The relationship between service analytics and Artificial Intelligence in library ecosystems. Empirical evidence and findings from the SHIFT project

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Abstract: Building on conceptual advances in service analytics and the integration of Artificial Intelligence (AI) within library ecosystems, this paper proposes an empirical study that examines the relationship between service analytics and AI usage in libraries, considering this relationship as a defining factor in the evolution of libraries as service systems empowered by emerging AI technologies. Grounded in the theoretical frameworks of Service-Dominant Logic and Service Science, the research explores the role of AI-enabled solutions in facilitating value co-creation through accessible, inclusive and user-centered cultural services. Additionally, the research analyses stakeholder perceptions within the Horizon Europe SHIFT project (Metamorphosis of cultural Heritage Into augmented hypermedia assets for enhanced accessibility and inclusion). The proposed analytical framework is multidimensional, structured around four key dimensions (curation, accessibility, inclusion and digital storytelling) and leverages data collected from professionals working in libraries, museums and related cultural heritage organizations. This paper argues that a systemic transition towards data-driven and AI-enabled services is under way, leading to improved information discoverability, the development of adaptive interfaces and enhanced user engagement through narrative-based digital mediation. The main findings indicate that AI-assisted platforms function as integrative mechanisms that complement traditional collection management and information retrieval infrastructures, enabling personalized services, contextualized access, and continuous service innovation. In this context, the paper provides a coherent service ecosystem perspective by linking service analytics with AI, thereby supporting the evolution of cultural heritage institutions towards resilient, inclusive and scalable service systems, with practical relevance for both theoretical advancement and the design of next-generation digital cultural services.

Keywords: Public libraries, Artificial Intelligence, Digital services, Inclusion, Accessibility, Cultural storytelling, SHIFT, Horizon Europe, Stakeholder requirements study, Service analytics.

Relația dintre analiza serviciilor și inteligența artificială în ecosistemele bibliotecare. Dovezi empirice și rezultate ale proiectului SHIFT

Rezumat: Pornind de la progresele conceptuale din domeniul analizei serviciilor și al integrării inteligenței artificiale (AI) în ecosistemele bibliotecare, prezentul articol propune o cercetare empirică ce abordează relația dintre analiza serviciilor și utilizarea AI în biblioteci, considerând această relație drept un factor definitoriu pentru evoluția bibliotecilor ca sisteme de servicii împuternicite de tehnologii emergente bazate pe AI. Fundamentată pe cadrele teoretice ale Logicii Dominante a Serviciilor și ale Științei Serviciilor, cercetarea investighează rolul soluțiilor bazate pe AI în facilitarea co-creării valorii prin servicii culturale accesibile, incluzive și orientate către utilizator. Studiul analizează percepțiile actorilor relevanți în cadrul proiectului Horizon Europe SHIFT (MetamorphoSis of cultural Heritage Into augmented hypermedia assets for enhanced accessibility and inclusion). Cadrul analitic propus este unul multidimensional, structurat pe patru dimensiuni (curatoriere, accesibilitate, incluziune și storytelling digital) și valorifică date colectate de la profesioniști din biblioteci, muzee și alte organizații similare din domeniul patrimoniului cultural. Prezenta lucrare argumentează existența unei tranziții sistemice către servicii bazate pe date și împuternicite de AI, care conduc la îmbunătățirea regăsirii informațiilor, dezvoltarea interfețelor adaptive și creșterea nivelului de implicare a utilizatorilor prin mediere narativă digitală. Principalele rezultate indică faptul că platformele asistate de AI funcționează ca mecanisme integrative ce completează infrastructurile tradiționale de gestionare a colecțiilor și de regăsire a informațiilor, facilitând servicii personalizate, acces contextualizat și

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inovare continuă a serviciilor. În acest context, articolul oferă o perspectivă coerentă asupra ecosistemelor de servicii, prin corelarea analizei serviciilor cu inteligența artificială, contribuind la evoluția instituțiilor de patrimoniu cultural către sisteme de servicii reziliente, incluzive și scalabile, cu relevanță practică atât pentru dezvoltarea teoretică, cât și pentru proiectarea serviciilor culturale digitale de nouă generație.

Cuvinte cheie: biblioteci publice, Inteligență Artificială, servicii digitale, incluziune, accesibilitate, storytelling cultural, SHIFT, Horizon Europe, studiu privind cerințele părților interesate, analiza serviciilor.

1. Introduction

Digital transformation of public libraries and museums is accelerated by technological developments, user expectations and increasing pressures for social inclusion. In addition to the digitization of collections, they are increasingly being reorganized as 'user-centred' service ecosystems that make access to knowledge dependent on digital technologies, with participatory and impact oriented approaches. This is a result of three changing forces: a greater demand for quick-and-easy digital resources, new user demographic and inclusion needs and a rapid scaling up of the amount and nature of digital cultural assets (IFLA FAIFE, 2020; UNESCO, 2021; European Commission, 2022).

Over the last decade, European libraries have increasingly evolved into hubs of digital transformation, providing access to infrastructure, digital skills and public services. At the same time, there is a shift towards user-centred service models based on needs assessment, user experience and continuous feedback. In this context, libraries are gradually adopting service design and co-creation approaches to align institutional objectives with user expectations. In Romania, several intelligent systems illustrate the potential of AI-based applications for the preservation and enhancement of digital cultural heritage, including the INTELLIT platform dedicated to Romanian literary heritage (Gavrilă et al., 2021). During the 2000s, prior to the adoption of AI in cultural heritage institutions, the development of libraries transitioned from traditional library infrastructures to digitally mediated information services, with information technologies transforming collections, improving access and introducing new forms of knowledge management, thus laying the foundation for contemporary digital library ecosystems (Banciu, 2001). Another development has been the increasing use of libraries as venues for equity and inclusion for diverse groups, achieved through physical adaptations and digital transformational approaches that prioritize accessibility, including alternative formats, assistive technologies, user-friendly interfaces, automated translation, and personalization, making accessibility a core quality criterion of public services (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022).

