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Intelligent Educational Environments and Ubiquitous Computing for Continuous Learning and Digital Literacy Development

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Abstract

Ubiquitous Computing (UC) allows learning at any time and location, promoting a lively and engaging educational experience. Advancements in Information and Communication Technologies (ICT) have been essential in implementing the Internet of Things (IoT). The IoT is a nascent technology that includes networks of linked, Internet-enabled devices fitted with detectors, processing units, and sensors, allowing substantial cooperation and interaction among them. This study investigates how intelligent settings, augmented by IoT and AI technologies, enable learners to cultivate digital literacy abilities essential for the contemporary workforce. This study introduced

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Intelligent Educational Environments and Ubiquitous Computing for Continuous Learning and Digital Literacy Development (IEE-UC-CL-DLD). The revolutionary IEE-UC has been developed using technologies (portable, mobile, networking) that provide learners with educational experiences outside the conventional classroom across real and virtual environments. IEE-UC is an innovative technology that has emerged from significant technical developments in ICT. This revolutionary learner-centered methodology is designed to improve CL-DLD via innovative technologies and the IoT. The study instruments included a suitability evaluation form for an IEE platform to provide CL environments to enhance citizens' DLD. The study findings indicated that the IEE-UC platform, designed to provide a CL environment for enhancing citizens' DLD, has been effectively built and deemed suitable.

Keywords: Ubiquitous Computing, Digital Literacy, Intelligent Educational Environments, Continuous Learning, Internet of Things, Information and Communication Technologies.

1 Introduction

Recently, the notion of learning has been examined from a constructivist perspective. Constructivism posits that learning is the outcome of individual construction by learners via their interaction with the learning context (Chuang, 2021). According to the constructivist learning paradigm, media-mediated teaching facilitates optimum learning experiences. The diversity of activities and the utilization of media/resources in education persist in expanding and evolving with information and communication technology advancements. Information and Communication Technology (ICT) facilitates the development of diverse activities that can convert traditional services into adaptable, personalized, and efficient operations via technical equipment and digital resources (Al-Rahmi et al., 2020; Udayakumar et al., 2023). The primary consequence of the swift advancement of ICT is the advent of Continuous Learning (CL), which occurs anywhere and at any time (Mundt et al., 2023). Historically, ICT items such as cell phones, electronic gadgets, the Internet of Things (IoT), and wireless connections have been primary catalysts for implementing mobile learning concepts (Ruzibaeva et al., 2024).

Digital Literacy (DL) positively influences students' competencies, vital for effective CL. Electronic devices envelop our surroundings. Digital content resources are more readily accessible than conventional paper-based tools for CL. Contemporary enterprises and institutions utilize computers to supplant personnel engaged in repetitive physical and cognitive activities. Computers also aid personnel engaged in non-routine problem-solving activities. Organizations require people to use ICT in the workplace for interaction, distributing data, and modeling business operations. Learners with robust Digital Literacy Development (DLD) encounter improved academic performance and reduced job prospects (Khanlou et al., 2021).

Pedagogical elements significantly impact students' achievement, intentions, and behaviors regarding mobile learning, mainly by providing enhanced content, instructional resources, methodologies, and CL settings that can elevate students' achievement (Lin et al., 2020). One fundamental aspect of selecting and utilizing instructional materials, tactics, and successful CL settings is considering individual learner variances. Learners will acquire knowledge at varying rates and through diverse methods according to their requirements, interests, or preferences. Utilizing strategies tailored to students' requirements, hobbies, and attributes will foster an Intelligent Educational Environment (IEE) and enhance academic performance (Yağcı, 2022). Ubiquitous Computing (UC) is a new educational strategy aligned with established CL concepts (El-Haggar et al., 2023). UC aims to cater to learners and their CL preferences by delivering appropriate knowledge at any time and location according to their requirements and aspirations (Kurbanazarova et al., 2024). UC encompasses genuine CL environments, pervasive

electronic materials, IoT, practical items, mobile phones, and wireless networks, facilitating on-demand CL tailored to learners' requirements and behaviors (Raman et al., 2024). This research proposes Intelligent Educational Environments and Ubiquitous Computing for Continuous Learning and Digital Literacy Development (IEE-UC-CL-DLD).

