Redesigning Personal Learning Environments: Consolidation of Empirical Findings and Conceptual Research Against the Background of a National Educational Infrastructure

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Abstract: Personal Learning Environments (PLE) are often associated with learning spaces that offer learners the ability to structure and self-regulate their learning processes. From a technical point of view, current learning spaces are often fragmented and do not comprise educational content, services, and tools within a shared learning space. In this paper, we present our findings from an empirical study conducted with (n=)32 samples of students, to identify the present needs for designing a networked digital learning space. Furthermore, we break down how we integrate and/or redesign existing educational services, technologies, and tools to align with the current demands. We enhance the discourse on the added values of functionalities for a national digital educational infrastructure by categorizing them according to the SAMR model. SAMR is an acronym for Substitution, Augmentation, Modification, and Redefinition. This categorization enables a more differentiated understanding of the components within a PLE and how they interact. Based on such an understanding, characteristics for an efficient e-learning infrastructure can be determined from the learner's perspective.

1 INTRODUCING A NATIONAL INFRASTRUCTURE FOR EDUCATION

During their lifelong learning path, individuals frequently encounter challenges associated with both vertical and horizontal transitions. Vertical transitions involve moving across different educational sectors, such as transitioning from school to higher education. During these transitions, individuals must repeatedly recompile personal data and educational materials. Horizontal transitions refer to movement within the same educational sector, such as when students transfer between universities or participate in international education programs. Generally, both vertical and horizontal transitions present challenges in the continuity and recognition of educational progress in a digital learning environment (Knoth. et al., 2022).

In 2021 the German Federal Ministry of Education and Research (BMBF) initiated the development of a National Infrastructure for Education, designed to interconnect learners, educators, and educational offerings (BMBF, 2021). This initiative aims to allow learners to seamlessly construct their individual lifelong learning pathways, transitioning from one educational offering to another throughout their lifetime. An open beta version is announced for 2025. The prototype of this infrastructure and the subject of this article is developed in the BIRD Project. BIRD serves as a technical reference and also provides associated research results (Knoth. et al., 2022).

In a previous project, more than 170 user stories were collected from learners and teachers. This systematic description was further condensed into concepts of a Personal Learning Environment (PLE) (Kiy et al., 2014), which constitutes a component of the initial feasibility study and continues to represent the core of the BIRD prototype (Bustorff et al., 2023). Additional components were implemented, such as the Learning Path Finder (LPF) to support users with personalized recommendations based on their concerns and shared data, showcasing educational of-

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ferings and diverse information for potential educational pathways (Ziemann et al., 2023). Moreover, the Buddy Finder (BF) is currently being introduced by BIRD to facilitate mutual exchange among users. It is tailored to improve user interaction and collaboration, fostering a community-oriented approach to learning and knowledge exchange (Eilebrecht and Beskorovajnov, 2025). A fundamental premise in the conception of the prototype was to not replace established offerings, but only to interconnect them and thus to supplement them with new functions, tools or usage options (Lucke, 2024). For this reason, we rely on the SAMR model (Puentedura, 2006) as a sorting key for dealing with educational services. In this article, we compare the idea of expanding existing services both from the empirical perspective of a user survey and from a conceptual point of view and condense both into a more nuanced understanding of PLEs.

The remainder of this article is structured as follows. In Section 2, we review current strategies for personal, smart or adaptive learning environments. Then we examine the findings from user surveys and studies on digital learning spaces in higher education in Section 3, focusing on student expectations and experiences. This is further elaborated in Section 4 with a description of the BIRD prototype as a realization of a PLE. After a brief recapitulation of the architecture, components and functions of the infrastructure, particular attention is paid to the analysis according to the SAMR model. Based on this differentiated understanding, a concept of a PLE within the national educational infrastructure is outlined in Section 5. Conclusively, the findings are summarized and an outlook on future directions for research and development is given.

2 EXISTING APPROACHES FOR PERSONAL LEARNING ENVIRONMENTS

Though the notion of a PLE has existed for some time, it has been thus far understood from a personal or institutional perspective (Ebner and Taraghi, 2010; Buchem et al., 2011; Hafer et al., 2014). Different patterns for PLE implementations have been identified (Kiy and Lucke, 2016), while all have in common to put the learner in control of his own learning process for accomplishing the desired learning goals. Before the advent of virtual solutions, analog and later hybrid solutions already existed that included physical notebooks, filing systems, study groups, libraries, resource centers, et cetera, but the flexibility and broad range of connecting various digital content, services, and tools via the internet was a major driver of previous digital PLE developments.