Digital cultural heritage is now being actively developed and libraries are becoming increasingly involved in digitization, collection aggregation and promotion. However, digital availability alone cannot guarantee use, understanding or relevance. In an environment dominated by short, interactive and highly visual content, the biggest challenge for any heritage institution is the ability to keep culture appealing, comprehensible and meaningful to a broad spectrum of people (Bawden & Robinson, 2020). The application of AI in libraries and cultural heritage institutions has attracted significant interest within the Library and Information Science literature, with machine learning and other technologies, such as natural language processing, data-driven recommendation systems supporting collection analysis, metadata enrichment, discovery and user interaction. The adoption of AI is altering professional practice by fostering service innovation and raising issues related to ethics and organisational challenges (Cox, 2022). Machine learning approaches have also extended to the field at large scale for the analysis of cultural heritage in digital archives and libraries for interpretation, classification and information discovery (Cordell, 2020). Furthermore, the literature emphasizes the need for responsible and ethically grounded AI use, as well as governance frameworks around transparency, bias, accountability and public trust (Padilla, 2019). At the European level, infrastructure for digital cultural heritage has been built through joint projects and research programmes, with the Europeana ecosystem providing large-scale access to digitised cultural resources from libraries, museums and archives. These platforms

facilitate cultural data reuse for learning, research and innovation, as well as AI and data-driven service analytics to improve accessibility, discoverability and user-centred interpretation. Other complementary projects, such as AI4Culture, also stimulate the progress of AI tools for data enrichment, automated analysis and intelligent access to digital collections, further reinforcing the role of AI in the European cultural heritage ecosystem (Europeana Foundation, 2024). A fourth emerging trend is the integration of AI and service analytics to enhance the delivery, personalization and evaluation of library services. AI supports functionalities such as content recommendation, machine translation, image recognition and description, summarization, search optimization and virtual assistants, extending institutional interaction capacity, while service analytics enables the analysis of usage behaviours, access barriers, user preferences and intervention outcomes. This integration is essential for libraries acting as evidence-based public service infrastructures, where decisions rely on data and measurable impact (Böhmann, Leimeister & Möslein, 2014; Akter et al., 2020; IFLA FAIFE, 2020). Although service analytics is well established in service science, its application in public and cultural heritage contexts remains limited. It is defined as the systematic use of operational data, user behaviour patterns and technological infrastructures to support service design, evaluation and continuous innovation, yet it has been predominantly applied in commercial and IT service environments. This highlights the need for empirical research on its application in cultural heritage institutions, particularly in supporting inclusive and user-oriented digital services (Spohrer & Maglio, 2007; Maglio & Spohrer, 2010; Böhmann, Leimeister & Möslein, 2014; Akter et al., 2020).

The integration of AI into digital public services is increasingly discussed in the literature, including in the contexts of digital governance and e-government, where AI is approached as a service infrastructure and a mechanism for increasing efficiency and accessibility (Dumitrache, Stănescu & Paraschiv, 2023). Within the Horizon Europe programme, the digital transformation of cultural heritage institutions is addressed as a strategic priority. Although heritage institutions and libraries hold valuable cultural resources, access remains unequal, especially for people with visual and hearing impairments and other vulnerable groups. Increasingly, these barriers are digital, including inadequate interfaces, lack of alternative descriptions, insufficient contextualization and limited interactive support. Within European research, the digital transformation of cultural heritage institutions is a strategic priority under the Horizon Europe programme, particularly through the cluster associated with the call HORIZON-CL2-2021-HERITAGE-01-04. This framework brings together projects such as MEMENTOES, MEMORISE, MuseIT and PREMIERE, which explore immersive, multisensory and AI-based technologies to enhance the accessibility and interpretation of heritage collections. In this context, the SHIFT project contributes by investigating how AI can transform cultural assets into augmented hypermedia resources, supporting more inclusive, personalized and data-driven cultural services.

The SHIFT project responds to these challenges by developing assistive solutions and AI-based technologies designed to transform the user experience and enable the curation, presentation and interpretation of heritage in an accessible and inclusive way. The research rationale of the project is thus twofold. On the one hand, SHIFT acts as a technological catalyst, exploring how AI can generate alternative content, support translation, personalize cultural itineraries and create adapted forms of storytelling. On the other hand, SHIFT acts as an organizational catalyst, proposing a model of service innovation in which the requirements of users and professionals are systematically collected and integrated into the solution design process (Vargo & Lusch, 2004; Lusch & Nambisan, 2015; Akter et al., 2020). This empirical analysis extends the application of service analytics to cultural heritage services against this background. In contrast, past studies have focused on service analytics in a commercial service setting, examining how service analytics indicators can be interpreted in relation to digital cultural heritage infrastructures and accessibility-oriented technologies. The present applied research explores the role of how technological practices, satisfaction with digital systems and expectations regarding service functionalities shape the perceived value of AI-enabled services in libraries and heritage institutions by examining stakeholder perceptions gathered from the SHIFT project.

This empirical analysis is based on the hypothesis that AI technologies designed for libraries and museums may have limited effectiveness due to gaps in understanding user requirements.

Cultural heritage ecosystem stakeholders are users, professionals, technology developers and institutional actors, with varying expectations regarding access, relevance and service experience. Based on these dissimilarities, service design approaches to AI-assisted cultural environments should be inclusive and user-focused (OECD, 2019; IFLA FAIFE, 2020; UNESCO, 2021).

