Matching Criteria of Andragogue Profile Components into the Adult Learning Ecosystem Model

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Abstract

This article addresses the development and processing of an andragogue profile designed for integration into the adult learning ecosystem. In this context, the andragogue profile is considered as a key element ensuring optimal interaction between the andragogue and the learner. The andragogue facilitates individualized learning conditions by providing a flexible study plan and leveraging the full potential of semantic technologies.

The authors emphasize the importance of semantic personalization of the learning process through the creation of personal learning trajectories (PLTs). These trajectories account for diverse learner needs and capabilities, defining individualized interaction plans between the learner and the andragogue. In this research, we propose the method of constructing an extended andragogue profile that incorporates additional characteristics related to various aspects of andragogue`s skills, knowledge and research specialization. These characteristics can be used to develop PLTs for adults on various stages of their lifelong learning (LLL). The extended profile integrates structure elements from both teacher and researcher profiles, supplemented by specific parameters of andragogue`s activities by modeling of characteristics influenced the PLT construction, interaction with learners, and other critical aspects of the educational process. Utilizing this profile can ultimately improve the quality of learning. For a multi-criteria evaluation of the andragogue profile, we apply the Saaty Analytic Hierarchy Process (AHP) method to determine the weighting coefficients of individual parameters such as professional competence, psychological profile, technological literacy and motivational characteristics.

Keywords
Andragogue profile, adult learning, personal learning trajectories, learning ecosystems.

1. Introduction

The digital learning environment now provides access to a large number of information resources that can be used for personalized learning [1], aligning with the individual characteristics of learners. These characteristics include their information perception, local and global learning goals,

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preferences, as well as additional knowledge and skills, as highlighted in numerous scientific studies [2, 3].
However, effective personalization of learning also requires identifying educators who can provide the most suitable learning experience for a particular learner or group of learners.

The optimality of the learning process can be assessed using various criteria based on an analysis of parameters related to educators, learners and *learning objects* (LOs) involved in this process. Comparing the values of these parameters necessitates formalizing the structure of all elements within the learning ecosystem and implementing tools to determine their semantic similarity. This comparison can be achieved using external knowledge sources, such as ontologies, taxonomies, and structured classificators within the learning domain.
Lifelong learning (LLL) involves more complex and detailed models of personalized learning, and the interaction of educators with adult learners is based on cooperation and causes the analysis of a larger number of aspects, compared to the learning of children and adolescents.

Andragogues are specialists that provide various learning services oriented on adults, taking into account their age, educational background, professional characteristics and individual specifics. These tasks require a broad range of andragogue`s professional competencies, extending beyond traditional pedagogical skills and competencies [4]. Key competences for adult learning include teaching, consulting and other activities similar to those of conventional educators. However, these tasks are more complex due to the heterogeneity of the adult learners and the multifaceted nature of their goals. The professional activity of andragogues is based on analyzing larger volumes of information, necessitating the development and implementation of specific methods and models for collaboration with adult learners.

These challenges underscore the need for constructing an andragogue profile capable of modeling key properties such as professional competencies, skills, teaching methodologies, student and colleague feedback, scientific publications and educational projects. These factors influence the development of *personal learning trajectories* (PLTs) and enhance the effectiveness of andragogue–learner cooperation.

The structure of the andragogue profile should integrate elements from both teacher and researcher models, supplemented by specific parameters that reflect the unique characteristics of andragogue`s activities. To support andragogue activities through digital tools, it is essential to formalize a structured andragogue profile that encapsulates these properties. This profile aims to optimize andragogue–learner interactions within adult learning ecosystems (ALE). Multi-criteria comparisons of andragogue profiles require methods for determining the relative importance of individual criteria based on the specific needs of adult learners.