Personal contexts are far more common for PLE than institutional ones (Kiy and Lucke, 2016). Yet, typical IT services especially in higher education institutions continuously evolved towards a consistent ecosystem (Hafer et al., 2014), which could sometimes be considered a PLE like the Potsdam (Kiy et al., 2014) or Graz (Ebner and Taraghi, 2010) solutions. Both have a modular approach that combines existing components such as widgets or (micro) services. Further debate on PLE conceptions is dominated by smart or adaptive approaches, fostering the potential to adjust the offered content or tools to the current needs of the users based on analyzing their data traces in the system. This might be more promising as more data becomes available and more systems are involved, which has brought forth visions of a larger data ecosystem (BMWK, 2024; Degen et al., 2025). At the same time strong concerns have been raised both on pedagogical (Schiefner-Rohs et al., 2024) and on ethical issues (Wiegerling et al., 2020) of such data-driven approaches.

Cross-institutional approaches have so far remained a vision (Kiy et al., 2014), not to mention national approaches. There have been attempts like the US initiative ”in Bloom” for K-12 education, which were shut down amid vociferous discussions. Data security issues have come to the fore, however, different paces in the technology and education sectors may also have been an obstacle (Bulger et al., 2017). Similar situations have arisen on state level in Australia (Tatnall and Davey, 2018). Furthermore, in some cases teachers refused to migrate to a new platform due to the lack of advantages compared to existing solutions they had in place (Jørgensen et al., 2023), while in others initiatives have proven productive because they fulfilled a need (Partners et al., 2021). This emphasizes the need for an approach that combines user requirements, existing services and the potential benefits of connecting them. The approach should range from replacing, modifying and extending to supplementing.

3 EMPIRICAL FINDINGS ON THE ADVANCEMENT OF LEARNING SPACES

This section reports results of a study that investigated wishes and experiences of students in digital learning spaces in higher education (n=32 students). The aim of this study is to explore the needs of students in digital learning spaces and to identify potential directions for building an educational infrastructure by redesigning or remodeling existing personal learning spaces. As this is an exploratory study aimed at gathering preliminary insights on the needs of students rather than drawing definitive conclusions, we assert that the smaller sample size does not compromise the validity of the study. Furthermore, we support our preliminary findings with follow-up studies, which are beyond the scope of this paper.

In this regard, this study investigates the following research questions:

- What are the expectations of students for a digital learning space?
- How do empirical findings contribute to the identification of components and features for designing a learning space?

Before we delve into the findings of designing learning spaces, we attempt to familiarize the concept of digital learning spaces and highlight their role in redefining learning processes. Digital Learning Space, per se, refers to a decentralized collection of educational solutions and digital resources that are constructed on existing technical structures, pedagogical practices, and organizational infrastructures (Bygstad et al., 2022).

In this research, we use the existing body of knowledge to design, remodel, and reuse existing learning spaces. In addition to that, we derive inputs from a sample of students through an empirical study that was conducted in order to support the present needs for designing a networked digital learning space, i.e., the flexible combination of different educational tools in an adaptive infrastructure (Kiy et al., 2014).

The collection of data follows a learner-centered design approach - where we distributed a self-designed survey (or questionnaire) among university students with different disciplines and educational backgrounds. A custom-designed questionnaire was used to address the research objectives i.e. to assess participants' perceptions of digital learning environments, as no existing standardized instrument addressed the specific variables of interest [networking opportunities, organizational tools, collaborative features, support mechanisms, personalized suggestions, and customization options]. Since the study involves understanding the experiences of students within digital learning spaces, we targeted users of Moodle.UP and Campus.UP. Moodle.UP is the central learning management system provided by the university to manage courses, course materials, examinations, and registrations to students. Campus.UP is a flexible learning environment where services such as Moodle, Cloud storage, Mail system and the University library system are all connected to the platform. It also allows users to create digital workspaces to manage and organize their own learning processes.