The paper is organized as follows: Section 1 presents the conceptual framework and the research setting, discussing European trends in the evolution of library services, the justification for the Horizon Europe SHIFT project and the research premises from the stakeholders' perspective. Section 2 describes the research design, instruments used for data collection, sample characteristics and methods of analysis, both quantitative and qualitative, employed in the study. In Section 3, the empirical findings are presented, organized around four main analytical axes — curation, accessibility, inclusion and digital storytelling — and includes a relational analysis of service analytics and expectations of AI-assisted functionalities. Section 4 is devoted to the discussion and conclusions, emphasizing the theoretical and practical contributions of the study to the development of services offered in the digital environment, with reference to library and cultural heritage ecosystems.

2. Materials and methods

This applied research adopts a mixed-method approach that combines quantitative descriptive analysis and qualitative thematic interpretation to provide an empirical basis for the design of AI-assisted digital service ecosystems for libraries and cultural heritage institutions. The methodology is aligned with research in the fields of service analytics, service design and human-centred computing, and is designed to capture both the functional dimensions of services and the perceptions, expectations and experiences of the actors involved (Lusch & Nambisan, 2015; Diao et al., 2016; Akter et al., 2020).

2.1. Research design and methodological rationale

The research is structured as a stakeholder requirements analysis framework, a well-established method in the design of complex information systems and digital services, frequently used in European research and innovation projects. This approach is based on the premise that the value of a public digital service is co-created through the interaction of multiple categories of stakeholders and cannot be assessed exclusively through technical indicators. (Vargo & Lusch, 2004; Vargo & Lusch, 2008; Lusch & Nambisan, 2015; Vargo & Lusch, 2016). The methodological framework of the empirical analysis was structured around four dimensions relevant to digital heritage ecosystems: digital curation, accessibility, inclusion and digital storytelling. These dimensions guided both the design of the questionnaire and the subsequent analysis of the data (Vargo & Lusch, 2004; Petrie & Kheir, 2007; Vargo & Lusch, 2008; Lusch & Nambisan, 2015; Vargo & Lusch, 2016; Calderon-Rehecho et al., 2021; IFLA, 2022).

2.2. Research tool: the SHIFT questionnaire

The main data collection tool was the SHIFT Questionnaire: Stakeholder Requirements Study on Cultural Curation, Accessibility, Inclusion and Storytelling, designed and applied in an online format. The questionnaire was conducted between 13 and 27 March 2023, in coordination of the National Association of Public Librarians and Libraries in Romania (ANBPR), and distributed to approximately 350 stakeholders selected from the partners' databases. Respondents included information professionals from libraries, museums, heritage institutions and technology-related areas across several European countries. The questionnaire comprised several thematic sections aligned with the four analytical pillars, as well as an introductory section on respondents, and included single-answer items, multiple-choice questions, Likert-scale measures and a limited number of open-ended questions, thereby enabling both quantitative and qualitative analysis.

2.3. Sample and categories of respondents

The questionnaire was completed by 74 valid respondents from various professional fields, including librarians, curators, researchers, cultural managers, UX designers, IT specialists and project coordinators. This diversity was intentional and reflects the actual structure of the cultural services ecosystem, where the design and delivery of digital services involve multidisciplinary skills. The count of valid responses varies slightly from one questionnaire item to another (between N = 74 and N = 76), owing to the branching logic of the online questionnaire. Individual questions were presented only to respondents who had selected certain options in the previous items, leading to different valid response counts for specific sections of the survey. An exploratory segmentation was conducted to identify differences in stakeholder perspectives based on professional roles, grouping respondents into three categories relevant to digital cultural service design and delivery: cultural heritage professionals (e.g., librarians, curators), technology and design specialists (e.g., IT developers, UX designers), and institutional or managerial actors (e.g., directors, project managers). This classification reflects the multi-actor structure of digital cultural heritage ecosystems and was used to support the comparative interpretation of questionnaire items related to AI functionalities, accessibility requirements and digital storytelling.

2.4. Quantitative analysis methods

The quantitative analysis was conducted through the calculation of absolute and relative frequencies for each item, the identification of priority indicators (e.g., the proportion of respondents selecting specific features), and the comparison of importance and satisfaction levels across different dimensions of digital services. The SHIFT questionnaire did not include a direct measure of the relationship between service analytics and AI; however, this applied research operationalizes this relationship through proxy indicators such as technological practices, satisfaction with existing systems and expected service functionalities. The AI dimension is reflected in preferences for tools such as automated cataloguing, virtual guidance, image analysis and personalized recommendation systems. The relational descriptive analysis of these variables enables the empirical exploration of the links between service analytics and AI, highlighting the convergence between technological practices, user experience and expectations regarding AI-assisted digital services in cultural heritage ecosystems. Quantitative indicators were interpreted not as an end in themselves, but as tools to support service design decisions. (Spohrer & Maglio, 2007; Maglio & Spohrer, 2008; Böhmann, Leimeister & Möslein, 2014; Banciu, Petre & Dumitrache, 2019). In addition to descriptive statistics, a relational descriptive analysis was conducted using cross-tabulation and comparative interpretation of selected questionnaire items to explore associations between technological practices, satisfaction with existing systems, accessibility priorities and expectations regarding AI-assisted digital services.

2.5. Qualitative analysis, ethical considerations and methodological limitations

The qualitative aspect of the applied research involved the analysis of interviews and the interpretation of open-ended responses through thematic analysis, with the goal of identifying emerging themes, explicit expectations, and critical issues voiced by the participants. This interpretation was undertaken alongside the literature on service science and digital heritage, the aims of the SHIFT project, and European conceptual frameworks concerning digital accessibility and inclusion (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022) to generate integrated insights connecting empirical findings with strategic implications for libraries and heritage institutions. The participation in the questionnaire was voluntary and adhered to the principles of informed consent, anonymity and data protection, with no involvement of sensitive data or any form of intervention in the participants' lives. The main methodological limitations are the sample size and self-reported data, but these are mitigated by methodological consistency, quantitative-qualitative triangulation and the practical relevance of the findings for the design of AI-assisted digital services.

