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Alternative Assessment Approaches in Contemporary Primary School Foreign Language Education: Global Practices and Practices in Turkey

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ABSTRACT

The widespread adoption of foreign language teaching at the primary school level worldwide has made the assessment of young language learners a significant area of research and application. Unlike the assessment of adult and adolescent language learners, the assessment of children learning foreign languages at an early age requires consideration of variables such as developmental appropriateness, cognitive maturity, affective characteristics, attention span, task experience, and classroom interaction. Therefore, whether one-off, high-risk, and mostly paper-and-pencil based exams adequately represent children's foreign language development is a significant point of debate. Current research shows that alternative approaches such as formative assessment, performance and task-based assessment, portfolio, self-assessment, peer assessment, teacher observation, project-based assessment, and technology-assisted assessment can contribute to a more holistic monitoring of the development of young language learners. However, alternative assessment does not mean completely abandoning traditional tests; it requires the purposeful and systematic combination of different assessment evidence. This section first addresses the developmental and pedagogical characteristics of primary school foreign language assessment, and then examines alternative assessment approaches used worldwide in light of current research. The second main dimension of the section discusses assessment practices in primary school foreign language education in Turkey, in the context of teachers' practices and the program and measurement-evaluation changes implemented by the Ministry of National Education in recent years. In the final section, international research is compared with practices in Turkey, and an integrated, developmentally appropriate, and learning-supportive assessment model is proposed for primary school foreign language education.

Keywords: young language learners, primary school foreign language education, alternative assessment, formative assessment, portfolio, self-assessment, performance assessment.

1. INTRODUCTION

The introduction of foreign language teaching to earlier ages has become a significant education policy trend worldwide in the last few decades. The strengthening position of English as a global language of communication, increased international mobility, and expectations regarding the cognitive, communicative, and cultural gains that early language learning can provide have supported the widespread adoption of foreign language teaching at the primary school level. With this development, researchers have increasingly

focused not only on which foreign language should be taught to children, using which methods, and at what age, but also on how children should assess the language they learn.

The assessment of young language learners differs in many ways from the assessment of adult or adolescent learners. Children's cognitive development levels, literacy skills, attention spans, abstract thinking capacities, assessment experiences, and affective characteristics can vary significantly with age. Therefore, directly adapting assessment tools developed for adults to children may negatively impact the validity and usability of the measurement tool. Butler (2018) emphasizes that the context of the task and age appropriateness are critically important in the assessment of young learners. Nikolov and Timpe-Laughlin (2021) comprehensively reviewed the last two decades of research on the assessment of young language learners and showed that the field has evolved from a structure consisting solely of standardized tests to a broader research area encompassing different dimensions such as formative assessment, alternative assessment, technology-mediated assessment, play-based assessment, and teacher assessment. The researchers particularly emphasize that in assessing children, it is crucial to consider not only “what is being measured” but also “why, how, by whom, and in what context it is being measured.” (Cambridge University Press)

This development necessitates a rethinking of the traditional meaning of the concept of assessment. In the traditional understanding, assessment is often seen as an activity carried out at the end of the teaching process, determining how much the student has learned. In contrast, in the formative assessment approach, assessment is embedded within the learning process, and the evidence obtained is used to shape subsequent teaching decisions. Black and William's (1998) influential work on formative assessment has highlighted the importance of using classroom assessment information to improve teaching and learning. This change is even more important for primary school foreign language education. Because children's language development often occurs in the form of small but continuous advancements. A student's ability to recognize a word, to use the word alone, to use the word in a sentence, and to use the word in a real communication context do not indicate the same level of learning. Therefore, assessment should include not only the capacity to produce "correct answers" but also evidence of the use of language in a meaningful context. The aim of this section is to examine alternative assessment approaches used in current primary school foreign

language education considering international research and to compare these approaches with current assessment policies and classroom practices in Türkiye.

2. THEORETICAL AND PEDAGOGICAL FOUNDATIONS OF PRIMARY SCHOOL FOREIGN LANGUAGE ASSESSMENT

2.1. The Concept of Young Language Learner and Assessment

The concept of "young language learner" can encompass different age ranges in different studies. Nikolov and Timpe-Laughlin (2021) consider the literature to include the foreign or second language learning and assessment processes of children between the ages of three and fourteen. In the context of primary school, however, there can be significant differences even within the same class in terms of students' ages, cognitive development, and literacy levels. Therefore, it is not possible to talk about a single "child assessment model" in the assessment of young learners. The assessment experience of a first-grade student will not be the same as that of a fourth-grade student. In particular, written self-assessment, long performance tasks, or complex rubrics may not be suitable for younger age groups. Age-appropriateness of assessment tasks does not only mean that the task is fun. The cognitive process expected from the student, the language used, the length of the instructions, the task duration, the quality of visual aids, and the literacy level the student needs to complete the task should also be considered. From this perspective, one of the fundamental questions in assessment design should not be "Can the student do this?" but rather, "Has an appropriate assessment environment been created that allows the student to demonstrate what they are capable of doing?"

2.2. Assessment of Learning, Assessment for Learning, and Assessment as Learning

In contemporary assessment literature, assessment is considered in terms of its different functions. Assessment of learning aims to determine the level reached by the student at the end of learning. Assessment for learning emphasizes the use of assessment information to improve learning. Assessment as learning, on the other hand, focuses on the student monitoring, evaluating, and adjusting their own learning. In primary school foreign language education, these three approaches can be considered not as

alternatives to each other, but as complementary elements. For example, a teacher can assess a student's vocabulary knowledge with a short test at the end of a unit. This serves the function of assessment of learning. The same teacher can reorganize their teaching by observing in which contexts students can use words throughout the unit; this corresponds to the assessment for learning approach. A student evaluating their own development with expressions such as "I can name five animals" can be an example of the assessment as learning approach. Therefore, the fundamental value of alternative assessment methods is not to replace the traditional exam with another "exam." The main goal is to design assessment in such a way that it undertakes different functions at different stages of the learning process.

3. ALTERNATIVE ASSESSMENT METHODS USED WORLDWIDE IN PRIMARY SCHOOL FOREIGN LANGUAGE EDUCATION TODAY

3.1. Formative Assessment

Formative assessment refers to the use of evidence regarding the student's learning process to improve teaching and learning. Therefore, formative assessment is not a single tool. Asking questions, observing students, giving short performance tasks, providing feedback, and giving students the opportunity to evaluate their own learning can all be considered within the scope of formative assessment. Formative assessment is particularly functional in primary school foreign language classes because children's performances can vary from day to day. A student may be shy in a verbal activity one day and more successful another. It is healthier for the teacher to consider evidence obtained at different times rather than making a decision based on a single performance. Another important feature of formative assessment is feedback. However, feedback should not be limited to general expressions such as "Good," "Very good," or "Wrong." It should include information that helps the child see the next learning step. For example, feedback such as "You used the animal words correctly. Now try to make a complete sentence" shows the student's current success and next goal together.

3.2. Performance and Task-Based Assessment

Performance assessment requires the student to demonstrate their knowledge and skills through a task. This approach is particularly important in language teaching because knowing grammar or vocabulary is not the same as being able to use language communicatively.

At the primary school level, performance tasks can be short and close to children's daily lives. For example, in the task "My Family," the student might be asked to create a poster introducing their family and write a few sentences about the poster. In the task "At the Restaurant," students might take on the roles of customer and waiter and engage in a short dialogue. In such tasks, not only grammatical accuracy should be assessed. The student's ability to achieve the communicative goal, use appropriate vocabulary, respond to the other person, and complete the task can also be among the assessment criteria.