Out of 42 students who participated in the study (Moodle.UP = 37; Campus.UP = 5), we received 32 completed questionnaires (Moodle.UP = 28; Campus.UP = 4). Therefore, we excluded 10 incomplete questionnaires from our evaluation. The student population was spread across six faculties, and were experienced with digital learning for over 5 years (Moodle.UP = 43%; Campus.UP = 60%).

The questionnaire was designed in such a way that it would take as little time as possible to complete (SD = 10.0 minutes) (Campus.UP = 36 questions; Moodle.UP = 21 questions). We integrated questions that aligned with our research scenario: (i) experiences of students in digital learning spaces, (ii) experience with Moodle.UP or Campus.UP platforms, and (iii) expectations for improving digital learning spaces.

As mentioned in the introduction, our fundamental goal with this study was to explore established offerings, by supplementing them with new functions, tools, and usage options. Taking this into account, we formulated our questions, with the aim of conceptualizing further functionalities for our components. The following information is requested from the users:

1. Experience with digital learning space
   - Usage frequency of collaborative tools,
   - Familiarity with sharing, privacy protection, organizing learning processes,
   - Experience with digital learning and content management systems
2. Experience with digital learning and content management systems
   - Help and support function,
   - Desired additional features one likes to have,
   - Additional improvements on existing tools,
   - Further tools
3. Wishes for a digital learning space
   - Interaction and Connectivity,
   - Functionalities for a personal workspace,
   - Privacy measures
4. General information
   - Interaction and Connectivity,
   - Functionalities for a personal workspace,
   - Privacy measures

On average, students reported that they use digital collaboration tools almost every day (2-3 times per week). Furthermore, the measures on the ability to organize one's own learning pathway, and to find suitable digital tools were higher compared to previous semesters, revealing that the situation of technology use has changed with more students having digital literacy.

A previous study (Bond et al., 2018) reported that students and teachers use a limited number of digital tools for predominantly assimilative tasks, with learning management systems perceived as the most useful tool. The current investigation has revealed that students are open to trying out new digital learning spaces with improved functionalities – networking opportunities with other learners, and an open environment to organize, configure, and receive support for performing learning activities (Table 1).

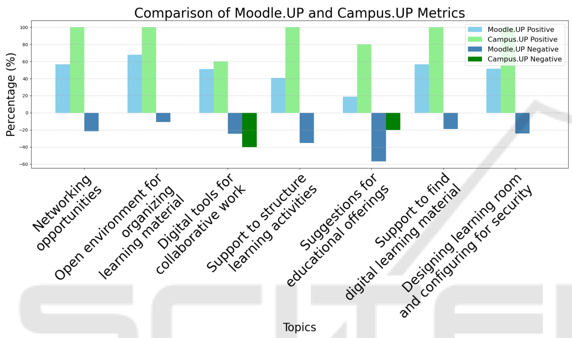

Figure 1: A closer look at the agreements and disagreements of students on "how useful the mentioned functionalities" are for a digital learning space.

Figure 1 provides a visual representation, with data along the positive axis indicating agreement with the specified functionality, while data along the negative axis reflects a lack of preference towards the specified functionality. Notably, the majority of students show an indifference towards digital tools for collaborative work, as well as for suggestions regarding educational offerings. Nevertheless, table 1 indicates significant variability in these mentioned aspects, implying that the questions formulated to assess these aspects may have been either unclear or insufficient to elicit a definitive response.

As a supplementary remark for this section, we point out that the data presented here shows only one facet of the project. Multiple studies and extensive research works were conducted to derive the holistic ecosystem. The scope of this research is to discuss the technical components, their functionalities, and compare the different elements against the SAMR model categories.

Table 1: Descriptive statistics on student preferences for a digital learning space. The Likert scale data indicates the most frequent response: 1 = Totally disagree, 2 = Disagree, 3 = Agree, 4 = Totally agree. Rows marked with "High variability" show wide-ranging perspectives.