3. Results

The results indicate a strong demand for AI-assisted digital systems that support accessibility, personalization and interactive cultural engagement. The findings are structured according to the four analytical pillars of the research: curation, accessibility, inclusion and digital storytelling (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022).

Based on data collected within the Horizon Europe SHIFT project, Figure 1 is an illustration of the author's findings regarding preferences among respondents regarding the formats of digital content transformation and which types of digital representations and formats are deemed most relevant to promote access, interpretation, and engagement within cultural heritage environments.

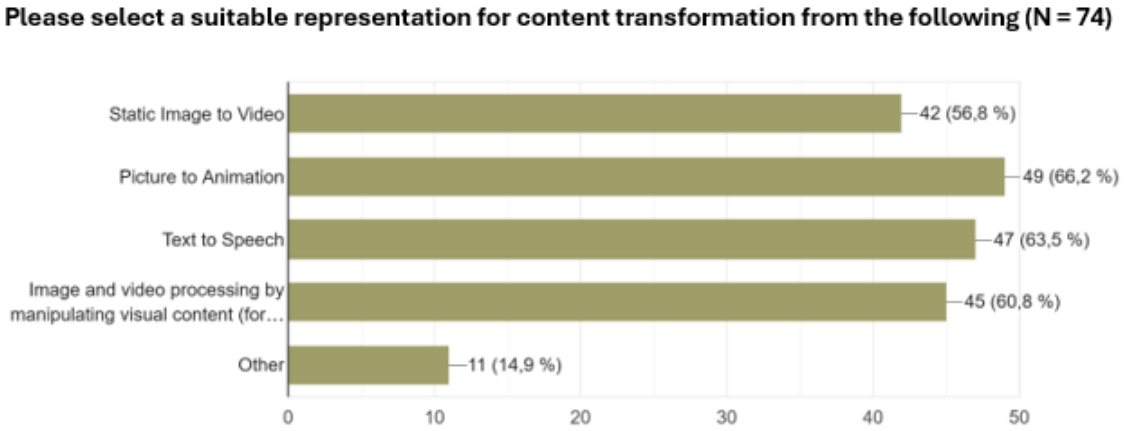

Figure 1. Respondents' preferences regarding forms of digital content transformation

3.1. Sample profile and digital maturity of respondents

The questionnaire was completed by 74 valid respondents, while some questionnaire items reached 76 valid responses due to the branching logic of the survey and item-specific response patterns. From a socio-demographic point of view, the distribution indicates a predominantly professionally active sample: the 46–60 age group represents 45.9%, the 36–45 age group represents 33.8%, while the 26–35 age group represents 12.2% (N = 74). In terms of gender, the majority of responses were from women (70.3%), followed by men (29.7%) (N = 74). The sample includes a variety of roles (librarians, museum and heritage professionals, researchers, managers, UX, IT), which reinforces the value of the analysis as an ecosystem diagnosis. Regarding current technological practices, 43.2% of respondents reported that they already use technology-assisted curation systems, while 50% reported that they do not (N = 74), indicating significant potential for growth in technology adoption and, at the same time, a need for intuitive solutions and institutional support for implementation. (Spohrer & Maglio, 2007; Maglio & Spohrer, 2008; Böhmann, Leimeister & Möslein, 2014)

Based on the data collected within the Horizon Europe SHIFT project, Figure 2, created by the author, shows the attitudes of stakeholders towards technology-assisted systems and the benefits they can enable for streamlining curation processes, improving access to cultural content, and supporting more effective organization and information retrieval in digital cultural heritage environments through improved efficiency.

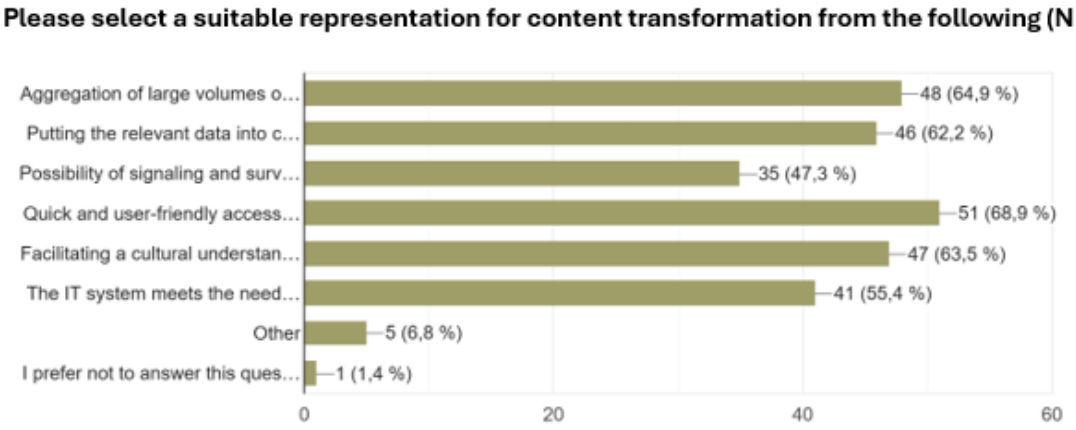

Figure 2. Perceived benefits of a technology-assisted system for streamlining curation processes

In terms of satisfaction with existing systems (scale 1–5), the distribution is concentrated in the middle range: score 3 is dominant (45.9%), followed by scores 4 (20.3%) and 5 (17.6%), while low scores (1 and 2) total 16.2% (8.1% each) (N = 74). This statistical structure suggests that current solutions are perceived as functional but insufficiently optimised for real needs, particularly in terms of accessibility, personalisation and workflow integration. (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022)

3.1.1 Stakeholder segmentation and variation of priorities

Given the heterogeneity of the sample, an exploratory stakeholder segmentation was conducted to examine differences in expectations regarding AI-assisted cultural heritage services. Respondents were grouped into three categories – cultural heritage professionals, technology and design specialists, and institutional or managerial actors – revealing non-uniform priorities across groups. Cultural heritage professionals emphasize functionalities that support interpretation, contextualization and accessibility, reflected in preferences for digital storytelling, alternative descriptions and adaptive interfaces.