2. Key competencies of andragogues

In the context of rapid technological and socio-economic changes, the ability of adults to engage in LLL [4] becomes critically important. Supporting LLL requires the implementation of a personalized approach in education that involves construction and implementing PLTs [5] that enable education based on abilities, interests, needs, motivation, opportunities and experience of adults, as well as enabling flexible learning pathways. PLT constuction necessitates the involvement of external knowledge sources related to both the learning domain and the subjects within ALE (Figure 1) that can vary significantly in volume and structure [6]. Unlike other digital learning ecosystems, ALE involves a greater number of parameters describing both biotic components for describing the diverse knowledge and competencies of people with heterogeneous work and learning experience, as well as abiotic components that define the motivation and cognitive characteristics of learners across different age groups [7]. Consequently, efficient analyze of such knowledge causes the need in appropriate semantic technologies and software tools based on formal models of all ALE elements.

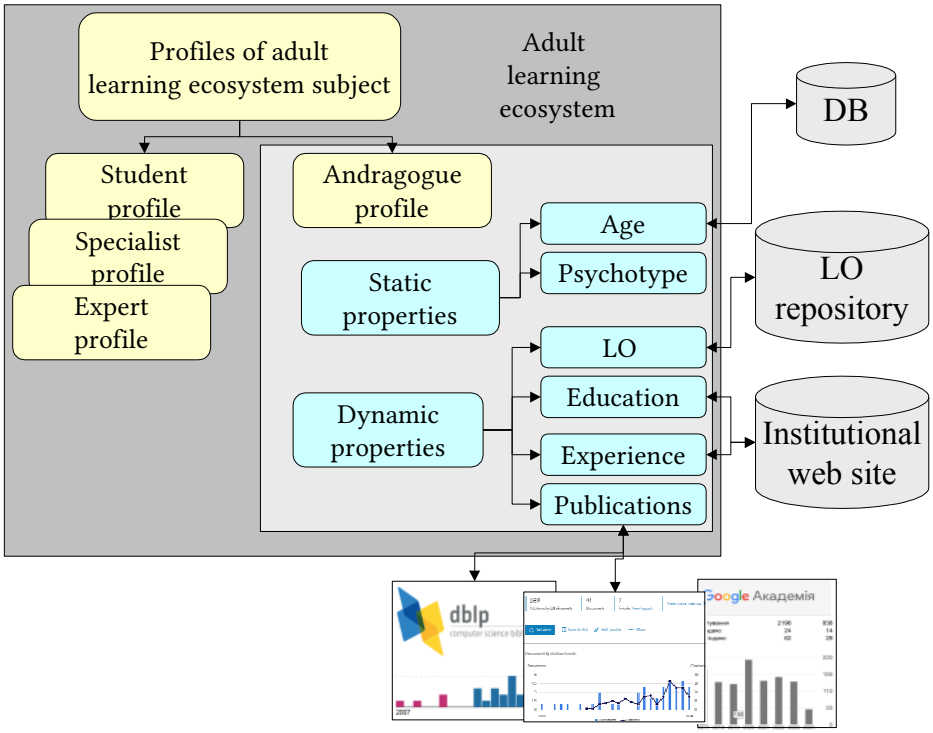

Figure 1: User profiles of adult learning ecosystem subjects.

While traditional educators focus on foundational knowledge acquisition, skill development, and the upbringing of children and adolescents, andragogues cultivate additional competencies that support adults' professional or personal growth [8]. The professional activity of andragogues is aimed at flexible supporting continuous and individualized learning (whether formal, non-formal and informal) tp adults with diverse and complex structure of skills, experience and motivations.

The interaction between andragogues and learners is based on cooperation and takes into account a broader range of factors due to the heterogeneity of the adult learning audience. Adults typically have a clearer understanding of their learning goals, expected outcomes, and preferred learning processes. Furthermore, andragogues need possess deep expertise in their learning domain for effective knowledge sharing with their students. As a result, the andragogue model is inherently more complex then the model of of a traditional pedagogue, encompassing a greater number of parameters. This complexity underscores the need for specialized software tools based on semantic technologies to support andragogues in their professional activities.