Statement	**N Moodle (Campus)**	**%**	**Mean (SD)**	**Likert Mode**
My digital learning space (DLS) offers me the opportunity to network with other learners.	17 (4)	45.95 (80)	2.86 (3.2)	3
An open environment allows me to organize my learning material.	20 (4)	54.05 (80)	3.03 (3.2)	3
DLS proactively supports me in structuring my learning activities.	13 (4)	35.14 (80)	2.57 (3.2)	3
I think it is good when my DLS supports me in finding learning material.	18 (3)	48.65 (60)	2.78 (3.4)	3
I can design my DLS individually and configure it according to my private security needs.	13 (3)	35.14 (60)	2.85 (3.4)	3
I cannot find digital tools for collaborative work within my DLS.	High Variability			
My DLS proactively supports me in structuring my learning activities.	High Variability			
In my DLS, I receive suggestions for educational offerings that match my profile.	High Variability			

4 CROSS-INSTITUTIONAL INTEGRATION OF EDUCATIONAL SERVICES

In this section, we provide a short recap on the technical aspects of the national digital education space. It implements the user needs for learning spaces as identified above, as well as some other functionality for education, and can be understood as a PLE. This PLE is analyzed by using the SAMR model (Puentedura, 2006) with a special focus on the defined interfaces, which provide the means for flexible combination of educational services.

4.1 Architecture of the National Digital Infrastructure for Education

The architecture of the BIRD prototype contains the following main components (Knoth. et al., 2022):

- The frontend is realized as a web application through which the connected educational services are accessible in an integrated form. This portal comprises various sections where users can manage their own educational data, discover relevant educational offerings, and engage in exchange with others.
- The middleware constitutes the core of the infrastructure. Operating in the background, it facilitates data exchange between various educational offerings through the developed interfaces and data structures. Notably, this includes the implementation of Single Sign-On (SSO) (allowing access to different services with just one account) and Metadata Management (for managing the properties of connected contents, tools, etc.).
- The personal wallet, typically hosted on a smartphone, stores certificates and learning artifacts acquired during an individual's educational journey. Educational services can request these documents via the middleware. Upon authorization by the user, they can be directly transmitted to the respective service. Importantly, there is no central storage or transfer of personal data within the middleware.

Other educational providers can connect their services with the infrastructure via the defined interfaces to SSO, metadata and wallet. Depending on the depth of integration, these services either retain their existing user interfaces and merely benefit from the data exchange across the infrastructure, or they are integrated more seamlessly as an infrastructural component using the shared frontend. Thus, the added value relies on the existence of third-party educational repositories and other educational services, that shall not be replaced, but connected and extended.

4.2 Required Components and Functions

Utilizing the existing structure of prototype components as a guiding framework, student wishes were categorized against the BIRD components. Table 2 shows the main components, dimensions, and the corresponding functionalities derived from the empirical study.

Table 2: Clustering wishes of students for a digital learning space against existing BIRD components.

Component	**Ecosystem dimensions**	**Functionalities**
(I) Learning Path Finder	Digital infrastructure	Support in finding suitable digital learning materials; Bundled provision of digital services and offers
(II) Buddy Finder	Communication and Collaboration	Provision of networking opportunities; Provision of digital tools for collaborative work
(III) Data Wallet	Data model	Openness of data; Customization of data handling mechanisms
(IV) Personal workspace (Arbeitsbereich)	Interaction and technical interoperability	Ability to organize learning materials; Ability to structure learning activities
(VI) Integration of existing services	Additional tools	Collaborative text/canvas; Personal calendar; Etherpad; Miro/Mind maps; Surveys; Archive management; Integrated zoom; Word-cloud generator; Presentations; Exam administration system

- The Learning Path Finder (LPF) primarily presents students with personalized selections of educational offers and information. With the identified student needs, the LPF should also aid in discovering appropriate digital learning materials and ensure a centralized provision of digital services and offers (Ziemann et al., 2023). This assimilation is crucial in promoting a seamless learning experience (Zimmerman, 1994).
- The Buddy Finder (BF) is a new approach to anonymously connecting peers (Eilebrecht and Beskorovajnov, 2025). It can be considered central to the Communication and Collaboration dimension. Based on the results, it emerges to be a significant feature to offer ample networking opportunities.
- The Data Wallet ensures openness and transparency of data, and allows customization to data handling mechanisms. The crucial dimension of this component is the freedom to manage one's own data according to their preferences while ensuring open access to necessary information.
- The Personal Workspace pertains to the Interaction and Technical Interoperability dimension. It provides users with the ability to organize learning materials and structure their learning activities

effectively. With this component, the infrastructure achieves well-structured interactions and operational compatibility, thereby simplifying and enhancing the learning process.