The CEFR Companion Volume addresses language use within an action-oriented framework and expands on areas such as interaction, mediation, online interaction, and plurilingual/pluricultural competence. Furthermore, the inclusion of the Pre-A1 level has allowed for a more detailed description of the performance of beginner language users. This approach is important at the primary school level because it makes visible the children's initial small communicative gains.

3.3. Portfolio Assessment

A portfolio is a systematic collection of a student's work over a specific period. Unlike traditional exams, a portfolio aims to make visible not just a student's performance at a single point in time, but their overall development.

In a primary school English portfolio, the student may include:

• short written works,

• drawings,

• project work,

• vocabulary work,

• short speaking recordings,

• teacher feedback,

• self-assessment forms.

A significant advantage of portfolios is that they allow for comparison of a student's development over time. When a student's performance at the beginning and end of a term is compared, their development can be concretized.

A literature review on portfolio assessment shows that portfolios have potential benefits in terms of success, metacognitive skills, self-regulation, assessment literacy, and digital skills in foreign language learning; however, there are also problems such as time, digital competence, anxiety, and reliability (Cong-Lem, 2019).

Therefore, the success of a portfolio depends not only on the existence of the portfolio file, but also on the student's selection of products, their consideration of their development, and the teacher's provision of regular feedback.

3.4. Self-Assessment

Self-assessment is the student's evaluation of their own performance or learning process according to certain criteria. At the primary school level, self-assessment is particularly important in terms of developing the student's learning awareness. However, the traditional assumption that young students cannot self-assess is not entirely supported by research. The study by Butler and Lee (2006) is an important example in this respect. Examining the self-assessments of Korean primary school students regarding their English oral performance, the researchers found that on-task self-assessment, which was conducted immediately after the task, was more consistent with the students' actual performance compared to general and context-independent off-task self-assessment. In addition, it was observed that on-task self-assessment was less affected by the students' personality and attitude characteristics.

This result shows that it is not that children cannot self-assess, but how self-assessment is designed is critical. For example, “How good are you at English?” The question might be too general for a primary school student. Instead, concrete statements such as:

• “I can name five animals.”

• “I can ask my friend about his/her favorite food.”

• “I can say three things about my family.” can be used.

In a longitudinal study by Butler and Lee (2010) with 254 Korean sixth-grade students, it was observed that students regularly conducted self-assessments throughout a term; it was determined that students' self-assessment skills improved over time and had some positive effects on English performance and self-confidence regarding learning. However, it was also reported that the effects were small. Therefore, self-assessment should not be considered as the student “giving themselves a grade,” but rather as a formative tool that allows the student to monitor their learning.

3.5. Peer Assessment

Peer assessment involves students giving feedback on each other's work. At the primary school level, peer assessment should be initiated with simple and low-risk tasks.

For example, students can evaluate their friend's short speech using three criteria:

1. The student used English.

2. The message was understandable.

3. The task was completed.

A significant pedagogical advantage of this approach is that students learn to evaluate not only their friends' performance but also their own. However, the reliability of peer assessment may be limited at young ages. Friendship relationships, social status, student shyness, or insufficient understanding of the assessment criteria can affect the results. Therefore, peer assessment should be used especially for formative and low-risk purposes.

3.6. Teacher Observation

Teacher observation is a natural and powerful assessment resource in primary school foreign language education. Teachers can observe how students use language while playing games, working in pairs, singing, or performing a task. However, unsystematic observation can be susceptible to teacher bias. Therefore, observation can be supported with checklists. For example, a teacher:

For example, teachers may use observable indicators such as:

Area	Observable behavior
Listening	Follows a simple instruction.
Speaking	Can provide basic information about themselves.
Interaction	Can ask a simple question to a peer.
Vocabulary	Can use target vocabulary in context.
Pronunciation	Speaks in a way that does not interfere with intelligibility.

Such a system can transform teachers' naturally occurring classroom observations into more systematic sources of assessment evidence.

3.7. Project and Product-Based Assessment

In project assessment, students are expected to create a specific product. At the primary school level, projects do not have to be long-term and academically research-oriented. For example:

My Dream House

It can be designed in the form of the student drawing a house, labeling the rooms in English, and describing their house in a few sentences. This type of task can simultaneously provide evidence of vocabulary, writing, speaking, and visual expression skills. However, a significant issue in project assessment is how much of the student's product is their own. Parental support can be high, especially at young ages. Therefore, not only the final product of the project but also the preparation process in the classroom and the student's performance in explaining the product should be evaluated.

3.8. Game-Based Assessment

Game-based assessment allows children to demonstrate their language performance through game-like tasks during assessment. One of the important advantages of this approach for young learners is that it can reduce assessment anxiety and allow observation of students' natural interactions. Nikolov and Timpe-Laughlin (2021) note that game-based and technology-mediated assessments are increasingly being researched in the literature on the assessment of young language learners.

For example, a simple classroom game like “Find Someone Who” can be used to assess students’ questioning and answering skills. Instead of giving points, the teacher can record students’ communicative behavior using an observation form. The critical point here is not the game itself, but what kind of assessment evidence the game produces.

3.9. Digital and Technology-Supported Assessment

Digital technologies offer new possibilities for the assessment of young language learners. Digital portfolios, audio recordings, video tasks, interactive games, and digital stories can document not only written but also spoken and visual language use. Technology has significant potential, especially in speaking assessment. In the study by Michot et al. (2024), a speech recognition system was developed to automatically recognize the spontaneous speech of young English learners, and approximately 85 hours of speaking data from 4th–6th grade students were used. The study shows that automated speech recognition systems trained on adult speech may not be sufficiently successful in children's speech, and that the recognition of children's language errors by the system without "correction" is also a significant problem.

This result points to an important issue in AI-assisted assessment: technology can automate assessment, but it does not automatically guarantee assessment validity. In particular, age, voice characteristics, accent, level of language development, and types of errors must be considered in children's speech.

4. STRENGTHS AND LIMITATIONS OF ALTERNATIVE ASSESSMENT

The most important advantage of alternative assessment methods is that they do not reduce student learning to a single measurement tool. Portfolio development, performance tasks can make real language use visible, self-assessment can reveal learning awareness, observation can highlight classroom behaviors, and peer assessment can reveal interactive learning.

However, alternative assessment should not be considered simply as a dichotomy of "better than traditional tests."

Firstly, alternative assessment can be time-consuming. Especially in portfolio and performance assessments, the teacher's need to provide regular feedback to each student can create a significant workload. Secondly, alternative assessment is open to differences in raters. It is possible for teachers to make different decisions in evaluating open-ended performances. Thirdly, self and peer assessments depend on students' assessment literacy. Fourthly, in methods such as projects and portfolios, students may have different levels of support in their home environment. Therefore, the use of alternative assessment methods does not eliminate assessment problems; it brings with it different validity and reliability issues.

For this reason, the most defensible approach can be considered as assessment triangulation or, more broadly, evidence diversification. When a student's performance is observed at different times, on different tasks, and by different evaluators, it may be possible to reduce errors that may arise from a single measurement tool.

