 7 million new registered learners, reaching a total of 162 million registered learners.

We continue to present several Authoring Tools, both open source or free solutions and commercial ones, some more complex, requiring increased effort from content creators, others more accessible, but with spectacular results. Thus, eXeLearning is an open source application developed within the eXe project, with the aim of offering teachers support in publishing web-based materials, without them knowing HTML or XML. The initiators started from the need for a tool that would help especially university teachers, to obtain courses in accordance with an academic structure, which could be integrated into existing LMS platforms. The project was made possible thanks to funding from the New Zealand Tertiary Education Commission in 2004. Then in 2007, it was continued, with the involvement of CORE Education. To date, eXelearning has gathered a global community of contributors, who help the development of new technologies.

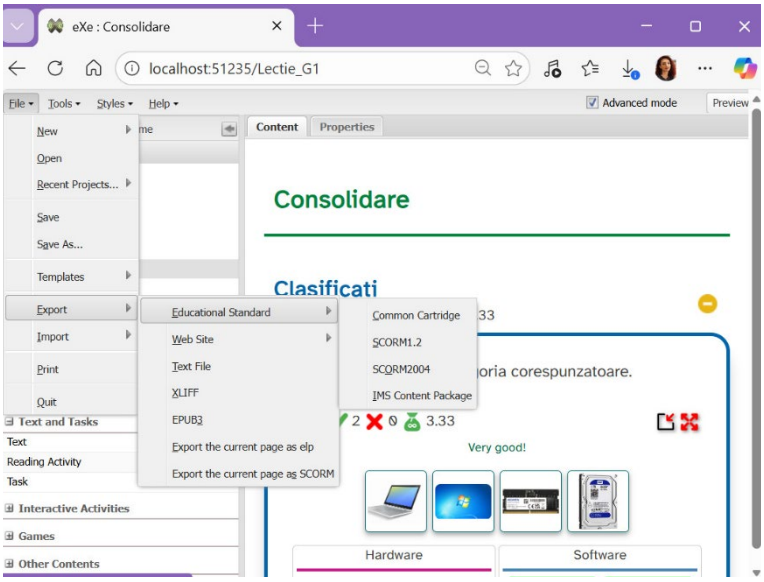

Figure 1. eXeLearning 2.9

In creating interactive lessons, the application uses formal elements that the creators have called instructional devices or iDevices. These iDevices are structured according to the items in the pedagogy, so as to allow the creation of a coherent scenario from a didactic point of view, especially for online learning. With the launch of version 3.0.0 in October 2025, eXeLearning officially moves to the stable 3.0 line, representing a major change compared to previous versions, whose editing interface was accessed via a web browser. This new version includes all the functionalities and corrections implemented in the beta and release-candidate (RC) periods until the time of launch. The interface is modernized, and the iDevices elements are updated. eXelearning offers full support for local installation, for the most popular operating systems, ensuring the necessary portability. It also allows collaborative editing, facilitating teamwork, in the online version. But, according to Releases · exelearning/exelearning, SCORM 2004 export has been temporarily removed.