- Furthermore, users mentioned additional tools they would like to include into the ecosystem. The findings are presented in the 'Integration of Existing Services' component. Users wish to integrate a variety of additional tools such as a collaborative text/canvas, personal calendar, collaborative editors, virtual whiteboards/Mind maps, surveys, archive management, integrated video conferences, word-cloud generator, presentations, and an exam administration system. These tools not only augment the learning experience but also ensure an uncomplicated and comprehensive utilization of the available resources.

A Learning Guidance was added subsequently, which completes the E-learning arrangement. It is based on the concept of self-regulated learning and thus represents a component that supports learners both in their learning process and in navigating between the other components (LPF, Buddy Finder, Data Wallet, Personal Workspace, etc.). A chatbot supports the learner through the cycle of self-regulated learning (D'Mello and Graesser, 2012) with hints, references and explanations. The concept of the Learning Guidance is based on theoretical findings and should be evaluated in a further study.

To further validate the findings, qualitative investigations (n = 7) were carried out in the form of interviews on the BIRD prototype (Bustorff et al., 2023), where different concepts were tested. These concepts covered a range of functionalities that were discussed above, and can be categorized as follows:

1. Recommendation for individual educational path
2. Information on individual educational pathways
3. Protected digital file folder
4. Exchange of ideas with other learners
5. Evaluation of one's own educational path
6. Desired specifications
7. Handling of data
8. Login and usage behavior

In the next sections, we will sort the listed components (as shown in Table 2) inline with the SAMR categories and discuss the evolution of personal learning environments with respect to the national educational infrastructure.

4.3 Positioning in the Media Ecosystem

Our method of classifying the types of values follows the SAMR model (Puentedura, 2006). It represents a framework used to evaluate how technology is integrated into teaching and learning processes. SAMR stands for Substitution, Augmentation, Modification, and Redefinition. It suggests that as educators move through these levels, they are leveraging technology to increasingly enhance and transform learning experiences, moving from merely enhancing traditional practices to enabling entirely new possibilities for teaching and learning.

Categories that appear higher in the framework correspond to greater innovation. The following table (3) describes the functions of the PLE approach that were identified during the design of the prototype based on the three dimensions of functionality (Bustorff et al., 2023).

In the next section, we dive deeper into those categories and what they imply.

- Substitution: The national infrastructure for education is not intended to substitute already existing educational services. The meta-platform should not have the functionalities to serve as a Learning Management System (LMS). School Clouds and LMS of Higher Education Institutes (HEI) can be used seamlessly with our approach. Another example is digital credentialing. Digital credentials only serve as certified copies of their analog 'originals'. All tools integrated in the infrastructure serve as extensions for existing formal and informal e-learning scenarios and contexts. Only fully integrated editors could be seen as substitutions, if they replace existing proprietary office software suites.
- Augmentation: We utilize existing LMS and add new functions, for example, options for transferring data and artifacts with the wallet and the platform, SSO, and the use of external databases (the data room). Upon integration into our data ecosystem, they can be augmented with metadata for searches and repositories for learning artifacts. Web 2.0 brought new spaces and tools for learners. Even spaces that are not designed for learning, such as YouTube, are frequently used by learners. In 2020, 83 percent of German students between 12 and 19 used Youtube for learning purposes (mpfs, 2020). This bottom up approach in conquering new technologies for learning can be seen as a form of hacking. The same can be observed with social media services, where a lot of informal learning takes place. Recent publications refer to micro learning or improving lan-

guage skills with Instagram or TikTok (Heilmann, 2024). Open-Source services of the Fediverse (like Mastodon) could be added to give learners more networking possibilities.

- Modification: With the “Working Space” we offer users a highly customizable virtual desktop, that allows them to collaborate with others, and use innovative tools. The “Working Space” is independent from local devices. It enhances reuse and promotes the remix culture (OER movement) by providing learners with access to necessary tools for those new tasks. It can also help editing formats that are not supported in normal office software suites like interactive content (H5P for example) or courses of LMS, cMOOC’s or OpenCourseware (not particularly prevalent in German-speaking countries). With the network that comes with the national educational infrastructure users can connect with the “owners” of learning artifacts. That makes collaboration easier and reduces parasocial interaction, which is common but has rarely been examined in many asynchronous virtual learning contexts (Kumar et al., 2021).

Table 3: Examples for functionalities sorted according to the SAMR categories.