5. ASSESSMENT PRACTICES IN PRIMARY SCHOOL FOREIGN LANGUAGE EDUCATION IN TÜRKIYE

5.1. Current Framework of English Teaching in Türkiye

In Türkiye, foreign language education in state schools is conducted from the second grade onwards at the primary school level. Significant changes have been made to the curricula in recent years. As a result of the update made by the Board of Education in 2025, the "English Course (Grades 2, 3, 4, 5, 6, 7 and 8) Curriculum" was accepted in line with the updates within the scope of the Turkish Century Education Model and started to be implemented gradually from the 2025-2026 academic year. The Ministry's statement indicates that the program update was carried out especially in line with Foreign Language Area Skills. (Millî Eğitim Bakanlığı, 2025)

This development is important in terms of assessment. Because as the language skills targeted by the curriculum expand, the assessment system should not be limited only to tools that measure vocabulary and grammar knowledge. In other words, the success criteria of a skills-based program should also be skills-based.

5.2. Transition to Process-Oriented Assessment in Türkiye

In Türkiye, it has been observed that the process-oriented approach has been strengthened in the understanding of assessment at the primary school level in recent years. The "Teacher Guidebooks for Formative Assessment Activities for Primary Schools," published by the Ministry of National Education in 2024, aims to conduct classroom measurement and evaluation practices with a process-oriented and developmental understanding. The Ministry stated that the guides were prepared in line with the Turkish Century Education Model curriculum and the Ministry of National Education Measurement and Evaluation Regulation.

This situation shows that the official assessment policy in Türkiye is moving from a traditional "outcome-oriented" approach to a more "process and development" oriented approach. However, an important distinction should be made here: the inclusion of formative assessment in the program is not the same as the teacher actually conducting formative assessment in the classroom. The fact that a method is included in the policy text does not mean that it is applied effectively and systematically by the teacher.

5.3. Research on the Assessment of Young Language Learners in Türkiye

One of the studies that directly addresses the assessment of young language learners in the Turkish context is the research by Tanyer and Susoy (2018). The researchers examined the perceptions and practices of Turkish EFL teachers regarding the assessment of young language learners and conducted semi-structured interviews with 13 English teachers. One of the main aims of the research is to reveal how the assessment of young learners at the second and third grade levels is carried out.

The importance of this research for Turkey is that it makes visible the relationship between teachers' thoughts on assessment and actual classroom practices. There can be a difference between ideal pedagogical approaches to assessing young learners and the actual conditions of the classroom. It is thought that factors such as class size, lesson duration, curriculum intensity, material resources, teachers' assessment training, and the school's assessment culture may play a role in the emergence of this difference. Therefore, the widespread adoption of alternative assessment methods in Türkiye cannot be achieved simply by telling teachers to "use portfolios" or "conduct self-

assessment." Teachers need to improve their assessment literacy regarding why, when, and how to use these tools.

5.4. Portfolio and European Language Portfolio Experience in Türkiye

The European Language Portfolio offers a significant experience in terms of alternative assessment practices in Türkiye. Yılmaz and Akcan (2012) examined how the European Language Portfolio was integrated into the English learning processes of young learners in a study conducted with fourth and fifth-grade students in Türkiye. The research was conducted with students aged 9–11 over a 12-week period; classroom observations, teacher interviews, student focus group interviews, audio recordings of self-assessment sessions, and student-teacher materials were used.

The findings of the research show that the European Language Portfolio is implemented through five basic applications:

1. developing awareness,

2. monitoring goals,

3. making choices,

4. reflecting,

5. self-assessment.

These results are important in showing that alternative assessment in Türkiye is not just “another measurement tool”. Portfolios are also a pedagogical tool that supports students' participation in the learning process and their reflection on their learning.

Atikol's (2008) study also examined the views of English teachers in Türkiye regarding the assessment of young learners, particularly the applicability of portfolio assessment. In the first phase of the study, 26 English teachers in Çanakkale were worked with, and in the second phase, the experience of applying portfolio assessment in the classroom of young learners was examined.

When these studies are evaluated together, it can be said that the portfolio approach is not a new idea in Türkiye, but there are still dimensions that need to be developed in terms of sustainable and systematic application.

6. COMPARISON OF WORLD PRACTICES AND PRACTICES IN TÜRKIYE

When international research and studies in Türkiye are evaluated together, a striking parallel emerges. While more contextualization, process-orientedness, student participation, and alternative types of evidence are coming to the fore in the assessment of young language learners worldwide, a similar transformation is seen in official program and policy documents in Türkiye. However, there is a significant difference between the two levels: the gap between policy change and classroom implementation.

In Türkiye, the strong inclusion of the concept of formative assessment in official documents in recent years is an important development. However, for teachers to be able to translate this into daily classroom practice, variables such as assessment literacy, time, class size, materials, and institutional support need to be considered together.

The international literature similarly does not view alternative assessment as a simple technique. Nikolov and Timpe-Laughlin (2021) emphasize that research on the assessment of young learners encompasses different purposes, stakeholders, and assessment methods. Therefore, the goal for Turkey should not be to completely eliminate traditional exams, but to develop a balanced system where traditional and alternative assessment methods are used together for appropriate purposes.

7. AN INTEGRATED ASSESSMENT MODEL FOR PRIMARY SCHOOL FOREIGN LANGUAGE EDUCATION

Based on the research discussed in this section, an Integrated Developmental Language Assessment Model can be proposed for primary school foreign language education.

The model is based on four fundamental principles:

7.1. Diverse Evidence

A student's language development should not be determined by a single test. Different types of evidence should be used, including written, oral, observational, and student-based evidence.

7.2. Continuity

Assessment should not be conducted only at the end of a unit or term. Small, low-risk assessment activities should be carried out throughout the learning process.

7.3. Student Participation

The student should be removed from being a passive object of the assessment process. Age-appropriate self-assessment and peer feedback activities should be used.

7.4. Feedback to Instruction

One of the main functions of the assessment result should be to help the teacher decide on the next teaching step. These principles can be concretized with the following example system:

Stage	**Assessment**	**Instrument**	**Main purpose**
Beginning	Diagnostic	Pictures, brief Q&A	Identifying prior knowledge
Process	Formative	Observation, checklist	Monitoring development
Process	Performance	Task	Assessing authentic language use
Process	Self-assessment	Can-do statements	Developing learning awareness
Process	Peer assessment	Simple checklist	Providing feedback
End of unit	Performance	Speaking/project	Assessing integrated language use
End of term	Portfolio	Student work samples	Documenting development

Traditional short tests are not entirely excluded from this model. Short, structured tests for vocabulary, specific language structures, or certain aspects of reading skills may still be functional. However, these tests should not be assumed to represent a student's entire language proficiency.

8. TEACHER ASSESSMENT LITERACY AND IMPLEMENTATION PROBLEMS

The successful application of alternative assessment methods largely depends on the teacher's assessment literacy. The teacher should know not only how to use a rubric or checklist, but also how to determine the purpose of the assessment, collect appropriate evidence, interpret the evidence, and reflect the assessment result in teaching.

For example, a teacher might give a student a score of 7 out of 10 for their oral performance. However, if it is not clear what a score of 7 means and what the student should do next, the contribution of this score to learning will be limited. Instead, the teacher can give short feedback such as:

Strength: You can name and describe your family members.

Next step: Try to ask your partner one question.

This approach focuses on the evidence of learning and the next step rather than the score. Especially at the primary school level, the impact that assessment results can have on the student's motivation and self-perception should also be considered. If a child develops a fixed perception of "I am unsuccessful in English" at an early age, it can negatively affect their subsequent learning processes. Therefore, the assessment language should also be age-appropriate, supportive, and developmentally focused. 9.

CONCLUSION

In primary school foreign language education, assessment today has a broader meaning than simply determining the extent to which a student remembers the information included in the curriculum. The developmental characteristics of young language learners, the gradual and context-dependent nature of language learning, and the importance of communicative competence necessitate making assessment systems more flexible and multidimensional.