2 Background and Related Works

Literacy encompasses the social processes involved in generating and understanding meaning through text. An individual concentrating on text comprehension engages in reading to learn, so literacy is achieved. For youngsters to read for CL, they must first acquire reading skills. Significant discussions exist around the appropriate age for children to cultivate reading abilities and how CL to read should occur during early childhood (Khanlou et al., 2021).

Early literacy development frequently establishes a differentiation between code-related and meaning-related abilities (Mathur et al., 2024). Code-related competencies encompass print expertise, the alphabet, and phonological understanding, among other elements—meaning-related competencies including vocabulary, grammatical proficiency, and oral storytelling abilities (Tortorelli et al., 2021). The knowledge of the causes, correlations, and predictions of children's reading achievements and deficiencies in primary and secondary school has significantly increased in the past few decades. This understanding has facilitated the creation of standard and nonstandardized approaches to assess reading growth in young children.

A prevalent type of nonstandardized literacy growth measurement is observations by educators and associated evaluations, including guidelines, scales for rating, and galleries of children's work (Kremmel & Harding, 2020). The lack of standardized methodologies results in inconsistent measurement of kids' abilities throughout the population. A prevalent criticism of nonstandardized approaches is that instructor observations tend to be casual rather than systematically organized, leading to assessments of abilities that only represent the instructor's subjective evaluation of the kid.

The Dynamic Determinants of Basic Early Literacy Skills exam is a well-recognized standardized tool for assessing literacy development (Ihmeideh & Al-Maadadi, 2020). It primarily emphasizes code-related competencies. The assessment comprises the following sections: beginning sounds proficiency, letter naming proficiency, phonemic segmentation proficiency, nonsense word proficiency, and word usage fluency. The appropriateness and other standardized tools for assessing young children's literacy progress have sparked much discussion. Issues have been raised over the time necessary for such assessments, interruptions that hinder the precise evaluation of talents and the restricted test-taking skills of young children to gauge competency (Kennedy & McLoughlin, 2023; Raudenbush et al., 2020). In light of these issues, this study has modified information from standardized assessments to conform to the guidelines of the local IEE system. This research measured abilities specifically in three essential areas of literacy growth: alphabet acknowledgment, phonological understanding, and understanding of print. Significant artifacts were produced to ensure the legitimacy of the kid evaluations.

DL encompasses several fields and diverse methods. Jamil et al. developed a deep learning paradigm incorporating digital software and hardware, including cognitive, motor, social, and mental abilities (Jamil & Belkacem, 2024). The International Association for Technology in Education delineated its DL typical and indicators as inventiveness and originality, interpersonal relationships, study and knowledge fluency, essential thinking/problem resolving and making choices, online citizenship, and technology activities and ideas. Birt et al. delineated a collection of DL competencies, encompassing ICT proficiency, knowledge about data assessment, communication skills, and Internet/network fluency (Birt

et al., 2023). Gao et al., underscored the coexistence of several aspects defined by technical, cognitive, and moral aspects (Gao & Clark, 2023). Lnenicka et al., suggested a DL paradigm comprising four skill categories: operating skills, formalized skills, data skills, and leadership abilities (Lnenicka et al., 2020). The Media Awareness Networks of Canada defined technologically savvy persons as those who can utilize, comprehend, and produce content with digital technology. United Nations Educational, Scientific and Cultural Organization (UNESCO) identifies six fundamental abilities of DL: accessing, handling, evaluating, combining, generating, and disseminating information (Llopiz-Guerra et al., 2024; Reddy et al., 2023). These abilities must be utilized alone or cooperatively within a networked, computer-assisted, and web-based setting for IEE, employment, or recreation. Reddy et al. delineated DL competencies in seven domains: knowledge of data, working together, interaction and sharing, literature and knowledge production, assessment and problem-solving, and technological activities (Reddy et al., 2023). The analysis sought to examine the notion of DL, its applications for enhancing CL effectiveness, and the components of DL for college students.

3 Proposed Intelligent Educational Environments and Ubiquitous Computing for Continuous Learning and Digital Literacy Development

After elucidating the characteristics of the IEE-UC-CL-DLD approach, the system's framework, components, and interrelations are delineated from a top-down perspective.

Structure: The model is delineated as a four-tier construction, seen in Figure 1, whereby homogenous objects are structured to execute various functions by designated workflows that provide a specified result at each stage and after every phase.