3. Problem definition

The development of software tools to support andragogues in their professional activities requires the formalization of all ALE components relevant to PLT development. While numerous studies focus on student profiling and the creation of meta-descriptions for LOs and disciplines, andragogue profiling has largely remained overlooked by researchers. We propose to create an andragogue profile schema that integrates elements of the researcher and teacher models, augmented with parameters specific to adult learning to optimize learner–andragogue interactions.

4. Subjects of adult learning ecosystems and their modeling

PLT is a structured framework of goal-oriented learner activities co-developed by the andragogue and the learner, tailored to a learner's individual objectives. Conceptually, PLT serves as a dynamic *interaction plan*, enabling the andragogue to adapt strategies based on the learner's evolving needs and feedback. Other ALE subjects that we describe in [5], such as *domain experts* and *technical support specialists,* also participate in PLT creation, but their role is less significant. Therefore, the primary focus of PLT design is the matching of *andragogue* and *learner*

profiles with metadescriptions of LOs and *learning courses* (LCs) [9], utilizing external knowledge relevant to the domain.

In general terms, user profile is a structured representation of an individual user's preferences and needs, that the information system processes to define the user goals and capabilities [10]. User profiling in computer systems is the subject of various scientific studies [6]. Such profiles are aimed to reflect static and dynamic content, represent properties of individuals or groups, and employ various methods of information modeling and displaying.

Information systems supporting learning process place significant emphasis on student profiling and the creation of various structures to represent their characteristics and needs. A large number of student profiling models are implemented in e-learning systems [11, 12]. However, most of them focus on describing learners, while modeling of teachers receives less attention or remains outside the scope of analysis entirely. Moreover, these models often overlook the specifics of adult learning [13].

We identify the following key structural elements of the andragogue profile:

- Information about formal education (e.g., specialty code, academic degree);
- Practical experience (e.g., CVs, workplaces and positions);
- Publication activity (e.g., number of research and teaching-methodological works, Hirsch index);
- Teaching activity (Previously developed or lectured LCs);
- Results achieved by learners through collaboration with this andragogue;
- LC keywords and andragogue`s thesaurus.

Andragogue profiling in the PLT construction system involves models and standards for describing researchers and lecturers enriched by domain ontologies [14, 15] for unified population. However, profiles of andragogues should also be supplemented with specific elements that reflect their professional activities.

The set of *scientific publications and textbooks* authored by the andragogue, along with the *number of their citations*, provides a clear identification of their research interests and an assessment of their rating among other specialists in the field. Notably, scientometric databases are updated automatically, therefore new competency areas of the andragogues relevant to their publications are immediately added to their profiles, while citation indexes reflect the academic community's evaluation of these materials, serving as expert assessment of these results.

The set of LOs selected by the andragogue for teaching a particular LC can be analyzed to generate a set of keywords forming the LC thesaurus in the andragogue's understanding (e.g., based on the semantic markup of LO metadata. Thus, learners can predict LC topics. The keyword set itself can remain hidden from learners until the course begins, as it can be an intellectual property of the andragogue and its use is not free.

Thesaurus of the andragogue generated as a sum of LO keyword sets and keywords of his/her publications reflects andragogue`s sphere of competence.

Experience from previous interactions with learners, where the effectiveness of teaching subclasses of different learner types allows predicting the success of learning for the student for whom the PLT is created. This feature ultimately enables the system to generate recommendations for andragogue selection if alternative options are available.

The process of PLT construction includes matching between the learner's profile with the set of current competencies, the andragogue's profile, the set of available relevant LOs, and the LC description.

Additionally, we categorize the content of the andragogue's profile by access level;

- *open*: data visible to all ecosystem participants, but editable only by the profile owner and administration;

- *fully closed*: personal data visible only to the profile owner and analysis programs (e.g., for building statistical estimates);
- *partially open*: data visible only to a specific subsets of the educational process participants (e.g., learners who communicate with this andragogue or other andragogues).