	I. inform yourself	II. collect and work out	III. network
Redefinition	self-sovereign data management (wallet)	wallet	wallet
Modification	curated learning paths, recommendations for artifacts and courses	collaborative editors, highly personalizable virtual desktop	Buddy Finder
Augmentation	a seamless searchable data room, connected Content Management Systems (CMS)	OCR for certified copies, “bring your own cloud storage”, “bring your own LMS”	Social Media (not designed for learning purposes)
Substitution	-	fully integrated editors	-

The table shows that not all aspects of the SAMR model can be considered equally in the PLE concept. This is because the focus of the study is on the interoperability of existing services, which means that Substitution and Redefinition are less in demand. The PLE approach counters this problem by shifting the perspective from the Graphical User Interface (GUI) to the entire network of interactions and relationships. The following section shows the PLE concept itself and how it responds to the challenges highlighted by the SAMR model.

5 EVOLVED CONCEPTION OF PERSONAL LEARNING ENVIRONMENTS

The impact on the cross-institutional connection in a federal Personal Learning Environment is best visible for users in the component “Working Space”.

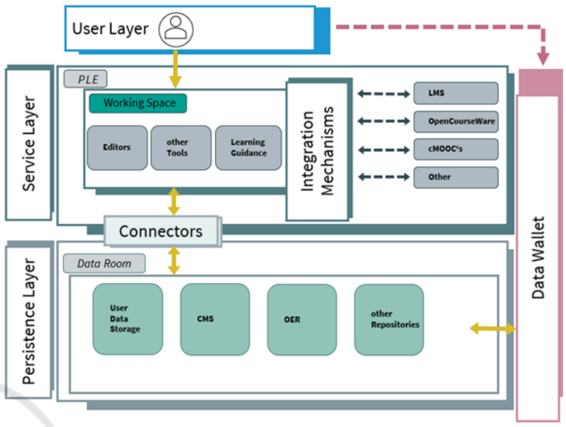

Figure 2: Personal Learning Environment in an national educational infrastructure.

The persistence layer contains learning artifacts that are mostly not assigned to a bigger context. Those are classified by structured metadata and collected in the next bigger space, the Data Room. The Data Room is linked to the PLE to exchange information (metadata) and artifacts. The PLE represents the service layer. Artifacts can be either created in the ”Working Space” and sent to the Data Room or can be claimed from the Data Room for reuse or remixing. The PLE consists of several connected services. The “Working Space” can be seen as the heart of the infrastructure, where participation of learners is enhanced. The PLE uses different integration mechanisms and levels to connect to and integrate microservices. Significant microservices in e-learning contexts are LMS, OpenCourseWare, cMOOCs, editors, and data storages among others. The higher the level of integration, the deeper the implementation in the infrastructure solution. These integration levels (descending from three to one) can determine if microservices are either substituted, modified, or augmented. The only redefining service is the data wallet approach. Users are given full control over their own data and data transfers. Therefore, the data wallet is a new solution built for a completely new task.

- level 3: Tools that are part of the GUI. This could either be Substitution or Redefinition if there is no existing service for this task. Editors, for example, could substitute already existing solutions in other environments (office suites), but we enhance them with collaboration features and additional data sovereignty. Redefining can be editors built for tasks where currently no solutions are offered. Some smaller projects, also funded by the Federal Ministry of Education and Research in Germany work on such innovative prototypes. Some of them may not work as “standalone” solutions, so they need to be integrated within a portal or LMS solution.

- level 2: Portlet integration with ”foreign” GUI. This could either be Modification or Augmentation depending on the added functionalities. Microservices in portlets could be “wrapped” LMS (see (Kiy and Lucke, 2016)), editors, CMS and others. We provide APIs to enhance their functionalities and connect them to the Data Room. Depending on how many “interfaces” are made available, it changes or adds to the connected service.
- level 1: hyperlinked and level 0: not mentioned but connected to the middleware. Hyperlinks are not truly integrated, therefore level 0 and level 1 are very similar in this discussion. Existing microservices are supplemented by a connection to the middleware and visualised on the platform via hyperlinks. This is the most basic form of integration from a user’s perspective.