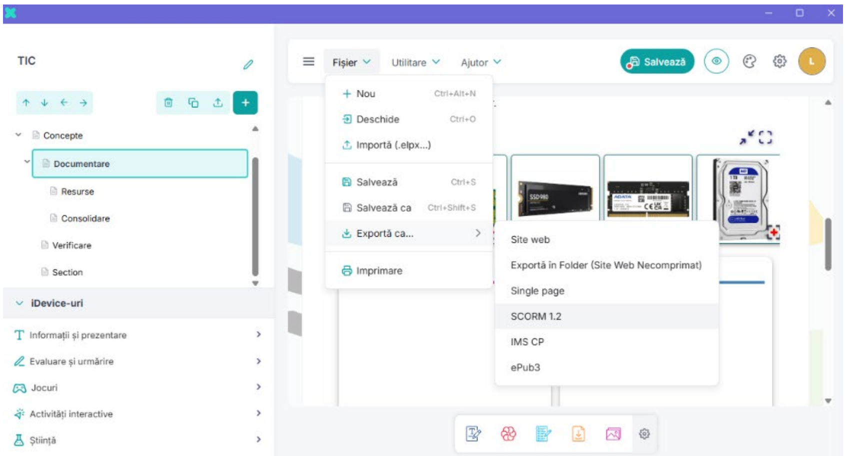

Figure 2. eXeLearning 3.0.0

LearningApps.org is a free Web 2.0 application designed to support teaching and learning processes with interactive exercises that can be grouped into collections according to a specific plan or scenario. These modular exercises can be used directly in different lesson sections to achieve specific objectives, but they can also be used for individual study. Being a free tool, content creators have contributed to building a large library of mini-applications that can be filtered by discipline or level of education. The so-called Apps are not complete lessons or courses, but their export in SCORM format allows their incorporation into materials created with more advanced tools, such as the commercial application presented below.

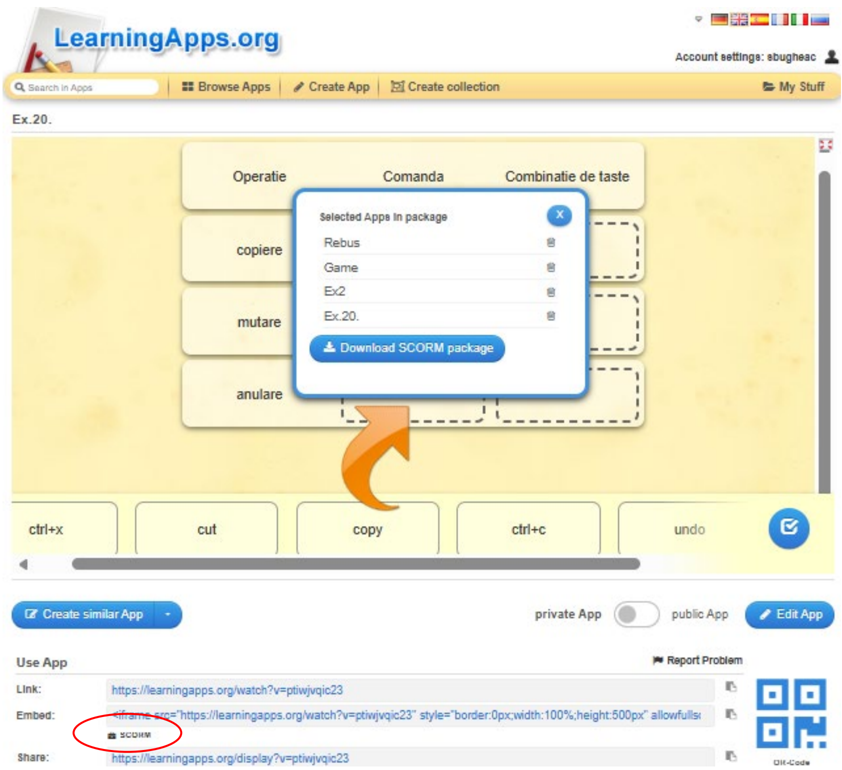

Figure 3. SCORM export in LearningApps

Next, we present an intuitive and accessible web platform, launched in 2016, with which teachers can create courses or interactive lessons. Although it is developed by a commercial company, teachers can access Wand through free Wand Create accounts, which offer 512 Mb of storage space, 15 activity templates and even the ability to create student classes and obtain progress reports. However, in order to obtain the respective lessons in SCORM format, they must be registered for the Wand Inspire level, possibly through accounts provided by the educational institution in which they work.