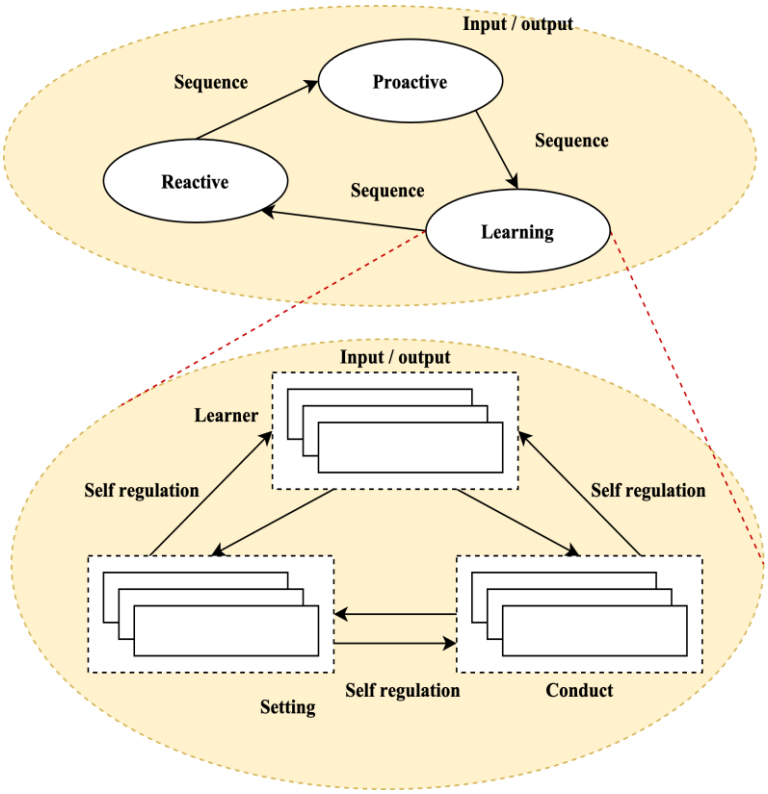

Figure 1: The Architecture of the IEE-UC-CL-DLD Model

Components: The items denoting an individual stage are organized based on a procedure initiated by specific stimulation (e.g., CL objectives to achieve and standards that limit and conclude the course of CL). This workflow activates an ongoing or ordered pathway that progressively produces a CL result, which develops as time passes until a designated objective is accomplished or a particular constraint is unmet (e.g., either a goal is attained or time expires).

Framework: The process flow delineates the sequence and character of operations to be executed, incorporating input, reasonable suggestions, self-regulation, self-feedback, and output moves.

Living Unit: The CL operation, as an evolving system, progressively develops during every phase, generating new states. These situations are deemed equilibrium because they maintain the unit's equilibrium based on specific standards; they are unchanging contends that halt functionality and yield a result.

Modes: The initial layer represents the essence of the CL procedure conceptualized as a cyclical progression using three modalities: proactive, studying, and receptive. These modalities delineate the initiation of the CL procedure, the execution of CL assignments, and the assessment of the current stage's outcomes and advantages accordingly.

Determinants: The following level implements the functionality associated with every mode via three variables that interact in reciprocal causation via self-regulated and feedback relationships, forming a dynamic and cyclical framework. The cycle starts with a student variable that does cognitive activities in reaction to external inputs from a specific modality. Subsequently, the behavior determinants are engaged to address unmet CL assignments, necessitating learner interaction with the surroundings through the setting determinants. The process continues when a student variable assesses the specified circumstances and determines whether to proceed (i.e., stability state) or terminate the cycle to produce a result.

Processes: The third level encompasses several self-regulated activities that fulfill the capabilities associated with a particular occurrence of modality and predictor.

Functionality: The fourth plane encompasses cognitive, self-regulated, and mental processes, tactics, and techniques that delineate the requirements and directions for the learner to engage in a self-regulated procedure linked to a combination of the method and an indicator.