In addition to describing personal information related to professional activities (e.g., ORCID), the andragogue profile contains parameters typically used to assess overall work and research effectiveness. These parameters are essential both for andragogue matching and PLT construction. Currently, various quantitative evaluation methodologies are employed to process such parameters, allowing simultaneous consideration of multiple factors.

5. Composite andragogue rating

Formalizing of andragogue profile requires grouping and more formal definition of these parameters. We propose to separate following categories of the andragogue properties: professional competence, motivation, psychological characteristics and technological literacy.

Professional competence P evaluates education, work experience, certifications, etc. :

$$P = wp_E * E + wp_C * C + wp_Q * Q, \quad (1)$$

where E is a professional experience (in years), C is a number of specialized certifications, Q is a current level of organizational position, wp_E, wp_C and wp_Q are weighting factors that determine the relative weight of andragogue`s competencies depending on the domain specifics [16, 17].

Motivational profile M reflects the andragogue's engagement in PLT creation and personalization readiness (0-10 scale). Its value is assessed via interviews/questionnaires.

Psychotype S evaluates communication skills, empathy and stress tolerance (1-5 Likert scale for each parameter) derived from psychological tests (e.g., emotional intelligence assessments):

$$S = \sum_{i=1}^{n} s_i * w_{s_i}, \quad (2)$$

where w_{s_i} are weights for selected psychological qualities.

Technological literacy T measures proficiency with actual educational platforms and digital tools. It combines normalized number of mastered platforms T_{pl} and the level of use of these technologies T_{tech}, assessed through practical tasks:

$$T = T_{pl} + T_{tech}. \quad (3)$$

Evaluations (1)-(3) are used to compute the composite andragogue rating of the R can be estimated by the formula:

$$R = a_P * P + a_S * S + a_T * T + a_M * M, \quad (4)$$

where a_P, a_S, a_T, a_M are weighting coefficients that reflect relative importance of parameter for specific andragogue roles.

6. Extended parameters of andragogue profile

The core set of andragogue profile parameters can be augmented with objective, dynamic and quantifiable metrics that reflect actual state of his/her competencies. Their data sources are scientometric databases (Scopus, Google Scholar, DBLP, etc.) with information about publication activity of researchers and LO sets that the andragogue develops, selects from repositories or accompanies with metadata for use in the educational process.

Scientometric indicators of the andragogue activity *B* are defined by key components: publication count *X* of scientific and methodological works fixed by scientometric base; Hirsch index *H*; citation count *Ref* defined as a number of references to andragogue publications:

$$B = w_X * X + w_H * H + w_{Ref} * Ref, \quad (5)$$

where wb_X, wb_H and wb_{Ref} are weighting coefficients that reflect relative importance of scientometric parameters.

Achievements of learners A tracks awards/grants/certificates earned by the andragogue's students in the relevant areas and combines key parameters: absolute count A_{abs} defined by the total number of awards, prizes, grants, certificates, etc. and normalized count $A_{norm} = A_{abs} / number\_of\_learners$:

$$A = w_{abc} * A_{abs} + w_{norm} * A_{norm}, \quad (6)$$

where w_{abc} and w_{norm} are weighting coefficients that reflect relative importance of A_{abs} and A_{norm} for current task.

Learning Objects of andragogue L [18] processed by andragogue that can be distinguished between: LOs developer personally by the andragogue Li; LOs placed by the andragogue to repository from external sources and accompanied by metadata Le; LOs used by the andragogue in educational process Lu:

$$L = w_{Li} * Li + w_{Le} * Le + w_{Lu} * Lu, \quad (7)$$

where w_{Li}, w_{Le} and w_{Lu} are weighting coefficients that reflect relative importance of LO processing type.