International research shows that approaches such as formative assessment, performance tasks, portfolios, self-assessment, and technology-assisted assessment have significant potential for monitoring the development of young language learners. However, research also reveals that alternative methods are not perfect. Portfolios can create time and reliability problems; self-assessment may not reflect students' true performance if not properly structured; rater differences may arise in performance assessment; and technology-assisted assessment can lead to validity problems when systems that are not sensitive to children's speech and language characteristics are used. Therefore, instead of positioning alternative assessment methods against traditional tests, it seems more appropriate to create an assessment ecosystem where different assessment methods serve different purposes.

The curriculum and measurement-evaluation reforms implemented in Türkiye in recent years have created an important infrastructure in this direction. The updated English Language Curriculum, which began to be implemented gradually from the 2025-2026 academic year onwards within the scope of the Turkish Century of Education Model, strengthens an understanding that centers on foreign language skills. (Ministry of National Education, Curriculum and Instruction Board) Similarly, the formative assessment guides published for primary schools support a process-oriented and developmental assessment approach.

Research in Türkiye shows that alternative assessment practices are not entirely new. Yılmaz and Akcan's (2012) European Language Portfolio study showed that young learners can participate in goal setting, choice making, reflection, and self-assessment processes. Tanyer and Susoy's (2018) study points out that the relationship between teacher perceptions and classroom practices should be considered in the assessment of young learners.

Considering these findings, the fundamental issue in terms of primary school foreign language assessment in Türkiye should no longer be the question of "should alternative assessment methods be used?" The more important question is, “Which assessment method should be used for which student group, for what purpose, to produce what evidence, and how should it change the teaching process?” The answer to this question will determine the future of primary school foreign language assessment. The ideal assessment system is one that does not reduce the student to a single test score; that monitors the student's development over time; that takes into account real language use; that involves the student in the assessment process; that

provides the teacher with information to reorganize teaching; and that brings together different assessment evidence. Consequently, the contemporary understanding of assessment in primary school foreign language education requires a shift from the question of "how many points did the student get?" to "what can the student currently do using the language, how are they progressing, and what is the next learning step?" This transformation is far more comprehensive than simply adding new assessment tools to the classroom; it requires a shift in pedagogical culture that makes assessment an integral part of teaching and learning.

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AI-Assisted Scientific Literacy in Medical Documentation and Secretarial Education: Evaluating Scientific and Health Information in the Generative AI Era

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ABSTRACT

The increasing integration of digital technologies and generative artificial intelligence (GenAI) into education and healthcare has transformed the ways in which students access, interpret, evaluate, and communicate scientific and health-related information. For students enrolled in Medical Documentation and Secretarial programs, these developments are particularly important because their educational and professional responsibilities involve medical terminology, health information, documentation, communication, and information management. In this context, simply accessing information or using artificial intelligence tools may not be sufficient. Students also need to evaluate the reliability of scientific claims, appraise health information, recognize limitations in AI-generated content, verify sources, and use information appropriately. This chapter examines the conceptual relationship between scientific literacy, health literacy, and AI literacy in Medical Documentation and Secretarial education. It discusses the opportunities and limitations of generative AI for accessing and evaluating scientific and health information and emphasizes the importance of critical verification of AI-generated outputs. Based on the literature reviewed, the chapter proposes a conceptual framework for AI-assisted scientific literacy in which scientific literacy supports the evaluation of scientific evidence, health literacy supports the appraisal and application of health information, and AI literacy enables learners to understand, critically evaluate, and appropriately use artificial intelligence systems. The chapter argues that the convergence of these three domains can provide an important conceptual basis for preparing Medical Documentation and Secretarial students for an increasingly AI-mediated healthcare information environment.

Keywords: Scientific literacy, health literacy, AI literacy, generative artificial intelligence, medical documentation, healthcare education, AI-assisted scienific literacy

1. INTRODUCTION

The increasing integration of digital technologies and artificial intelligence into healthcare and education is reshaping the ways in which health-related information is accessed, interpreted, and used (Abou Hashish ve Alnajjar, 2024). In this changing information environment, students preparing for careers in health-related fields need more than professional knowledge and technical skills (Yusuf et al., 2024; Sallam, 2023). They also need the ability to identify reliable information, evaluate evidence, recognize limitations in information sources, and make informed judgments based on scientific evidence. These competencies are closely associated with scientific literacy and health literacy.

Scientific literacy extends beyond the acquisition of scientific facts. The National Academies of Sciences, Engineering, and Medicine (NASEM, 2016) conceptualizes science literacy as involving knowledge and understanding of scientific concepts and processes, together with the ability to evaluate scientific information and use scientific knowledge in personal and societal decision-making. Contemporary approaches therefore emphasize not only knowing scientific information but also understanding how scientific knowledge is produced, evaluating scientific evidence, and judging the validity of scientific claims.

This evaluative dimension of scientific literacy is particularly important in health-related contexts. Health literacy has been conceptualized as a multidimensional competence involving the ability to access, understand, appraise, and apply health-related information to make appropriate decisions concerning healthcare, disease prevention, and health promotion (Sørensen et al., 2012). Thus, health literacy is not limited to finding health information; it also requires individuals to determine whether the information is understandable, relevant, trustworthy, and appropriate for use.

The importance of these competencies has increased with the expansion of online health information. Diviani et al. (2015), in a systematic review of 38 studies, found that lower health literacy was negatively associated with the ability to evaluate online health information and with trust in online health information. At the same time, the evidence concerning perceived information quality and the use of specific evaluation criteria was inconclusive. This finding highlights an important distinction between accessing information and evaluating information.

More recent literature has further demonstrated the scale of the problem. Zhang et al. (2024), in a systematic review of health misinformation literature published between 2013 and 2022, identified health misinformation as an important and persistent problem associated with digital media and public trust. These developments indicate that increased access to information does not necessarily result in improved information quality or informed decision-making.

The emergence of generative artificial intelligence (GenAI) has introduced a further transformation in the information environment. Generative AI systems such as ChatGPT can rapidly produce explanations, summaries, textual responses, and other forms of content in response to user prompts. Consequently, these systems have increasingly been incorporated into educational contexts. Yusuf et al. (2024), in a systematic mapping review, identified applications and potential impacts, ethical implications and risks,

user perspectives and experiences, adoption, and performance among major research themes concerning GenAI in education.

Empirical research has also provided evidence concerning the potential educational effects of ChatGPT. Albadarin et al. (2024), in a systematic literature review of 14 empirical studies, examined how students and teachers used ChatGPT in educational settings and identified both opportunities and challenges associated with its integration. The review reported applications including instant feedback, explanations, writing support, summarization, translation, personalized learning, homework assistance, and lesson planning. The authors also emphasized the importance of structured training, clear guidelines, and critical evaluation of information generated by ChatGPT.

Similarly, Deng et al. (2025), through a systematic review and meta-analysis of 69 experimental studies, reported positive effects of ChatGPT interventions on academic performance, affective-motivational outcomes, and higher-order thinking propensities. However, the authors also identified methodological limitations and emphasized the need for further research concerning longer-term effects. Therefore, the educational value of ChatGPT should not be considered independently from the limitations and conditions surrounding its use.

These findings suggest that the educational value of generative AI cannot be evaluated solely according to whether students can use AI tools or whether AI-generated answers appear useful. A critical issue is whether learners possess the competencies necessary to evaluate AI-generated information. This concern has contributed to the emergence of AI literacy as an important educational construct.