3.1 Research Design

The study employs the Researching and Developing for Education (R & D for School) methodology for product creation and feasibility assessment in the educational sector. This project established a UC educational platform comprising 1) A UC portal constructed using IEE and 2) A UC program inside the Educational Media curriculum. The product creation phases align with the IEE-UC-CL-DLD paradigm: Evaluation, Design, Growth, Implementation, and Assessment. This approach is selected because of its simplicity, comprehensiveness, and validation. Figure 2 illustrates the growth process of IEE-UC-CL-DLD.

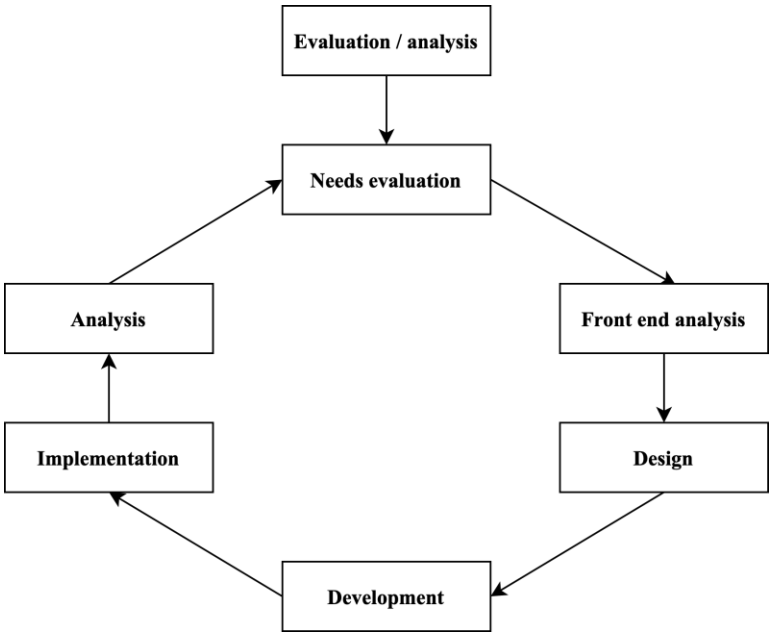

Figure 2: Workflow of the IEE-UC-CL-DLD

4 Results and Discussions

The research was conducted at the Elabuga Department of Kazan Federal College in the Volga Area. The study employed the following methodologies: source evaluation, surveys, experimentation, project approach, and mathematical statistics techniques. This research encompassed learners pursuing "Pedagogical Teaching" with a specialization in "Preschool Teaching and Primary Learning," representing various age groups (a total of 68 learners aged 20 to 40 years). To assess learners' DL across various age demographics, participants were categorized into four associations: 20-25 years, 25-30 years, 30-35 years, and 35-40 years (Figure 3). Each group included a nearly equal amount of pupils. The survey findings and design work estimations are provided according to age groups.

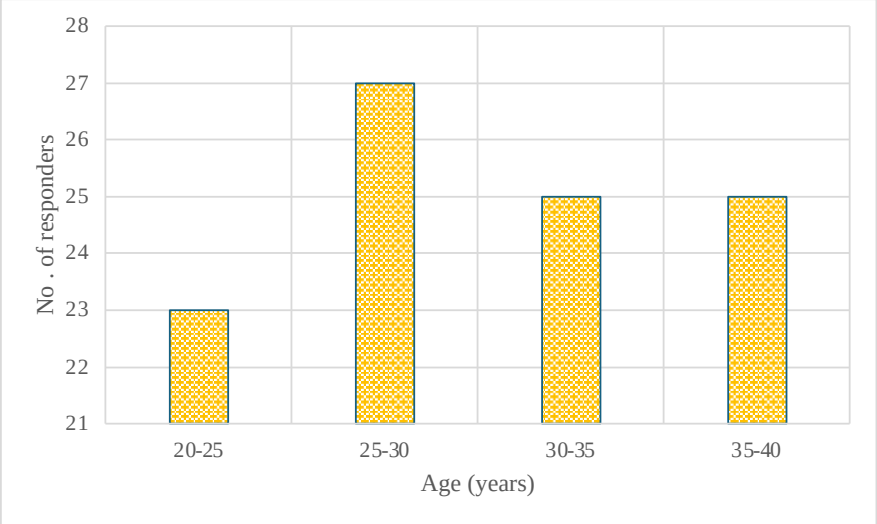

Figure 3: Age of Responders Analysis

A preliminary survey assessed the degree of digital competence and the inclination to utilize ICT in professional endeavors. The findings of the initial study are illustrated in Figure 4. Figures 4 (a), (b), and (c) depict the responses to queries 2 through 4. Responses to inquiries are categorized by age category. Every age group column is segmented into several colored sections, proportional to the reactions from kids within that age group.