The enhanced andragogue rating R^+ is enriched (4) by (5)-(7) elements:

$$R^+ = R + w_B * B + w_A * A + w_L * L, \quad (8)$$

where w_B, w_A, w_L are weighting coefficients that determine the importance of additional characteristics of the andragogue's work, relating to the scientific components and the real influence on learners.

7. Weighting methodology for multicriterial ratings of andragogues

The question arises of how to determine the weighting coefficients that determine the importance of andragogue profile elements into the integrated ratings. Different institutions use various criteria and methods that can depend of the rating goals, and therefore the obtained results differ significantly. Therefore, it is advisable to store original values of the andragogue profile parameters and to interpret them by weighting coefficients calculated according to the current assessment task with use of relevant methods. For example, *Saaty's Analytic Hierarchy Process (AHP)* [19] is recommended for objective weight determination, namely, by pairwise comparison of parameter significance that affect the evaluation result with a quantitative determination of their relative weight. AHP advantages in comparison with other multi-criteria evaluation methods such as the Weighted Sum Model and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) are flexibility, structured approach, adaptability and objectivity. It is important for evaluating of such complex objects as andragogue profiles, because AHL can consider their qualitative parameters as psychological profiles or motivational factors.

AHP method consists of problem decomposing into the simpler criteria of decision making and further processing these criteria by pairwise comparisons. The values of elements compares by different criteria can be measured on various scales (for example, andragogue length of teaching experience is measured in years, and content of publications – in pages). The criteria are prioritized in terms of their importance to achieving the goal. The prioritization process reduces the problem of different scale types by their importance for users. Thus, the multidimensional scaling problem is transformed into a one-dimensional one. The first stage identifies the most important elements of the problem, and the second stage considers the hierarchy as complete one if each element of selected level functions as a criterion for all elements of a lower level. The scale of coefficients

$aw_i^*, i = \overline{1,n}$ transforms into the standard form $w_i = aw_i^* / aw_i^* = aw_i^* / aw_i^*$, where $\sum_{i=1}^{n} w_i = 1$, and $w_i, i = \overline{1,n}$ are called normalized weights. AHP breaks evaluation into hierarchical criteria and quantifies relative parameter importance, identifies critical elements, then establishes inter-level dependencies.

This method standardizes weight assignment while accommodating domain-specific requirements. The relative attitude scale obtained from the pairwise comparison matrix of judgments is derived by solving the conditions:

$$\begin{cases} \sum_{j=1}^{n} a_{ij} w_j = \lambda_{max} w_i \\ \sum_{j=1}^{n} w_j = 1 \end{cases}. \quad (9)$$

As a result, the relative degree of interaction of the hierarchy elements can be established. This method includes procedures for synthesizing multiple judgments, obtaining the priority of criteria, and finding alternative solutions. The first stage identifies the most important elements of the problem, the second stage identifies the best way to verify observations and evaluate elements; the next stage may be to develop a method for applying the solution and assess its quality.

If $a_{ij} a_{jk} = a_{ik}$, then the matrix $A = (a_{ij})$ is consistent, and its main eigenvalue is equal to n. The general values of the eigenvalues are calculated by the formula (10):

$$Aw = \begin{matrix} \\ A_1 \\ \dots \\ A_n \end{matrix} \begin{matrix} A_1 \dots A_1 \\ \begin{bmatrix} w_1/w_1 & \dots & w_1/w_n \\ \dots & \dots & \dots \\ w_n/w_1 & \dots & w_n/w_n \end{bmatrix} \end{matrix} \begin{bmatrix} w_1 \\ \dots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ \dots \\ w_n \end{bmatrix} = nw. \quad (10)$$

For the current task of andragogues rating, the upper level elements of the hierarchy are professional competence, psychological portrait, technological literacy and motivational profile expanded by lower level elements, such as the andragogue current level of organizational position, number of publications, readiness to personalize learning etc.