Table 1, created by the author based on data collected within the SHIFT study, presents an exploratory segmentation of stakeholders and their priority orientations regarding AI-assisted cultural heritage services.

Table 1. Exploratory segmentation of stakeholders and priority orientations regarding AI-assisted cultural heritage services

Stakeholder category	Typical professional roles included in the sample	Main priorities regarding AI-assisted services	Illustrative functionalities emphasized
Cultural heritage professionals	Librarians, curators, museum educators, heritage specialists	Interpretation, cultural mediation, accessibility of heritage assets	Digital storytelling, alternative descriptions, adaptive interfaces, contextualisation tools
Technology and design specialists	IT developers, UX designers, information architects, digital content creators	Technical performance and analytical capabilities of digital platforms	Automated cataloguing, image analysis, predictive recommendation systems
Institutional and managerial actors	Directors, project managers, coordinators, administrative staff	Organisational efficiency and expansion of audience reach	Aggregation of cultural data, improved discoverability of collections, public engagement mechanisms

Advanced functional skills like automated cataloguing, image analysis, and predictive recommendation systems dominate the thoughts of technology and design specialists, indicating a strong emphasis on technical and analytical performance. Institutional and managerial actors consider more of the strategic agenda, looking for functionalities that contribute to higher

organizational efficiency, data aggregation, discoverability, and public engagement. The dataset is exploratory and does not support rigorous statistical testing, but the author notes variation across stakeholder groups which justifies the need for integrated digital service ecosystems that balance technological feasibility, cultural mediation, and institutional relevance.

3.2. Exposure to heritage institutions and current digital experience

Figure 3, created by the author and based on the findings of the SHIFT survey, illustrates the types of cultural heritage assets of greatest interest to respondents, highlighting user preferences for specific categories of cultural content and their relevance for the design of AI-assisted digital services in cultural heritage environments.

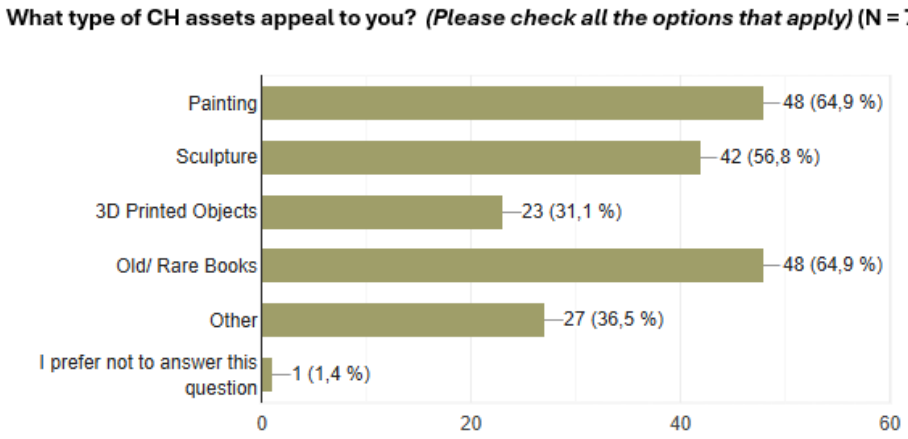

Figure 3. Types of cultural heritage assets of greatest interest to respondents

The frequency of visits to heritage institutions indicates that the public is connected to the field: most report annual visits (51.4%), followed by occasional visits (21.6%) and visits twice a year (14.9%) (N = 74). An important indicator of the relevance of digital intervention is that 94.6% say they gain knowledge about European culture after visits, confirming the role of these institutions as providers of educational and civic value (N = 74). Preferences for types of cultural assets are relevant for the design of AI functionalities: old/rare books and paintings are the most attractive (64.9% each), followed by sculpture (56.8%) and 3D printed objects (31.1%) (N = 74). This profile indicates high demand for AI functions such as automatic description, transcription, contextualisation and translation, and multimodal interpretation tools (text, image, audio) (OECD, 2019; IFLA FAIFE, 2020; Floridi, 2023). The overall experience with digital technologies in heritage institutions is predominantly positive: 77% report a "good experience" (N = 74). However, a critical indicator is that 29.7% have visited an institution with digital support (virtual assistants, devices, etc.), suggesting that the positive experience does not necessarily derive from advanced digital services, but rather from basic digitization or standard interfaces (N = 74). At the same time, the majority do not consider heritage content to be disengaging in the social media era (78.4% indicate that they find it engaging), which indicates that the problem is not a lack of cultural interest, but a lack of digital mechanisms through which interest can be converted into interaction, inclusion and effective access.

3.3. Results on pillar I: Curation and functional requirements

A key finding is the high level of consensus on the integration of technology into curation: 23% consider integration to be "essential", 14.9% "very important" and 56.8% "somewhat important", indicating a clear alignment of stakeholders towards technology-assisted curation (N = 74). The results suggest that stakeholders correlate technology-facilitated curation systems with increased efficiency in curating collections of cultural heritage items. Fast and user-friendly access is found to be the number one concern (76.2%), followed by the support for cultural understanding (69%), and the selection and highlighting of relevant data (54.8% and 52.4%). These trends suggest that AI-based curation platforms are perceived as mainly value-added to streamline internal

procedures and improve access to digital content. These findings suggest a strong appetite for service analytics applied to curation highlighting the importance for service analytics systems that minimize the entropy of information, optimize for relevance, and process workflows such as aggregation, description, retrieval and presentation (Spohrer & Maglio, 2007; Maglio & Spohrer, 2008; Böhmann, Leimeister & Möslein, 2014). A hierarchy of desired functionalities highlights access to diverse resources (83.8%) and relevant information (73%) as dominant, followed by rapid responses (56.8%) and intuitive interfaces (52.7%) (N = 74), indicating that value is perceived at the level of the integrated user journey rather than isolated functionalities.