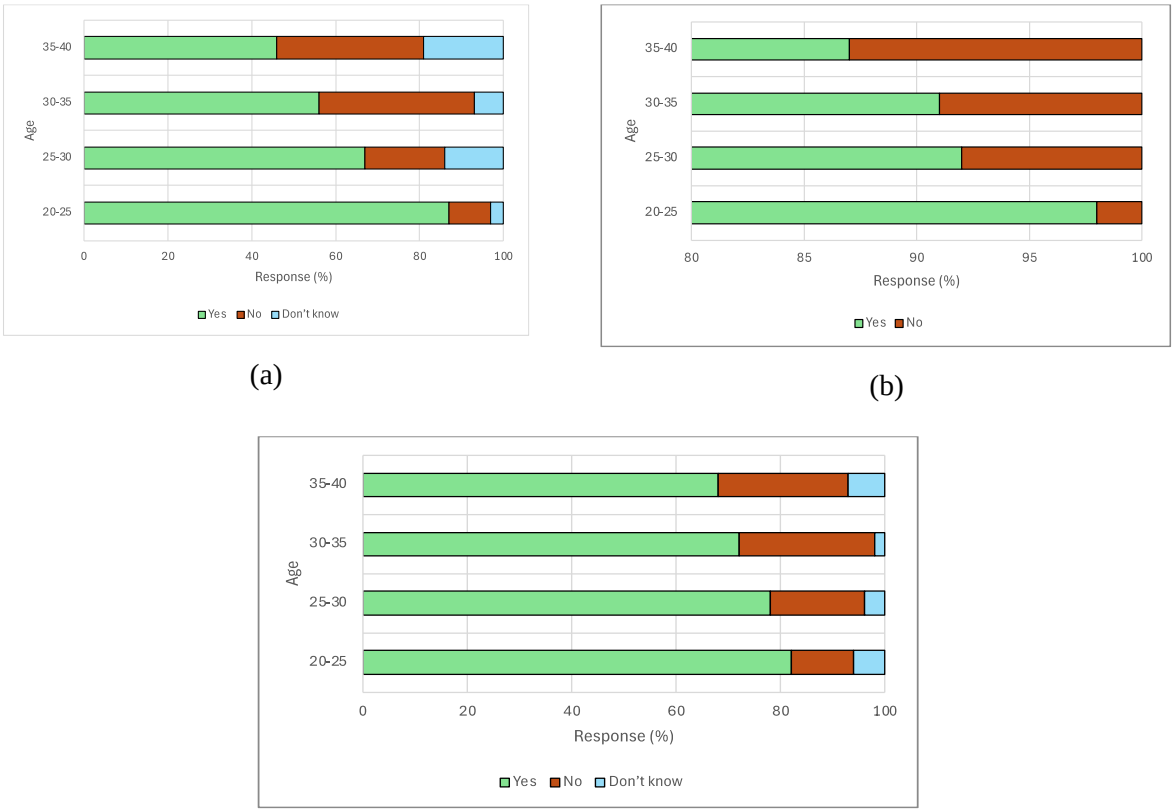

Figure 4: Initial Survey Result Analysis for (a). ICT Necessity, (b) Literacy Growth, and (c) ICT in Education

Examine the survey findings for every age demographic individually. Ninety-five percent of learners aged 20 to 25 believe that ICT is essential in preschool education. Every student desires to enhance their knowledge of information. 82% of them will utilize ICT in educational endeavors. Sixty-seven percent of learners aged 25 to 30 believe that data technologies are essential in early childhood education. 92% of students aspire to enhance their knowledge of information. Seventy-nine percent of them will utilize ICT in educational endeavors. Forty-four percent of learners aged 30 to 35 believe that information innovations are essential in early childhood education. Ninety-four percent of pupils aspire to enhance their information literacy. Seventy-six percent will utilize ICT in instructional activities—91% of learners aged 35 to 40 desire to improve their data literacy skills. Sixty-seven percent of them will use ICT in educational endeavors.