One layer remains that has to be taken into account: the subject or user layer. If we take the educational understanding of (Marotzki, 1990) and others, education means the transformation of world and self-relations. Transformation of world relations, in this case technical, is covered in the parts above. As for subjective transformation, the PLE approach can operate in two ways. As mentioned earlier with the data wallet approach, where the user is given full control over their data, learners are able to restore their data sovereignty which is often neglected by proprietary software solutions. Otherwise we provide easy and seamless access to learning artifacts and tools and support them with recommendation systems. Users can freely compile and arrange needed microservices in their personalized learning environment.

The next big step would be to integrate a media education concept that helps users with data literacy, by reducing technical barriers and those deriving from missing skills or knowledge. As can already be seen in the context of data literacy, adaptive skills are becoming increasingly important on the part of learners. In the context of lifelong learning, adaptive competences are becoming important in both vertical and horizontal educational transitions. Learners are focusing on regulating their own learning and adapting to changing circumstances (Götz and Nett, 2017). Self-regulated learning (SRL) enables learners to independently manage and organize their own learning through reflection and assessment. At the same time, it enables teachers and parents to react individually to the learner’s learning status and thus to support or challenge them accordingly. Skills in the area of SRL must be supported and trained at an early age in order to lay the foundation for independent lifelong learning (Schuster et al., 2020).

This action control, which originates from the individual, can be supported in the digital space, as it is possible to switch from linear sequences to an individualized construction of the learning process: from a rather rigid, linear sequence, for example when working with texts, to a sequence with different individual customization options, for example in school lessons or in Web based trainings (WBT), to a construction of the sequence by the learner themselves. The digital space enables the merging of different content and tools in an individual workspace via cross-references (Pätzold, 2004) (Walber, 2005).

6 CURRENT STATUS AND REMAINING WORK

There is some truth in the perspective that current LMS platforms tend to adopt a “one-size-fits-all” approach (Ben Rebah et al., 2023) and often do not adequately support informal learning. Most systems align with behavioral learning theories, which can limit the ability of learners to co-create and participate meaningfully. To foster greater participation, it is essential to shift the focus from the institution (school or university) to the learner.

Personal Learning Environments can be an important contributor to this transformation, if they combine quality-assured content from formal education to counter the risks of disinformation and the reproduction of “detrimental” practices with degrees of freedom from informal settings. However, this also necessitates a flexible technical infrastructure to integrate these diverse elements effectively. For example, it symbolizes the “chicken-and-egg problem” where both elements rely on each other to exist or function, thereby creating a circular cause-and-effect dilemma. This is where an interconnectivity infrastructure comes into play. Some problems that other approaches had in the past (see Section 2) have already been tackled in the national educational infrastructure. By building the infrastructure at the same time as exploring, connecting (metadata/semantic standards) and filling (OER Movement, nationwide “lernen:digital” project) the Data Room, it eliminates the need for users to function as “pioneers”. Furthermore, data security and sovereignty issues are prioritized by following the Data Wallet approach, addressing data security and sovereignty issues.

In the next iterative step, the matrix presented in Section 5 should be applied to locate all the microservices within the current agenda of the national educational infrastructure. Otherwise, the level of integration is not the only point at which our PLE approach can transform educational services and empower the learner themselves. So this topic could be considered at other levels, for example governmental aspects. In the interoperability framework provided by (Ben Rebah et al., 2023), four topics have been identified in this regard: legal, semantic, organizational and technical interoperability.

For a further media educational analysis of the PLE the dispositif (very short: network of intermedial and interdiscursive elements) model by Focault (Focault, 2000) could serve as an analysis template. Currently there are two coexisting and sometimes competing dispositifs: (i) the media and (ii) the educational dispositif. With the holistic approach of the national educational infrastructure there is a need for an e-learning dispositif, which consists of equal parts of educational and media aspects, taking into account all conditions of success for subjects for their lifelong learning tasks.

One of the main goals is not only to provide a technical solution but to guide users through all stages of lifelong learning. Seamless utilization and access in horizontal and vertical educational transitions, for example curated learning pathways, recommendations for learning artifacts and also a matching tool for finding learning buddies. This should be flanked by a media education concept that helps interested users to learn more about data sovereignty and data security in order to improve their media skills.

On the other hand, the media education concept should show ways, in which learners can be supported as best as possible in their learning process. The different needs of the users should be taken into consideration. An initial proposal for this support is the Learning Guidance, which should be tested and expanded in further studies. In this way, new developments in the field of PLE can be comprehensively adapted to the realities of users’ lives.

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