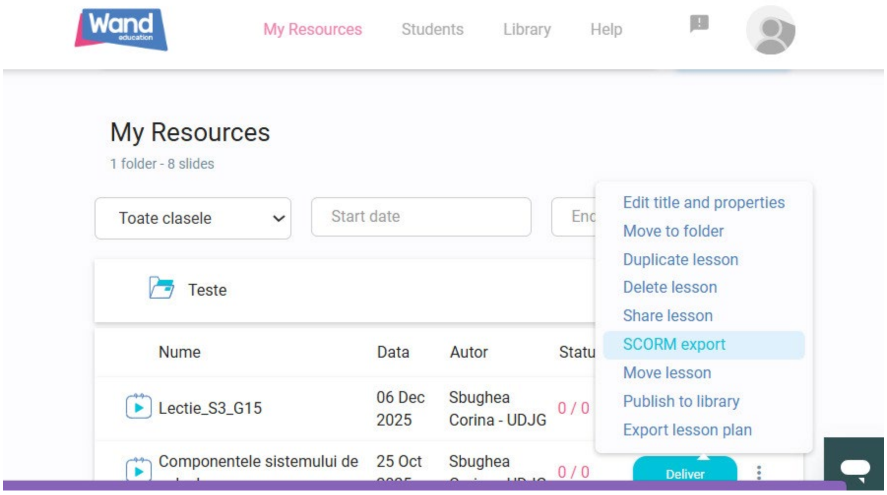

Figure 4. Wand Education

An interesting activity template that can be added to the lesson is the Virtual Laboratory, which allows the author to incorporate SCORM archives, regardless of the tool with which they were created (for example LearningApps or eXeLearning), thus achieving specific objectives.

But the most useful feature offered by the superior account is the possibility of generating lessons with Artificial Intelligence. The user must specify the level of education, the level of difficulty, the most accurate description of the requirement and even the activity templates that will be included. The generated lesson can be reviewed and completed later by the teacher and then exported in SCORM format to be integrated into an LMS.

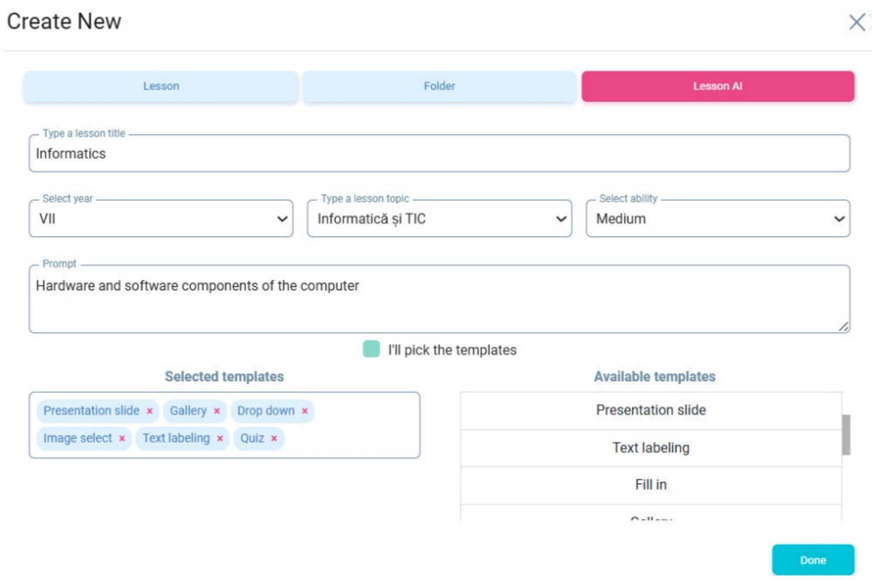

Figure 5. Lesson AI in Wand Education

If the SCORM standard was created to ensure standardization of e-learning content delivery and tracking, the question arose as to what the next stage in evolution was. SCORM 2024 represented a step forward in adaptability, although the rules are static and predefined. Today Intelligent Tutoring Systems (ITS) use learner models and artificial intelligence to dynamically adapt the learning path.