Long and Magerko (2020) conceptualized AI literacy in terms of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate with AI, and use AI appropriately in different contexts. More recent literature has also emphasized the multidimensional nature of AI literacy. Lintner (2024), in a systematic review examining 22 studies and 16 AI-literacy scales, highlighted the increasing importance of reliable approaches to measuring AI literacy.

The distinction between using AI and critically evaluating AI-generated information is particularly important in health-related education. Generative AI systems can produce fluent and plausible responses even when the underlying information is inaccurate, incomplete, or insufficiently supported by evidence. In healthcare education, Shorey et al. (2024) identified both educational and research opportunities associated with ChatGPT as well as

concerns regarding hallucinations, specialized healthcare knowledge, academic veracity, confidentiality, security, and the need for cross-verification.

Similar concerns have been reported in broader healthcare literature. Sallam (2023) identified both potential benefits and limitations associated with ChatGPT in healthcare education, research, and practice. Frequently reported concerns included inaccurate content, hallucinations, incorrect citations, bias, ethical issues, cybersecurity, and misinformation. These findings indicate that the educational potential of generative AI and its reliability as an information source should be treated as two distinct issues.

These developments are particularly relevant to Medical Documentation and Secretarial education. Students in this field are prepared for professional roles involving health-related information, medical terminology, medical documentation, patient records, healthcare communication, and information management. These professional responsibilities require students to accurately access, interpret, manage, and communicate health information (AHIMA, 2022; Knudsen & Bertelsen, 2023).

In this context, scientific literacy and health literacy can be considered complementary competencies. Scientific literacy emphasizes the evaluation of scientific evidence and claims, whereas health literacy emphasizes the ability to access, understand, appraise, and apply health information. The development of generative AI adds another layer to these competencies.

Students may increasingly use AI systems to search for explanations, summarize scientific information, generate texts, or clarify medical concepts. However, effective use requires more than prompt-writing or technological familiarity. Students need to recognize that AI-generated information may contain unsupported claims, inaccurate statements, incomplete explanations, or inappropriate references. Therefore, AI literacy in health-related education should include not only using AI, but also questioning, evaluating, verifying, and appropriately applying AI-generated information.

Taken together, the literature reveals an important conceptual intersection between scientific literacy, health literacy, and AI literacy. Scientific literacy provides the capacity to evaluate scientific claims and evidence; health literacy provides the capacity to access, understand, appraise, and apply health information; and AI literacy provides the capacity to understand, critically evaluate, and appropriately use AI systems.

The convergence of these three domains is particularly relevant in health-related vocational education, where students may increasingly encounter AI-

generated health and scientific information in both educational and professional contexts.

However, although research on generative AI in education and healthcare education has expanded rapidly, the existing literature remains concentrated primarily on general higher education, medical education, nursing, and broader healthcare contexts. Evidence specifically addressing AI-assisted scientific information evaluation among Medical Documentation and Secretarial students remains limited (Yusuf et al., 2024; Albadarin et al., 2024; Shorey et al., 2024). This represents an important research gap because students in Medical Documentation and Secretarial programs occupy a distinctive position at the intersection of healthcare information, documentation, communication, and information management.

Accordingly, this chapter aims to develop a conceptual framework for AI-assisted scientific literacy in Medical Documentation and Secretarial education. Specifically, it examines the relationship between scientific literacy, health literacy, and AI literacy; discusses the opportunities and limitations of generative AI for accessing and evaluating scientific and health information; and proposes a conceptual approach through which Medical Documentation and Secretarial students can critically search, evaluate, verify, and use AI-generated health and scientific information.

2. SCIENTIFIC LITERACY IN THE DIGITAL INFORMATION ENVIRONMENT

2.1. Scientific Literacy and the Evaluation of Scientific Evidence

Scientific literacy has traditionally been associated with knowledge of scientific concepts and processes. However, contemporary approaches emphasize that scientific literacy involves more than remembering scientific facts. It also requires individuals to understand how scientific knowledge is produced, evaluate scientific evidence, distinguish supported claims from unsupported assertions, and use scientific knowledge in decision-making (NASEM, 2016; Nordheim et al., 2019).

NASEM (2016) emphasizes that science literacy includes knowledge of science as well as familiarity with scientific processes and practices, the ability to evaluate the products of science, and the capacity to engage with scientific issues. This broader understanding is particularly relevant in digital information environments, where individuals encounter scientific information from sources with different levels of credibility.

The expansion of digital information has therefore changed the context in which scientific literacy is practiced. Scientific information can now be encountered through academic publications, institutional websites, social media, video platforms, search engines, online communities, and generative AI systems. Consequently, learners need not only information-access skills but also the ability to evaluate the quality and credibility of information (NASEM, 2016; Diviani et al., 2015)

For students in health-related vocational education, this evaluative dimension is especially important. Scientific claims concerning diseases, health practices, treatments, prevention, and other healthcare topics may be encountered in both educational and everyday digital environments. The ability to distinguish evidence-based information from unsupported claims is therefore an important component of professional preparation (NASEM, 2016; Diviani et al., 2015).

Scientific literacy in the contemporary information environment can consequently be understood as involving several interconnected competencies: accessing scientific information, understanding scientific concepts, identifying scientific claims, evaluating evidence, recognizing limitations and uncertainty, distinguishing evidence-based claims from unsupported assertions, and applying scientific knowledge appropriately.

2.2. Scientific Literacy and AI-Generated Information

The emergence of GenAI creates a new context for scientific literacy because learners may obtain apparently scientific explanations without directly consulting the original scientific literature. AI systems can summarize complex information and provide accessible explanations, but an AI-generated response should not automatically be treated as scientific evidence (Shorey et al., 2024; Sallam, 2023).

This distinction is particularly important because the linguistic fluency of an AI-generated response may create an impression of reliability. A learner may interpret a coherent and detailed answer as evidence that the underlying information is accurate. However, the quality of language used to present information and the scientific validity of that information are separate issues (Shorey et al., 2024; Sallam, 2023).

Therefore, scientific literacy in the GenAI era requires an additional evaluative step. Learners should be able to examine not only the content of an AI-generated response but also the evidence underlying that response. This may involve identifying original sources, checking references,

comparing claims with authoritative scientific sources, and recognizing uncertainty or limitations.

In this sense, AI literacy and scientific literacy become increasingly interconnected. AI literacy provides learners with knowledge and skills for interacting with AI systems and evaluating their outputs, while scientific literacy provides principles for assessing the validity of scientific information.

3. HEALTH LITERACY AND THE EVALUATION OF HEALTH INFORMATION

3.1. Understanding Health Literacy

Health literacy represents another important competency for students preparing for healthcare-related professions. Sørensen et al. (2012) conceptualized health literacy as a multidimensional competence involving the ability to access, understand, appraise, and apply health information.

This definition demonstrates that health literacy is not limited to finding information. Individuals must also determine whether the information is understandable, relevant, trustworthy, and appropriate for use (Sørensen et al., 2012).

The evaluative dimension of health literacy becomes particularly important in digital environments. Health information can be encountered through official healthcare institutions, academic sources, professional organizations, commercial websites, social media platforms, online communities, and increasingly, generative AI systems. These sources may differ substantially in terms of accuracy, authority, purpose, and evidential basis.

For students in Medical Documentation and Secretarial programs, health literacy can therefore be considered an important component of professional information competence. Although these students are not necessarily responsible for making clinical diagnoses or treatment decisions, their educational and professional activities require them to work with health-related information. Accurate interpretation and appropriate communication of such information are consequently important.