Accessibility is confirmed as a central criterion. In terms of aggregate needs, "accessibility" is selected as a major need by 82.9% of respondents (N = 76), surpassing storytelling (78.9%) and inclusion (77.6%) and ranking above cleanliness (69.7%). This distribution supports the claim that accessibility is perceived as an essential element of modern digital services (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022).

3.4. Results on pillar II: Accessibility - AI as access infrastructure

The findings relate a better user experience with AI-supported functionalities to help in guidance, automation, and personalized interaction. Virtual guides are the most widely supported of all options (73.7%). Then automatic cataloguing, automatic translations and recommendations (60.5% each), and image analysis are also well supported, receiving 53.9%. These trends corroborate that respondents appreciate AI tools mainly for enhancing orientation, accessibility and interaction in digital cultural heritage environments (OECD, 2019; IFLA FAIFE, 2020; Floridi, 2023). Interface accessibility (84.2%), personalization and language adaptation (67.1%), cross-platform availability (64.5%), content accessibility (63.2%) and easy navigation (61.8%) are the most selected features for the general public (N = 76).

Figure 4, created by the author and grounded in the findings of the SHIFT survey, illustrates respondents' perceptions of the attractiveness of a tool for modifying human representations in digital images of collections. It also exemplifies stakeholders' attitudes towards such functionalities and their implications from the perspective of ethical considerations and the adoption of AI-assisted digital services.

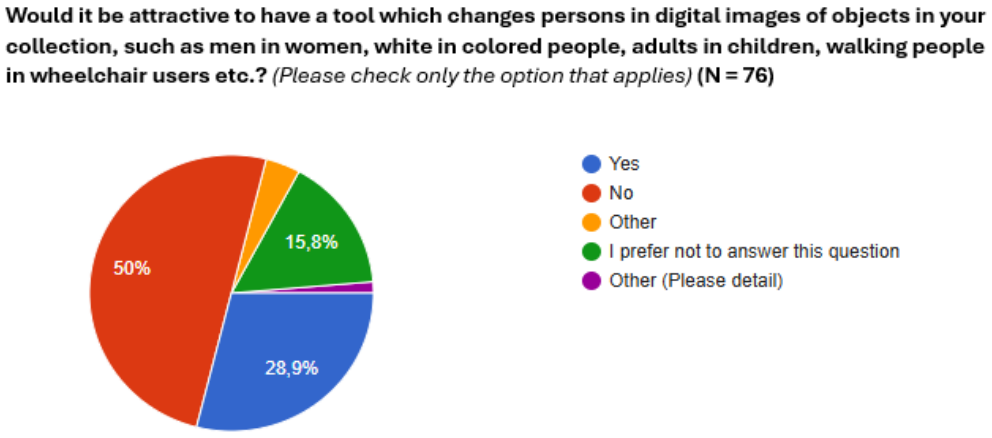

Figure 4. Respondents' perception of the attractiveness of a tool for modifying human representations in digital images of collections

From an analytical perspective, this result defines a minimum quality threshold: without interface accessibility, the other features (including AI) lose their perceived value. For people with visual impairments, the most selected features are: clear and intuitive interface (77.6%); appropriate fonts (73.7%); good color contrast, ability to change settings and alternative descriptions (69.7% each); and voice feedback (63.2%) (N = 76). Statistically, these results outline an "accessibility package" with high and relatively close frequencies, suggesting that respondents perceive accessibility as a system of interdependent requirements, not as a single function (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022).

3.5. Results on pillar III: Inclusion

Inclusion is assessed as a social value as much as a technical adaptation. The most selected inclusion-related attributes refer to the suitability of heritage content to user needs (65.8%), the contribution to cultural understanding (64.5%), and the expansion of the capacity to manage cultural assets and audiences (59.2%) (N = 76), indicating expectations that AI solutions should broaden participation and increase institutional relevance for diverse groups (OECD, 2019; IFLA FAIFE, 2020; UNESCO, 2021). Digitization of collections offers libraries and heritage organizations the opportunity to promote and expand the exposure of multicultural heritage. This encourages public participation in a wider range of cultural experiences. Digital infrastructures favor the preservation of cultural heritage assets and support social cohesion in an increasingly multicultural world (Banciu & Coardos, 2012). A key finding with ethical and design implications is the reluctance towards "identity-altering" image functions (e.g., gender or ethnicity), reflected in a high rate of non-response or ambiguous answers, indicating the need for responsible AI frameworks and clear governance on representation and cultural sensitivities (Jobin, Ienca & Vayena, 2019; UNESCO, 2021; Floridi, 2023).

3.6. Results on pillar IV: Digital storytelling

Digital storytelling is perceived as a mechanism for increasing engagement and mediating understanding. Among the types of digital stories, virtual tours are frequently selected (77.6%), along with stories that present oral histories (78.9%) and role-playing stories (72.4%) (N = 76).

Table 2, created by the author based on the analysis of the SHIFT survey results, presents the most frequently selected stakeholder priorities across the four analytical pillars (curation, accessibility, inclusion, and digital storytelling), highlighting the key dimensions that influence the design and delivery of AI-assisted digital services in cultural heritage ecosystems.