The limitations of SCORM in terms of collecting detailed data and making pedagogical decisions have led, in the AI era, to the adoption of more flexible standards, such as xAPI and cmi5, which facilitate the integration of ITS components into modern LMS systems. The new technology uses artificial intelligence that simulates the behavior of a human tutor, able to dialogue with the student. The most advanced systems are able to interpret the explanations of the learners and can adapt the pedagogical strategy and the answers provided, following the continuous assessment of the student's understanding.

Thus, Intelligent Tutoring Systems use artificial intelligence (AI) for adaptive learning, by analyzing students' learning patterns, to develop personalized learning processes, optimizing their performance. By using artificial intelligence, students' strengths and weaknesses can be identified and then their teaching strategies can be adapted to meet the individual needs of the learners. An example in this sense is the

Generalized Intelligent Framework for Tutoring (GIFT), developed by the ADL Initiative, to make the transition from content-centered delivery standards (SCORM) to adaptive educational systems based on artificial intelligence.

4. Bibliometric analysis

This short bibliometric note starts from a dataset exported from Scopus and processed in Biblioshiny/bibliometrix. The time window 2010-2025 includes 19,895 documents published in 2,293 sources, which already hints at a large field and, honestly, a pretty fragmented editorial landscape. The annual growth rate (23.48%) suggests the topic is not "settled" yet. It keeps expanding, mostly pushed by AI methods entering education and by the constant appetite for online learning solutions.

On the collaboration side, the dataset shows an average of 7.81 co-authors per paper and an international co-authorship share of 21.47%. So there is real cross-border work, but it is not a fully "global team by default" domain either. National and regional research cores still matter, and you can feel them in the network views.

The country collaboration network can be read like a map of co-authorship routes: larger nodes mean higher output, and thicker links mean collaborations that happen more often. In Figure 6, the center of gravity is hard to miss. China stands out both by volume and by its role as a connector. There are strong, repeated links from China to the USA and to the United Kingdom, and a very visible connection to Hong Kong, which makes sense if a large share of the work circulates inside the same academic-geographic space.

Around this core you can still see secondary "platform" countries (for example Australia and Korea), plus many smaller nodes spread across Europe, Asia, South America and Africa. What is interesting is that many of these nodes are connected, but often through thin lines. That usually means collaboration exists, but it is more punctual: one project, one consortium, one short phase. In other words, the field is global in geography, but not equally global in intensity.

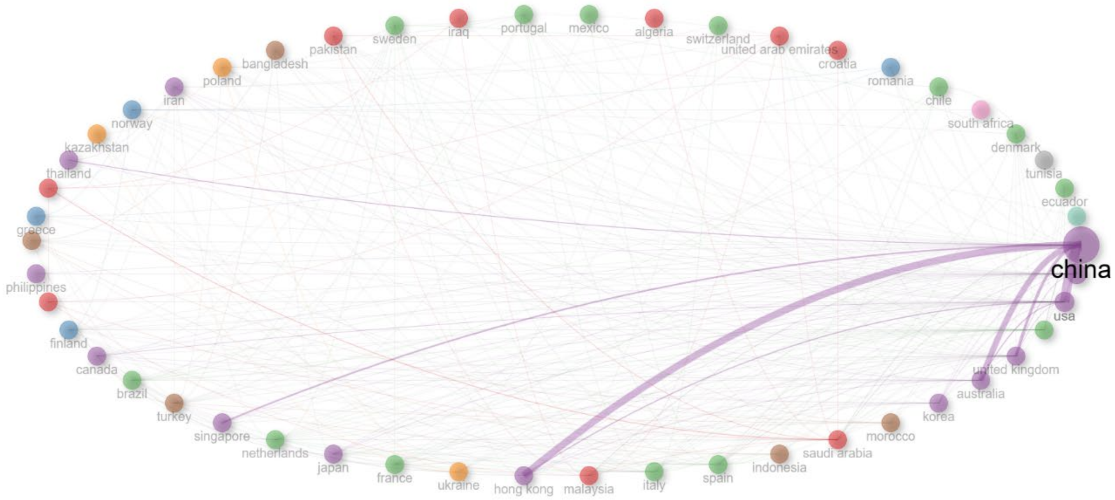

Figure 6. Country collaboration network (2010-2025)

A co-word (co-occurrence) map shows how ideas are linked in the literature: terms that appear together frequently move closer and form clusters. In Figure 7, the two big anchors are e-learning and learning systems. Most other topics seem to organize around them.