3.2. Online Health Information and Misinformation

The growth of online health information has increased opportunities for learning but has also created challenges concerning misinformation. Diviani et al. (2015), in a systematic review, reported that lower health literacy and

related skills were negatively associated with the ability to evaluate online health information and with trust in online health information.

The problem has become more complex with the expansion of digital media. Zhang et al. (2024) identified health misinformation as a persistent issue in the literature and examined its relationship with digital media and public trust.

In this context, health literacy should not be understood simply as the capacity to search for health information. It should also include the ability to ask critical questions concerning the source, evidence, currency, authority, consistency with scientific evidence, and limitations of the information encountered.

These questions become even more important when the information is produced by generative AI.

4. GENERATIVE ARTIFICIAL INTELLIGENCE AND AI LITERACY

4.1. The Educational Expansion of Generative AI

Generative AI has introduced a new form of interaction with information. Rather than simply retrieving documents containing particular keywords, users can communicate with AI systems through natural language and request explanations, summaries, comparisons, examples, and synthesized responses (Yusuf et al., 2024).

This capability has contributed to the increasing use of GenAI in education. Yusuf et al. (2024), in a systematic mapping review, identified applications and potential impacts, ethical implications, user perspectives, adoption, and performance as important themes in research concerning GenAI in education.

Research specifically examining ChatGPT has similarly identified potential educational benefits. Albadarin et al. (2024) reviewed 14 empirical studies and reported that students used ChatGPT for purposes including obtaining explanations, receiving feedback, improving writing, summarizing and translating texts, understanding concepts, and supporting personalized learning. The review also emphasized the importance of structured training, clear guidance, and critical evaluation.

Deng et al. (2025) conducted a systematic review and meta-analysis of 69 experimental studies and reported positive effects of ChatGPT interventions on academic performance, affective-motivational outcomes, and higher-

order thinking propensities. However, the authors also highlighted methodological limitations and the need for further investigation of longer-term effects.

These findings suggest that GenAI may provide meaningful educational support. Nevertheless, educational usefulness should not be equated with informational reliability.

4.2. AI Literacy as a Critical Competency

AI literacy provides a conceptual framework for understanding how learners can interact responsibly with artificial intelligence. Long and Magerko (2020) described AI literacy in terms of competencies that allow individuals to critically evaluate AI technologies, communicate and collaborate with AI, and use AI appropriately in different contexts.

This perspective is important because it moves beyond the idea that AI literacy simply means knowing how to operate an AI tool. A learner who can formulate prompts but cannot evaluate the resulting information does not possess all of the competencies required for responsible AI use.

Lintner (2024), in a systematic review of AI literacy scales, identified 22 studies validating 16 scales across different populations. The review highlighted the importance of reliable measurement and the multidimensional character of AI literacy.

For health-related vocational education, the evaluation and ethical dimensions are particularly important. Students should understand that AI systems can produce useful outputs but that these outputs are not automatically authoritative sources of scientific or health knowledge.

Consequently, AI literacy in Medical Documentation and Secretarial education should involve at least four interconnected capacities:

Understanding AI: knowing what AI systems can and cannot do.

Using AI: interacting effectively with AI systems for educational purposes.

Evaluating AI outputs: checking whether generated information is accurate, relevant, supported, and appropriate.

Using AI responsibly: considering academic integrity, privacy, confidentiality, attribution, and responsible information use.

The last two dimensions are especially important when AI is used to process or generate health-related information.

5. EVALUATING AI-GENERATED HEALTH AND SCIENTIFIC INFORMATION

The central educational challenge is not simply whether students use GenAI, but how they evaluate what GenAI produces. Generative AI systems can produce fluent and plausible answers even when the underlying information is inaccurate, incomplete, or insufficiently supported by evidence (Shorey et al., 2024; Sallam, 2023).

Research in healthcare education has documented this concern. Shorey et al. (2024), in a scoping review, identified educational and research opportunities associated with ChatGPT while also reporting concerns involving hallucinations, specialized healthcare knowledge, academic veracity, confidentiality, security, and the need for cross-verification.

Sallam (2023) similarly identified both potential benefits and concerns associated with ChatGPT in healthcare education, research, and practice. Reported concerns included inaccurate content, hallucinations, incorrect citations, bias, ethical concerns, cybersecurity, and misinformation.

These findings suggest that students should not approach AI-generated health information as a final answer. Instead, AI output should function as a starting point for verification.

A critical verification process can therefore be understood as a structured sequence in which AI-generated information is treated as a preliminary source that requires further examination. This process involves identifying the central claim, locating the original or supporting source, evaluating its credibility, comparing the information with authoritative evidence, identifying possible limitations or errors, and determining whether and how the information can be used responsibly (Figure 1).

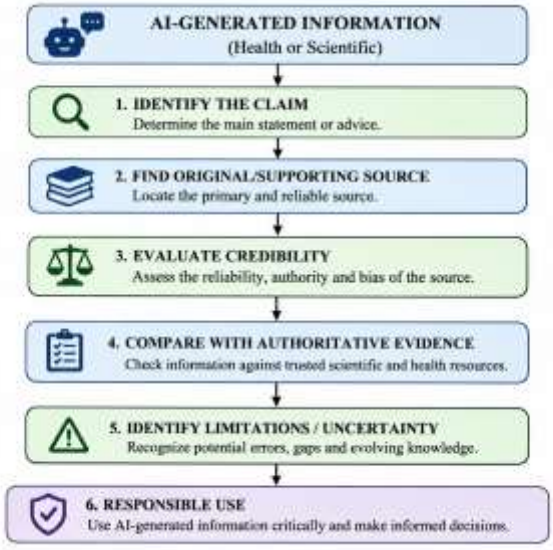

Figure 1. AI-Based Scientific and Health Information Verification Process

As illustrated in Figure 1, verification is not a single-step procedure but an iterative process. The evaluation of AI-generated information requires attention to both the content of the response and the evidence supporting it. When new evidence, inconsistencies, or limitations are identified, the information should be reassessed before it is used. This approach positions generative AI as a tool that can support information seeking while maintaining human judgment, evidence-based evaluation, and responsible use as essential components of the learning process.

The distinction is particularly important in healthcare-related education because the consequences of misinformation may extend beyond academic performance. Even when students are not directly responsible for clinical decision-making, their future professional roles may require them to handle health information accurately and communicate information appropriately.

Therefore, the ability to verify AI-generated information should be considered an important component of professional information literacy.

6. MEDICAL DOCUMENTATION AND SECRETARIAL EDUCATION

Medical Documentation and Secretarial programs occupy a distinctive position within health-related vocational education. Students encounter medical terminology, documentation procedures, patient records, healthcare

communication, and information management throughout their educational preparation and future professional practice.

This context makes the intersection of scientific literacy, health literacy, and AI literacy particularly relevant.

Students may use AI systems to clarify medical terminology, summarize scientific information, organize information, prepare educational materials, generate or revise written texts, and obtain explanations of health-related concepts.

However, these applications also create risks. AI-generated explanations may contain incorrect terminology or misleading interpretations. References may be incomplete or inaccurate. Health-related claims may be presented without adequate evidence. Students may also unintentionally provide confidential or sensitive information to AI systems (Shorey et al., 2024; Sallam, 2023).

Accordingly, AI use within Medical Documentation and Secretarial education should be approached through a competency-based perspective rather than a purely technological perspective.