Both the upper level weight coefficients a_P, a_S, a_T, a_M from (4) and w_B, w_A, w_L from (8) and the lower level coefficients from (1)-(3) and (5)-(7) such as wb_X, wb_H, , w_{Le} and w_{Lu} are compared pairwise. The experts performing these comparisons take into account the specifics of the assessment goals (for example, theoretical preparedness for adult learning or an assessment of the practical application of digital technologies) and reflect it into weights of profile parameters.

8. Specialized rating based on learning course semantics

Considered ratings reflect the qualifications and effectiveness of the andragogue work "as a whole" and don't take into account competence and experience in some particular learning domain. If the andragogue works in a fairly broad field, then it is advisable to specify these assessments for specific LC or discipline.

This goal needs in formalized knowledge about LC - for example, in the form of a thesaurus [14] that contains the key LC competencies and information about pertinent LO used for this LC. On base of this knowledge andragogue's rating can be concretized for $lc \in LC$.

Professional competence $P(lc)$ evaluates subset of andragogue`s education, work experience, certifications defined by (1) that concern this LC:

$$P = wp_E(lc) * E(lc) + wp_C(lc) * C(lc) + wp_Q(lc) * Q(lc), \quad (11)$$

where $wp_{E(lc)}, wp_C(lc)$ and $wp_Q(lc)$ are weighting factors that determine the relative significance of factors for LC.

Motivational profile $M(lc)$ reflects the degree of interest of the andragogue in PLT creation for particular LC.

Psychotype $S(lc)$ reflects the ability of the andragogue to communicate with students in the field of LC (this set takes into account only those psychological characteristics that are essential for this course):

$$S(lc) = \sum_{i=1}^{n} s_i(lc) * w_{s_i}(lc), \quad (12)$$

where $w_{s_i}(lc)$ – weighting factors specified for LC.

Technological literacy $T(lc)$ combines normalized number of mastered platforms $T_{pl}(LC)$ and the level of use of these technologies $T_{tech}(lc)$ used by andragogue for LC (not in general):

$$T(lc) = T_{pl}(lc) + T_{tech}(lc). \quad (13)$$

Evaluations (11)-(13) provide the computing of the andragogue rating $R(lc)$ for selected LC by the formula:

$$R(lc) = a_P(lc) * P(lc) + a_S(lc) * S(lc) + a_T(lc) * T(lc) + a_M(lc) * M(lc), \quad (14)$$

where $a_P(lc), a_S(lc), a_T(lc), a_M(lc)$ are weighting coefficients that reflect relative importance of parameter for specific LC. To determine these weighting factors, it is also appropriate to use the Saati`s AHP method with the determination of the pairwise relative importance by (9)-(10) of the coefficients for the parameters of different levels.

Similarly, the extended andragogue rating $R^+(lc)$ for a specific LC can be determined by supplementing (8) with the parameters used in the calculation (14):

$$R^+(lc) = R(lc) + w_B(lc) * B(lc) + w_A(lc) * A(lc) + w_L(lc) * L(lc), \quad (15)$$

where $B(lc)$ reflects scientometric indicators of the andragogue's activity that directly relate to the selected LC; $A(lc)$ describes student achievements based on the LC study of LC with this andragogue; $L(lc)$ reflects the number of LOs processed by the andragogue, and $w_B(lc), w_A(lc), w_L(lc)$ are weighting coefficients that determine the importance of these additional characteristics of the andragogue's work.

$B(lc)$ is defined by integration of data from scientometric databases about objects that are semantically similar to LC:

$$B(lc) = w_X(lc) * X(lc) + H(lc) + w_{Ref}(lc) * Ref(lc), \quad (16)$$

where $X(lc)$ is defined by number of the andagogue`s scientific and methodological publications relevant to the LC domain; $L(lc)$ is the number of references to publications from $X(lc)$, but general Hirsch index of this person is used (due to the complexity of its determination for an arbitrary subset of publications); $w_X(lc), w_{Ref}(lc)$ are their weighting factors for selected LC.