Table 2. The most frequently selected stakeholder priorities on the 4 analytical pillars

Analytical pillar	Top-ranked item identified by respondents	Frequency (n)	Percentage (%)	Interpretation
Curation	Facilitating access to various cultural heritage resources through the IT system	62	83.80%	Respondents emphasise the importance of integrated access to diverse cultural assets within digital heritage platforms.
Accessibility	AI-based virtual guides supporting visitor interaction	56	73.70%	Stakeholders expect AI tools capable of guiding visitors and facilitating navigation within cultural heritage collections.
Inclusion	Suitability of cultural heritage content for diverse categories of users	50	65.80%	Inclusive content design is perceived as essential for enabling equitable participation of diverse audiences.
Storytelling	Digital stories presented as virtual tours of cultural heritage	59	77.60%	Narrative-based digital experiences are perceived as an effective mechanism for engaging audiences with cultural heritage assets.

These profiles show the preference for formats involving spatial navigation, interactivity and contextualization, which point to the significant potential of AI in aiding personalization and adaptation to audience needs. In this regard, libraries are increasingly seen to serve as aggregators of cultural assets and facilitators of co-created knowledge (Vargo & Lusch, 2004; Lusch & Nambisan, 2015; Akter et al., 2020; Crihană, 2024), and digital storytelling helps in better user engagement and meaning-making.

3.7. Relational analysis of service analytics and AI-enabled service expectations

A relational descriptive analysis was conducted to examine how technological practices, satisfaction with existing systems and accessibility priorities relate to expectations regarding AI-enabled digital services. The analysis was based on selected questionnaire items with valid response counts ranging from N = 74 to N = 76, depending on item-specific branching.

3.7.1 Relational analysis between service analytics and AI-enabled functionalities

Data from the empirical analysis demonstrates that respondents using technology-assisted curation tools express a higher appreciation for AI functionalities, especially automated cataloguing, image analysis, and recommendation systems, indicating that familiarity with digital tools affects the perceived value of AI in cultural heritage environments.

3.7.2 Relationship between system satisfaction and demand for AI-based functionalities

The applied research reveals that respondents with moderate satisfaction with the current system possess the highest demand for AI-assisted features — mostly automated translation, virtual guidance and personalized recommendations — indicating that AI is considered a complementary infrastructure that enhances the current digital service ecosystems rather than replacing them.

3.7.3 Relationship between accessibility and preference for AI-assisted tools

The empirical research shows that respondents who prioritize accessibility are more likely to support AI-assisted functionalities such as automatic translation, voice feedback, adaptive interfaces and virtual guidance, indicating that AI functions primarily as an enabling infrastructure for inclusive access and interaction in digital cultural ecosystems.

4. Discussions & conclusions

The findings of the stakeholder questionnaire conducted within the SHIFT project reinforce and develop the author's thesis that libraries are asymptotically stable cultural and creative entities, in the sense that they can still successfully fulfil their fundamental civilising functions in light of the rapid pace of digital technology. Such stability cannot be interpreted as institutional rigidity, but rather as the ability to receive, absorb, integrate and reshape services without relinquishing the identity and public function of those services. From the perspective of service science, libraries can be conceptualised as complex socio-technical systems in which cultural resources, professional skills, technologies and users interact continuously to produce public value. Such configurations correspond to the concept of service systems, understood as dynamic arrangements of people, technologies and shared information that interact to co-create value (Vargo & Lusch, 2004; Spohrer & Maglio, 2007; Spohrer & Maglio, 2010). The theory of asymptotic stability, applied to libraries, suggests that they tend to constantly return to a "functional core" — access to knowledge, cultural mediation, education and inclusion — even if the tools and forms of delivery change.

This article introduces the concept of libraries as asymptotically stable info-documentation entities, inspired by systems theory. In dynamical systems theory, asymptotic stability refers to the capacity of a system to return to equilibrium after perturbations; transposed to libraries, this denotes their ability to preserve core societal functions — access to knowledge, cultural mediation and public learning — while adapting to technological, organizational and social change. Historically, libraries have integrated successive waves of transformation without losing their role as trusted public knowledge institutions, supported by their public mission, close relationship with communities and long-term stewardship of cultural resources. In this applied research, this functional core is operationalized through three service dimensions: access to knowledge resources, cultural mediation and inclusive public learning, observable through indicators such as information services, user engagement, accessibility features and community-oriented learning. The main perturbations include technological change (e.g., digitization and AI), evolving user expectations and increasing informational complexity, while the system’s stability is reflected in the capacity to integrate new infrastructures without compromising its public-service mission. This framework supports the interpretation of the empirical findings of the SHIFT research.

4.1. AI as service infrastructure, not as an end in itself

An important finding of the questionnaire-based analysis conducted within the SHIFT project is that stakeholders do not see the need for AI as an element of innovation in itself or as a disruptive agent they are looking for to align with trends, but rather AI as a service infrastructure: automatic translations, virtual guidance, multimodal accessibility, personalization and adaptive storytelling. From this perspective, AI acts as a facilitator, not as a disruptor, allowing libraries to stay relevant in a quickly transforming digital landscape (OECD, 2019; IFLA FAIFE, 2020; UNESCO, 2021). This corresponds with the idea of libraries as asymptotically stable entities able to adopt new technologies while preserving their role as cultural intermediaries. AI is therefore subordinate to service value and user experience, rather than redefining them (Vargo & Lusch, 2004; Petrie & Kheir, 2007; Lusch & Nambisan, 2015). Integrating AI into library service ecosystems presents strategic and ethical challenges, namely a balancing act between automation and human mediation, as service users seek efficiency and personalization in use without supporting the removal of professional interaction. The concern over identity-altering functionalities and algorithmic responsibility also signals the need for robust governance mechanisms that seek to position libraries as trusted mediators of responsible AI use (Jobin, Ienca & Vayena, 2019; OECD, 2019; IFLA FAIFE, 2020; UNESCO, 2021; Floridi, 2023).