The relevant question is therefore not simply whether students can use artificial intelligence. A more appropriate question is whether students can use artificial intelligence while critically evaluating, verifying, and responsibly managing the information it produces.

This shift is central to the conceptual framework proposed in this chapter.

7. TOWARD A CONCEPTUAL FRAMEWORK FOR AI-ASSISTED SCIENTIFIC LITERACY

The literature reviewed in this chapter suggests that scientific literacy, health literacy, and AI literacy should not be considered completely independent competencies in the context of AI-mediated healthcare education.

Scientific literacy provides the basis for evaluating scientific claims and evidence.

Health literacy provides the capacity to access, understand, appraise, and apply health information.

AI literacy provides the capacity to understand, evaluate, and appropriately use AI systems.

Their conceptual relationship can therefore be represented as follows:

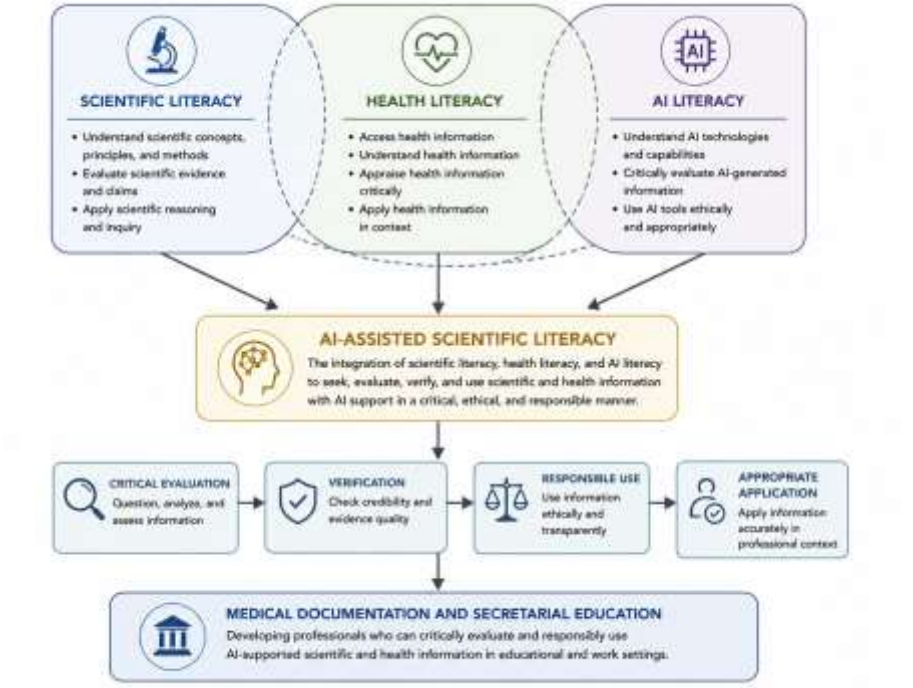

Figure 2. Conceptual Framework for AI-Assisted Scientific Literacy

This framework suggests that AI-assisted scientific literacy is not a replacement for scientific or health literacy. Instead, it represents a context in which these existing competencies become increasingly important because learners encounter AI-generated information alongside conventional information sources.

In other words, AI changes the information environment, but it does not eliminate the need for scientific evidence, health information evaluation, or professional judgment.

8. EDUCATIONAL IMPLICATIONS

The conceptual framework has several implications for Medical Documentation and Secretarial education.

First, AI literacy should not be treated solely as a technical skill. Students should be taught how AI systems can generate information and, more importantly, how the outputs of these systems should be critically evaluated.

Second, verification should become an explicit component of AI-supported learning. Students can be encouraged to compare AI-generated responses with textbooks, scientific publications, official healthcare institutions, and other authoritative sources.

Third, students should develop awareness of the limitations of AI-generated information. Hallucinations, inaccurate statements, incorrect references, bias, and incomplete explanations should be addressed explicitly during instruction.

Fourth, responsible use should be integrated into AI-related learning activities. Academic integrity, attribution, confidentiality, privacy, and responsible information management are particularly important in health-related educational contexts.

Finally, AI-assisted learning should be designed to promote active intellectual engagement rather than passive dependence. Instead of asking students simply to obtain an answer from AI, educational activities can require them to identify claims, verify evidence, compare sources, identify potential errors, and justify their conclusions.

Such an approach positions AI not as an unquestionable information authority but as a tool whose outputs require critical evaluation.

9. CONCLUSION

The emergence of generative artificial intelligence has fundamentally changed the information environment in which students learn and prepare for professional practice. For Medical Documentation and Secretarial students, this transformation is particularly significant because their educational and professional responsibilities involve health information, scientific knowledge, medical documentation, communication, and information management.

The literature reviewed in this chapter demonstrates that scientific literacy, health literacy, and AI literacy provide complementary foundations for navigating this environment. Scientific literacy emphasizes the evaluation of scientific evidence and claims; health literacy emphasizes the ability to access, understand, appraise, and apply health information; and AI literacy emphasizes the understanding, critical evaluation, and appropriate use of artificial intelligence.

The convergence of these three domains provides a useful conceptual basis for AI-assisted scientific literacy in Medical Documentation and Secretarial

education. In this framework, AI-generated information is not automatically accepted as reliable knowledge. Instead, students are expected to question, evaluate, verify, and appropriately apply the information produced by AI systems.

Therefore, the educational challenge of the GenAI era is not simply to teach students how to use AI. It is to prepare students to think critically while using AI. For health-related vocational education, this distinction is particularly important because the quality and reliability of information can have implications extending beyond academic performance to professional communication and healthcare information management.

Future research should therefore examine AI-assisted scientific literacy specifically among Medical Documentation and Secretarial students and investigate how scientific literacy, health literacy, and AI literacy interact in shaping students' ability to evaluate AI-generated health and scientific information. Developing and validating educational models and measurement tools in this area may contribute to the responsible and evidence-informed integration of generative AI into health-related vocational education.

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Learning analytics in Data Science Education: A Case Study and Conceptual Framework

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ABSTRACT

Nowadays, Data Science is a field that has created a need for good teaching methods that help students understand the concepts and develop practical skills in their application. Learning analytics is a new powerful methodology for analyzing educational data and improving teaching and learning.

This paper presents a case study of how learning analytics can be applied in the Data Science course offered at the master level. The study analyzes data collected from a multiple-choice test to uncover trends in student performance and to identify where students encounter the greatest difficulties. This study doesn't aim to produce general statistics. Instead, the study focuses on contributing methodologically by proposing a framework to integrate learning analytics into the data science education.

The study's results show that overall performance is good, but also difficulties are emerge in understanding assessment metrics and using statistical reasoning. Based on these findings, a conceptual framework is proposed for the application of learning analytics in teaching practices. The architecture of the framework is a continuous cycle of data collection, analysis, and teaching improvement.

This study expands the current understanding by illustrating that even small datasets can generate significant findings, thus providing a structured, data-driven teaching approach for data science instruction.

Keywords – Learning Analytics, Data Science Education, Educational Data Mining, Teaching Analytics, Framework

I. INTRODUCTION

Data Science, which combines concepts from engineering, statistics, and analytical reasoning, has recently become one of the most popular fields of study[1]. Organizations are increasingly using data in their decision-making processes[2], so universities must ensure that students learn both the theoretical and practical aspects of data analysis.

Traditional student assessment methods, such as exams, seminars, course assignments, etc. do not offer a complete picture of how students are learning. While these methods measure outcomes, they do not always explain how students learn, whether they have encountered difficulties, or which theoretical or practical concepts they have failed to grasp.