Close to this core, two strong technical poles are easy to spot: machine learning and deep learning. That is a sign the discussion is not only about platforms or course delivery, but also about predictive models, classification, and algorithms that learn from educational data. The presence of terms like students, learning algorithms, and student performance close to the center suggests a practical direction too: applications focused on outcomes (prediction, personalization, early warning signals).

On the periphery, you start seeing "younger" or more specialized themes. Federated learning and adversarial machine learning show up as distinct nodes: connected to the core, but not as deeply integrated as ML/DL. Quietly, that says privacy (distributed training) and robustness (adversarial settings) are gaining ground, even if they are not yet as mainstream as deep learning in education.

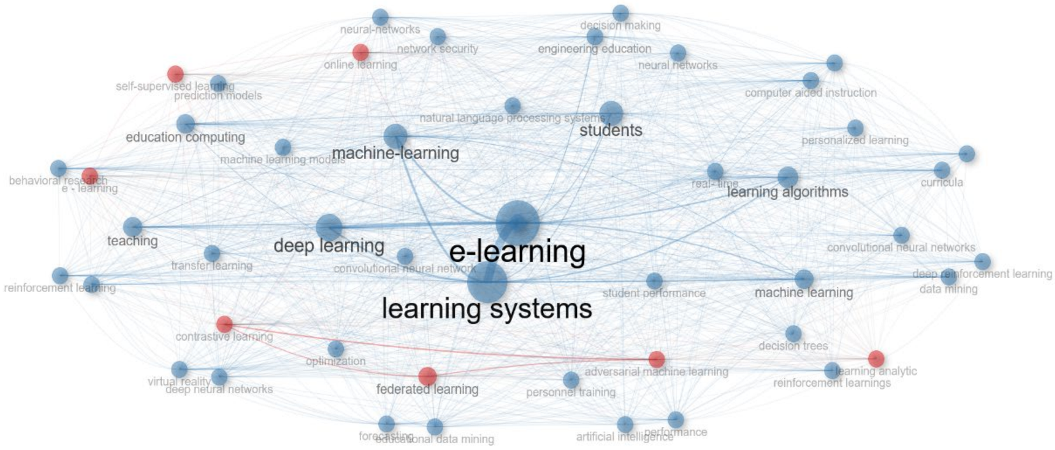

Figure 7. Co-occurrence network of keywords (co-word)

The three-field plot (Sankey-type) is useful because it answers three simple questions in one view: who publishes, where they are based, and what topics they connect to. In Figure 8, the visible author list is dominated by very frequent names typical for the Asian publishing space (Wang, Zhang, Liu, Chen, and similar), which aligns with China being the main country in the middle column.

In the country column, after China, India and the USA appear as major poles, followed by a group of countries with smaller volume but still present in the flows (United Kingdom, Australia, Germany, Indonesia, Korea, Saudi Arabia, Morocco). Practically, it looks like a mix of big research ecosystems (China/India/USA) plus several hubs that connect into collaborations or niche themes.

On the keyword side, the thickest streams go toward machine learning and deep learning, then toward online learning, educational data mining and learning analytics. It is also worth noticing the branches toward reinforcement learning (including deep reinforcement learning) and personalized learning. That feels like the literature is trying to move from "platform talk" to adaptive mechanisms: recommendation, real-time feedback, and personalization.