4.2. Structural strengths of libraries of the future

Given the SHIFT results, libraries demonstrate a set of structural strengths: social trust capital in an era of misinformation, a unique position in local ecosystems as accessible and public-oriented institutions, and experience with cultural diversity and vulnerable populations, which makes them key participants in digital inclusion (Banciu & Coardos, 2012; Jobin, Ienca & Vayena, 2019; Crihană, 2023; Floridi, 2023). AI-assisted amplification, which strengthens these strengths by allowing for scalability within services while still maintaining equity and universal access, is also highlighted in accessibility outcomes as a platform for inclusive access to heritage and knowledge, especially for people with different disabilities (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021; IFLA, 2022). Within such a context, libraries play a critical role in fostering the cultural ecosystem, as they blend heritage, education, community, and technology by offering an integrated service approach. These results further validate the potential of AI integration to radically alter access to knowledge and establish libraries as smart public infrastructures by providing evidence of the relationship between service analytics and AI through empirical data from the SHIFT stakeholder questionnaire (Spohrer & Maglio, 2007; Böhmann, Leimeister & Möslein, 2014; IFLA FAIFE, 2020).

4.3. AI and service analytics in digital library service ecosystems

A central conclusion of this applied research is that the value of AI in libraries lies in its integration with service analytics as a mechanism for designing, evaluating and adapting digital services. SHIFT data indicate that stakeholders prioritize coherent digital ecosystems over isolated advanced technologies, emphasizing accessibility, personalization and meaningful interaction (Spohrer & Maglio, 2007; Böhmann, Leimeister & Möslein, 2014). High frequencies for easy access to relevant information (73%), access to diverse resources (83.8%), rapid responses (56.8%) and intuitive interfaces (56.8%) show that value is perceived at the level of the overall service experience rather than individual functionalities. From a service analytics perspective, these findings suggest that users evaluate library services through the entire “user journey,” with AI enabling its data-driven optimization (Maglio & Spohrer, 2008; Diao et al., 2016; Akter et al., 2020).

4.4. Accessibility as the main vector of public value

A second empirically confirmed value differentiator is extended accessibility. SHIFT data show that accessibility is perceived as a core element of digital services, selected by 82.9% of respondents (N = 76), surpassing storytelling (78.9%) and inclusion (77.6%), while interface

accessibility is identified as a key function for the general public (84.2%), defining a minimum threshold for service acceptability (Petrie & Kheir, 2007; Calderon-Rehecho et al., 2021). AI-assisted functionalities such as machine translation, voice feedback, alternative descriptions, visual adaptation and virtual guidance act as access multipliers, reducing barriers for vulnerable groups, while service analytics enables their monitoring and evaluation as indicators of public service performance (Spohrer & Maglio, 2007; Böhmann, Leimeister & Möslein, 2014; Diao et al., 2016).

4.5. Personalisation and digital storytelling as mechanisms for co-creating value

A third value differentiator highlighted by the current applied research is AI's ability to support personalization and interactive digital storytelling. Respondents' preferences suggest strong support for virtual tours (77.6%), oral histories (78.9%) and role-playing narratives (72.4%), suggesting a need not just for information, but also for meaning, context, and engagement. These discoveries are in line with the Service-Dominant Logic paradigm, whose theory contends that value is co-created through interaction instead of being presented unilaterally (Vargo & Lusch, 2004; Vargo & Lusch, 2008; Lusch & Nambisan, 2015). AI personalizes content while service analytics generates data for ongoing adaptation with the goal of positioning the AI-assisted library as a site of cultural co-creation. This capability sets libraries apart from the commercial-level digital platform by strengthening their function of producing public worth and cultural legitimacy (Spohrer & Maglio, 2007; Böhmann, Leimeister & Möslein, 2014; Akter et al., 2020).

4.6. Theoretical and practical contribution

From a practical perspective, the applied research identifies three stakeholder priorities with direct implications for the design of AI-assisted cultural heritage services: diversified access to cultural resources, interface accessibility, and digitally mediated narrative engagement. These priorities are empirically reflected in the high support for access-oriented functionalities (83.8%), interface accessibility (84.2%), and storytelling-based interaction formats (78.9%), indicating that future digital library systems should be designed around discoverability, inclusion, and user-centered cultural mediation (Spohrer & Maglio, 2007; Akter et al., 2020; UNESCO, 2021). The applied evaluation also contributes to extending research on service analytics in the public cultural service ecosystem, further extending its application beyond commercial service environments. By operationalizing service analytics indicators through stakeholder perceptions related to technological practices and accessibility priorities, the research provides empirical evidence of how service analytics can support the design and evaluation of inclusive AI-assisted digital services in libraries and cultural heritage institutions. This empirical analysis emphasizes that the perceived value of AI applied to digital cultural services is mediated by indicators of service analytics, such as technological experience, satisfaction with digital infrastructures, and accessibility priorities, which influence people's expectations of AI-enabled functionalities. It confirms that AI develops largely in the context of service analytics functions where user behaviour, service demands and interaction characteristics converge in cultural heritage ecosystems. The applied research also supports the idea that the value of AI relies on service-analytical integration beyond its isolated technical functions. This article is relevant to Information Science, since it conceptualizes AI-assisted cultural services as socio-technical systems that are analysed through user-centred analytical indicators. Moreover, this empirical analysis reveals key design elements, such as intuitive interfaces, rapid access to relevant content, and narrative engagement, corroborating service analytics as an operational framework for the assessment of AI-enabled systems in line with stakeholder needs.

Author contributions

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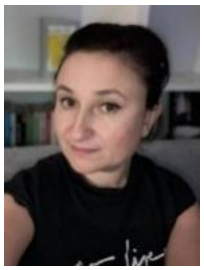

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