Learning analytics addresses this problem by allowing professors to collect and analyze data about their students to better understand how students learn and how to improve their teaching[3]. Professors/teachers can uncover performance patterns, learning gaps, and make changes to their teaching methods as needed.

There are not many studies that analyze how learning analytics can be used in small datasets based on in-class learning, especially in technical fields such as Data Science[4][5]. Most studies today focus on the use of learning analytics in large datasets [6][7].

This paper fills this gap by presenting a case study of using learning analytics in the teaching of the Data Science course. In this study, data collected from quizzes is used to identify patterns and to present a conceptual framework for integrating learning analytics into teaching practices.

II. LITERATURE REVIEW

Learning analytics and educational data mining are key research areas, focusing on improving learning outcomes through data-driven methods[8].

Siemens [9] defines learning analytics as the process of gathering and analyzing data about students to improve the learning environment. Ferguson [10] focus more detail how it can be used to retain students and increase their broader engagement.

Studies in Educational Data Mining have shown that historical data can be used to predict student performance and uncover learning trends that can be used to improve teaching [11]. Papamitsiou and Economides [12] emphasize the importance of analyzing how people learn and enabling adaptive learning systems to function.

However, many studies focus on very large datasets generated by online learning platforms, such as MOOCs. These studies are very valuable, but they may not show the dynamics in smaller settings, such as classrooms.

The use of learning analytics remains an unexplored field regarding its application at the class or course level, especially in more technical areas such as Data Science. This study contributes to the existing research by illustrating how learning analytics can be effectively used in these types of situations and suggests a conceptual framework for its integration.

III. METHOD

A. Research Design

The study uses a case study method and focuses on how learning analytics can be used in the Data Science course offered in the master's program. The goal is not to provide general statistical results, but to demonstrate how learning analytics methods can be used to obtain valuable information about how students learn.

B. Description of the Dataset

The data were collected from a final exam in the form of a quiz administered in the Data Science course. It contains the responses of approximately 140 students over the years for 30 multiple-choice questions. The test covers the main topics of the course, such as:

- How to do Data Science

- Statistical methods
- Data Visualization
- The basics of Python in Data Science
- Machine Learning Basics
- Model Evaluation
- etc.

C. Approach Based on Analysis

The analysis includes:

- descriptive statistics
- score distribution analysis
- question-level performance analysis
- identification of learning gaps

The study does not attempt to build a predictive model, but to learn more about how students learn.

IV. RESULTS

D. Overall Performance

The study of the data shows that the following:

- Mean score: 26.94
- Median score: 29
- Range: 18–30
- Standard deviation: 4.03

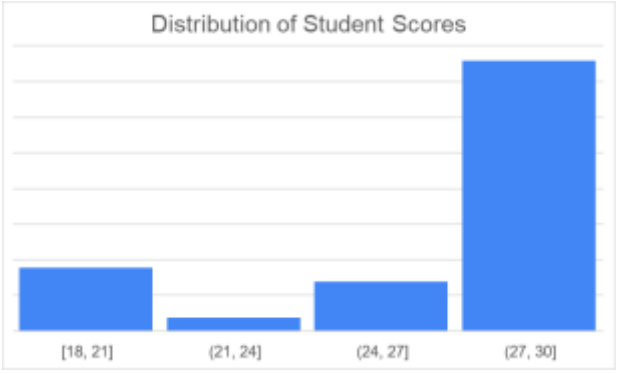

Fig. 1 Distribution of Student Scores

As can be seen in Figure 1, most students achieved the highest scores, which indicates that they understood the subject well. However, the low scores show that performance and learning outcomes are not always the same.

E. Question-Level Analysis

A detailed analysis of the questions shows that:

- Students understand the key concepts very well
- However there are many error rates in the more advanced analytical and mathematical concepts.

Generally, we can say that students have difficulty:

- interpreting evaluation metrics
- understanding model performance measures
- applying statistical reasoning

F. Identified Learning Gaps

Many learning gaps were found during the analysis of the dataset, as described below:

- confusion between evaluation metrics (e.g., precision vs recall)
- difficulty interpreting statistical measures
- limited understanding of model evaluation concepts

These results provide valuable insights for improving training methods.

V. A FRAMEWORK FOR LEARNING ANALYTICS IN DATA SCIENCE COURSE

In this paper, we present a conceptual approach for combining learning analytics with Data Science lessons. Figure 2 illustrates a cyclical framework with five main stages:

1. Data Collection involves gathering information about students' performance through assessments.
2. Data Processing means cleaning and organizing the information that has been collected.
3. Data Analysis involves using statistical methods to examine the data that has been collected.
4. Learning Gap Identification means finding out where students struggle with understanding the concepts.
5. Instructional Intervention means changing and improving the teaching methods.

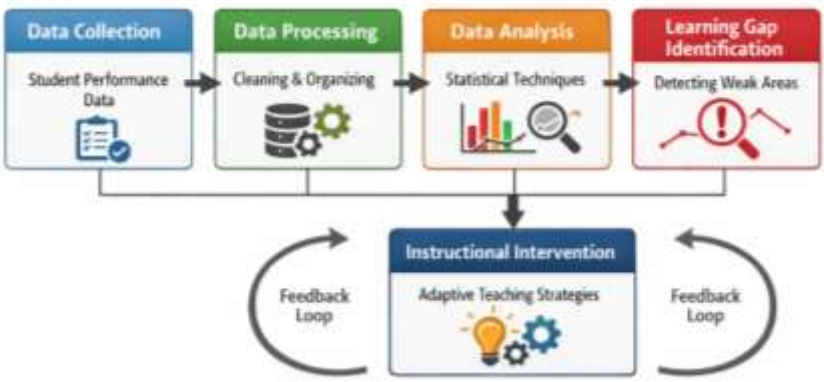

Fig. 2 Learning Analytics Framework for Data Science

The goal of this framework is to improve student learning and understanding over time by providing a repeating pattern for using learning analytics in a Data Science course.

VI. IMPLICATIONS FOR TEACHING AND BROADER IMPACT

The paper shows that even in small teaching environments, learning analytics can provide valuable information. Student performance is generally high, but the presence of learning variability shows that not all students achieve the same level of understanding. It is important to emphasize that this question-based study shows that students encounter more difficulties in complex analytical tasks than in the basic concepts of the subject. This implies that conceptual understanding, interpretation, and the use of knowledge should be given more attention during the teaching process. The problems challenges identified in metric evaluation and statistical reasoning are especially important in Data Science, where critical thinking is essential[13].

The study also challenges the notion that learning analytics solely requires large datasets, demonstrating that small datasets can also provide highly valuable and useful insights. These findings suggest that teaching methods should focus on clearly explaining basic concepts, directly addressing common misunderstandings, and using methods based on real-world data.

VII. CONCLUSION AND FUTURE WORK

This study demonstrates how learning analytics may be applied successfully in Data Science education through case studies. The findings show that, when properly evaluated, even small datasets can yield significant insights, particularly when assessments are used.

The framework provides a structured way to integrate learning analytics into teaching, supporting a continuous cycle of gathering data, analyzing it, generating knowledge, and adjusting teaching methods.

Another important finding of the study is that the value of learning analytics is not based on the size of the dataset. The proposed framework offers educators a structured means to utilize the data generated by teaching and learning in their instructional practices.

This paper can be extended in future research by adding more datasets, using predictive models, implementing real-time analytics systems, and exploring how this framework could be used in different classes or even across institutions.

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