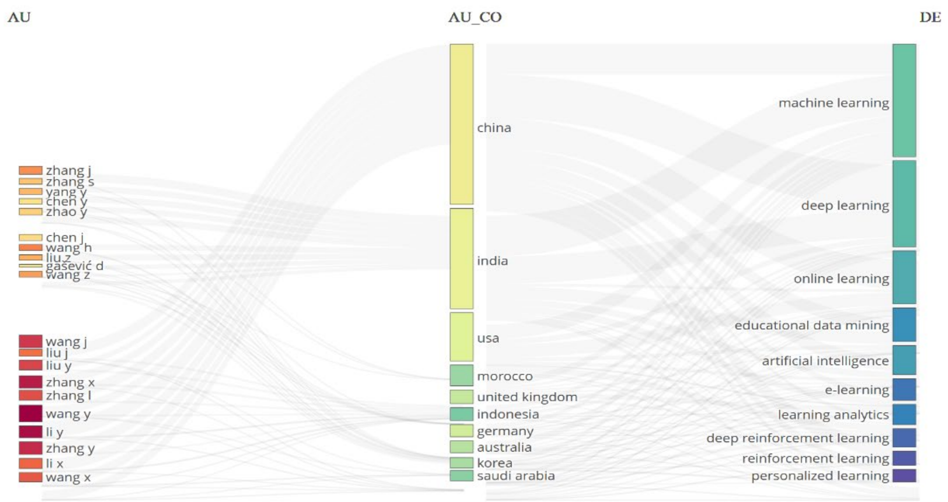

Figure 8. Three-field plot (Authors - Countries - Keywords)

The word cloud (Figure 9) confirms the same big picture, but in a more intuitive way. Learning systems and e-learning sit in front, with deep learning and machine learning right behind. At the same time, smaller but telling signals appear: federated learning, adversarial machine learning, and contrastive learning. This is a hint the field is not only about applying DL "as-is", but also about how to train models when data are sensitive and distributed (federated), and what to do when models can be attacked or fooled (adversarial).

On the pedagogical side, terms such as teaching, students, curricula, and computer-aided instruction keep the link to education itself, not only to algorithms. So even if the technical vocabulary is loud, the educational framing is still there, and it shapes what is considered useful or publishable.

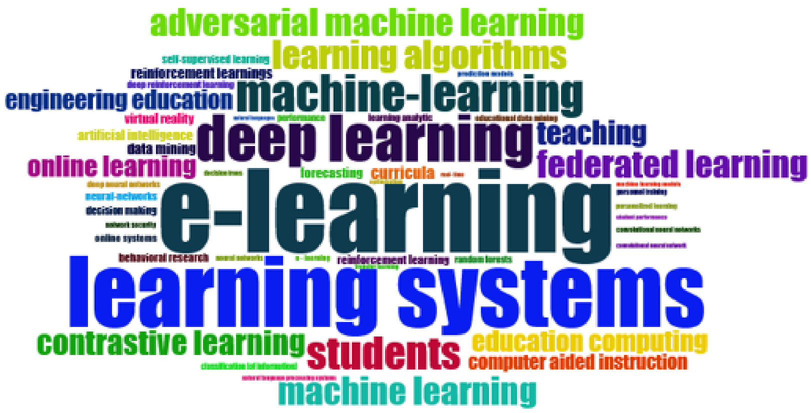

Figure 9. Word cloud of dominant terms

Factorial analysis projects terms into a two-dimensional space so that items that occur in similar contexts group together. It should not be read as a strict "geographic" map, more like a sketch of thematic neighborhoods. In Figure 10 we can see three rather clean zones.

In the upper-left (blue cluster) we have education computing, computer-aided instruction, teaching and students: the classic educational technology side. In the lower-left (red cluster) e-learning groups with machine learning and deep learning, which reflects the growing overlap between learning platforms and analytics/prediction tools.