A survey was subsequently administered to assess pupils' first digital proficiency levels across various age groups. The questionnaire's findings are displayed in Figure 5.

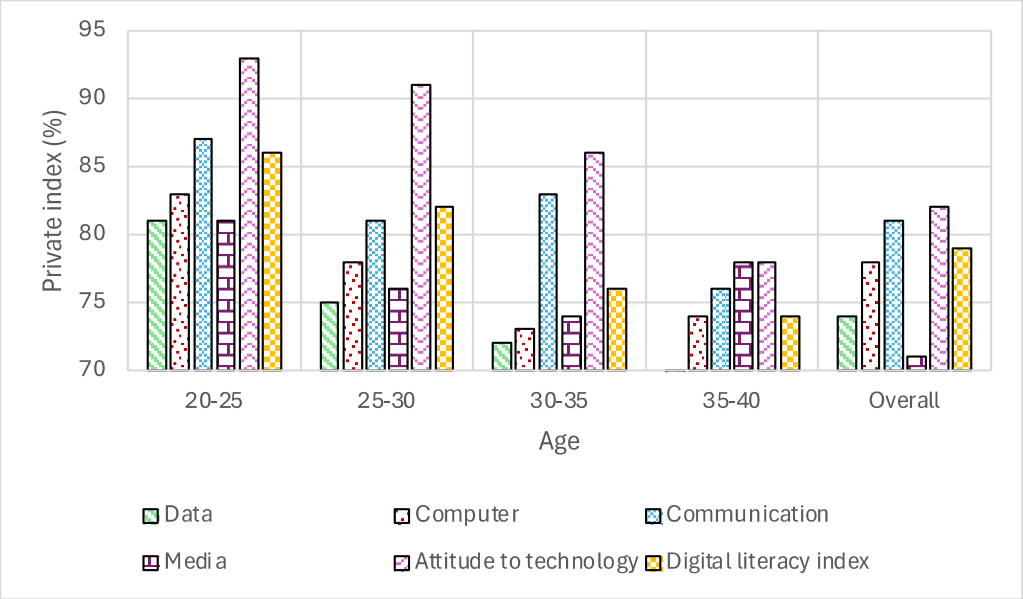

Figure 5: Initial Private Indicator Analysis

The group's mean DL score is 79%, which needs to be improved; therefore, efforts are required to enhance it. The most significant DL score (86%) is among younger pupils, while the lowest (73%) is reported in the oldest category, indicating a disparity in digital IEE across age cohorts.

Within the subject of "ICT," the following modules were completed: 1) Integrated Educational Gaming; 2) Fundamentals of Animation; 3) Fundamentals of Programming; 4) Networking Technology. Every module's construction constituted a distinct project. The project evaluation is on a scale of 0 to 5 points. A commission comprised of technology educators was established to assess the initiatives. The age groupings categorized the outcomes of the module generation. The findings encompass the mean score for each age group across all modules and the standard variation, as shown in Figure 6.

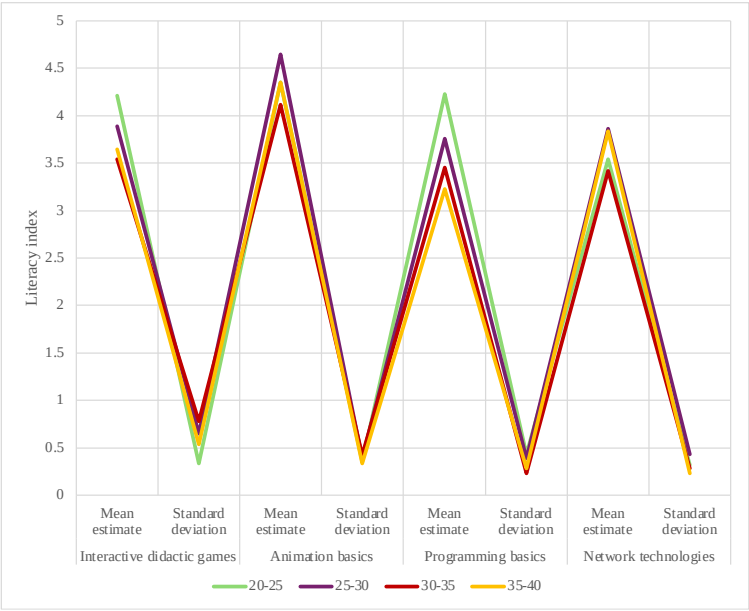

Figure 6: DL Analysis

Following the examination of the discipline, a survey was administered to assess the ultimate degree of DL among pupils across various age groups. The questionnaire findings are displayed in Figure 7.