$A(lc)$ is calculated on base of the number of student awards $A_{abs}(lc)$ in LC domain and defined its normalized count $A_{norm}(lc) = A_{abs}(lc)/number\_of\_learners$:

$$A(LC) = w_{abs}(lc) * A_{abs}(lc) + w_{norm}(lc), \quad (17)$$

where $w_{abs}(lc), w_{norm}(lc)$ are weighting factors according to rating goals

$L(lc)$ evaluation takes into account the type of the andragogue`s LOs processing: $Li(lc)$ is a number of LOs that the andragogue develops for this LC; $Le(lc)$ is a number LOs specified by the andragogue by additional metadata according to LC specifics; $Lu(lc)$ is a number of LOs used by

this andragogue foe LC learning; $w_{Li}(lc), w_{Le}(lc), w_{Lu}(lc)$ are their weighting factors for LO processing types:

$$L(lc) = w_{Li}(lc) * Li(lc) + w_{Le}(lc) * Li(lc) + w_{Lu}(lc) * Lu(lc). \quad (18)$$

Weighting factors used in (16)-(18) can be also defined wit use of Saati`s AHP method where high level of hierarchy is defined by $R^{+}(lc)$ parameters.

9. Conclusion and practical use prospects

We propose an andragogue profile schema that includes formal parameters of person , such as educational background, academic degrees, basic qualifications, and the courses they teach. This schema is expanded to incorporate specific characteristics that can influence the effectiveness of adult learning, such as:

- practical experience in the relevant field;
- scientific activity and impact (number of publications and citations, Hirsch index);
- psychological characteristics (empathy, communication skills);
- technological and digital literacy (ability to work with modern learning platforms);
- experience and learning outcomes of student (achievements, feedback).

Andragogue profiles developed according to this schema are interoperable and can migrate across systems with minimal adjustments. This profile structure is used in AndraMedia [20] as a part of PLT construction. Andragogue profiles are stored into ActiveBook repository (AndraMedia subsystem) [21] as Wiki pages, where semantic properties are used to represent their parameter values. These profile pages are populated via wiki templates; additional parameters use semantic markup. Other possible application areas of andragogue profile are centralized systems of formal education and decentralized platforms for andragogue-learner collaboration.

Additional parameters of the andragogue stored in the profile cause the broader functionality of services based on analysis of their values. Examples of semantic queries that can be performed by matching andragogue profiles with information about other elements of the adult learning ecosystem (some of them are currently implemented in the Andramedia system):

- Searching for the most qualified andragogue to develop a new LC defined by the set of competencies of this course (by comparison with competencies of andragogue`s LCs);
- Selecting an andragogue to teach LC to a group of students who already possess a certain subset of the LC competencies (optimization based on the subset of competencies);
- Recommending advanced master-classes or trainings (from the set of available resources) for andragogue to improve existing digital skills;
- Predicting the success of students in certain LC study with different andragogues.

Ratings of andragogues based on proposed model are flexible and scalable. The evaluation formula can be supplemented with additional parameters, such as assessments based on questionnaires for students who have previously studied with this andragogue, normalization with average institutional ratings, additional andragogue`s competencies relevant to learning process. Some profile parameters can be defined more precisely (e.g., using domain-specific scientometric data like DBLP and distinguish publications with different accreditation levels).

These enhancements require the following:

- changes of the andragogue profile structure defined by its metadata schema;
- determining the sources of additional parameter values;
- providing units of measurement and evaluating scales for the values of these additional parameters;

- establishing the access policy to the values of the profile parameters for different groups of users;
- integration with existing assessments and the results of their use in recommendations for andragogue selection and other PLT elements.

Expanding the andragogue profile structure provides learners with more criteria for selection and supports the construction of effective PLTs.

Declaration on Generative AI

During the preparation of this work, the authors used AI program Chat GPT 4.0 for correction of text grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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