On the right (green cluster) we see online learning together with federated learning and adversarial machine learning. This looks like a frontier area: themes coming from "serious" ML that enter education either because of scaling needs (online learning at large scale) or because of security and privacy concerns. If I had to summarize, the map suggests a mature core (e-learning + ML/DL) and fast-growing extensions toward distributed and robust approaches.

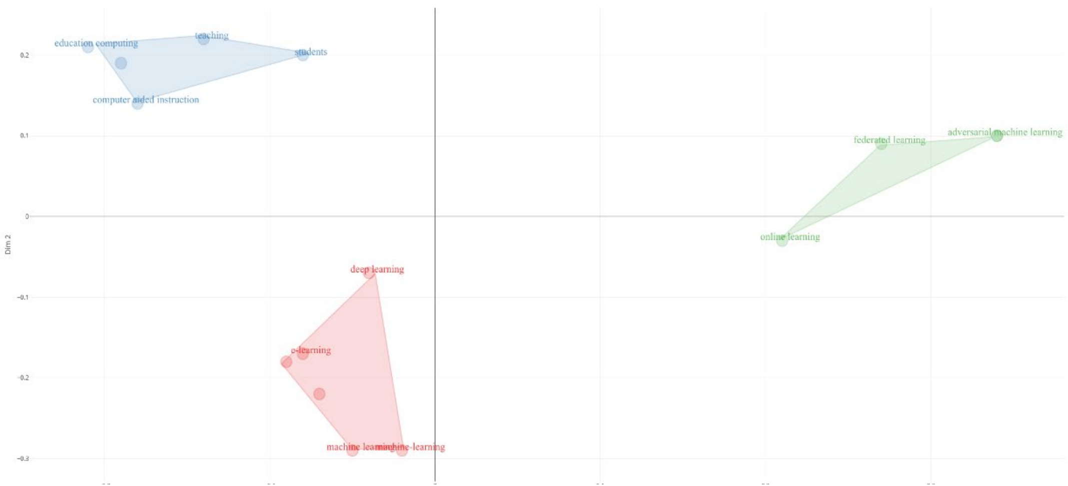

Figure 10. Factorial projection of concepts (MDS)

Putting the analysis together, the dataset describes a fast-expanding research area where e-learning and learning systems form the stable center, and machine learning / deep learning supply most of the methodological fuel. The geographic side is clearly global, but the intensity is uneven: China is the main hub, with strong ties to the USA and the UK, while many other countries connect through lighter, project-based links.

At the same time, the maps hint at what is "next": privacy-aware training (federated learning), robustness and security (adversarial ML), plus a push toward personalization and reinforcement learning. It's not a linear, clean trend. It is more like a core that keeps growing, with new technical branches attaching themselves as soon as they become useful for real educational settings.

5. Conclusions

Many benefits of implementing intelligent tutoring systems with big data analysis capabilities have been highlighted in the specialized literature. Tutoring systems integrated with artificial intelligence can use natural language processing and machine learning techniques to evaluate student responses and determine individual progress by analyzing their learning behaviors. (Lin, Huang, Lu, 2023). The same authors highlight the advantage of accessibility and flexibility introduced by this technology, by going through the course at the student's own pace. Intelligent Tutoring Systems also provide equal access to education, regardless of geographical area or financial status. But these advantages also come with a downside. Artificial intelligence can "learn" and propagate human prejudices. However, new technologies have revolutionized educational processes by reducing teacher efforts, through automatic assessments, but especially through student-centeredness and adaptive learning.

The topic of ethics and integrity in the use of generative AI in educational contexts has also been addressed by authors such as Bozkurt (2024). Starting from the conceptual hierarchy, data – information – knowledge – wisdom, the role of AI in generating information, previously obtained only through human contextualization and interpretation, is analyzed. The question thus arises whether automatic data processing, brought about by technological progress, can truly influence human wisdom by generalizing and abstracting synthetic information (obtained with AI).

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