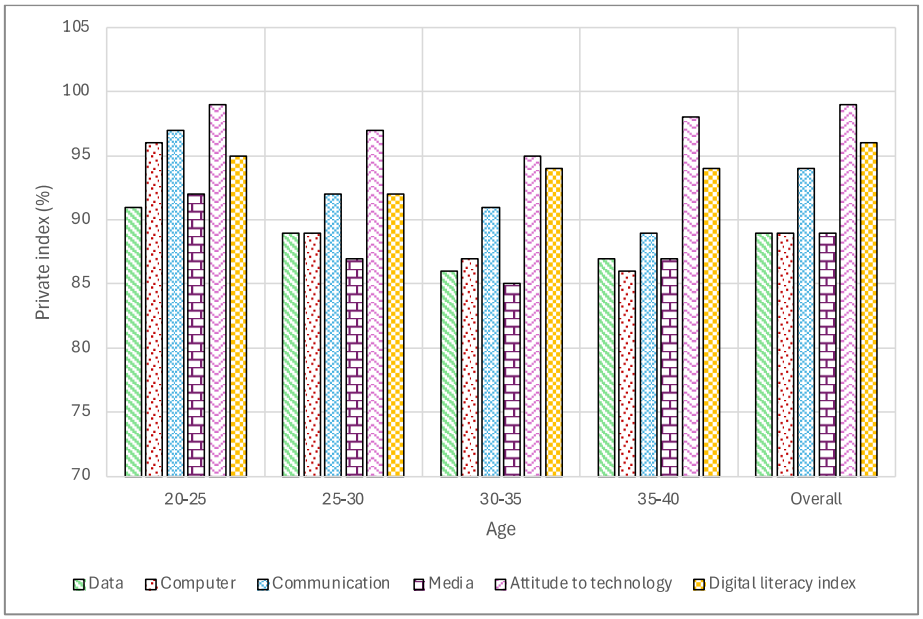

Figure 7: Final DL Indicator Analysis

The overall DL indicator of the respondents has significantly risen from 79% to 92% - a commendable level. The most significant DL measure (95%) is found among young learners, while the lowest (89%) appears in learners aged 30-35 and 35-40. Notably, the disparity in digital education across generations has markedly diminished, with the lowest index rising substantially from 73% to 89%, indicating the beneficial effect of the suggested system on enhancing DL levels. There is a notable enhancement in DL across all private indexes, substantiating the initiative's positive influence on all aspects of DL: data, computer, interaction, media comprehension, and technological mindset.

5 Conclusion and Findings

ICT has recently been incorporated into educational processes, resulting in trends such as electronic learning (e-learning) and UC. UC methods continually evolve alongside challenges, such as students' difficulties concentrating on CL goals and ineffective instructional resources and tactics. The present research has effectively established a UC-based CL ecosystem by enhancing several concepts of UC using IEE-UC-CL-DLD. This technology generates CL exercises that are adaptable to any location, time, and method, according to students' requirements and attributes.

The creation of the UC educational system has progressed through the phases of evaluation, planning, execution, and assessment. The ideas of UC have been effectively applied through numerous elements (materials and activities) available in IEE-UC-CL-DLD. Utilizing File, Chat and Forum functionalities can actualize the ideals of permanence, accessibility, immediateness, and interaction. The Assignment component (online text and file submissions) embodies the concept of context awareness for task, interpersonal, and environmental settings, while the Lesson element implements the idea of historical perspective.

The assessment of many dimensions of CL resources, including content, pedagogical elements, and linguistic features, indicates findings categorized as "Exceptional." Evaluating various aspects of CL media outlets, including course initiation, communication, and belonging, instructional assets for instruction and CL, student support, technological design, obviously conclusion, CL assessment, and the instructional planning cycle, yields outcomes in the "Exceptional" grouping. This indicates that the IEE-UC-CL-DLD system in this Educational Media program applies to training procedures.

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