THE IMPACT OF A PROJECT-BASED LEARNING ENVIRONMENT ON THE DEVELOPMENT OF UNDERGRADUATE STUDENTS' DIGITAL LITERACY SKILLS

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ABSTRACT

In recent decades, the research community has focused on younger generations' technology readiness, known as The Digital Natives Debate. At the higher education level, this debate led to studies on the quality of digital technology use among undergraduate students. However, empirical investigations on how digital literacy programs can support students' academic practices are still lacking. This paper presents the results of a project-based learning approach in higher education to enhance digital literacy skills in teaching. The findings demonstrate large effect sizes in favor of operational, information-navigation, social, creative, and critical skills, providing evidence that project-based learning can significantly improve digital literacy skills and support academic learning in higher education.

KEYWORDS

Project-Based Learning, Learning Environments, Higher Education, Digital Literacy Skills

1. INTRODUCTION

During the past decades, the research community has been exploring the attributes of younger generations with a focus on technology readiness through an ongoing dialogue known in the literature as "The Digital Natives Debate" (Bennet et al., 2008; Corrin et al., 2010; Judd, 2018; Evans & Robertson, 2020). This dialogue concerns the nature of skills that young people possess for the effective use of digital technologies, and how such skills can contribute to policy reform in education. In academic settings, this debate refers to whether younger generations, who have grown up and socialized using digital technologies, can use such technologies effectively for academic purposes (Judd, 2018; Evans & Robertson, 2020).

Specifically, the term "digital natives" has been attributed to young people due to their continuous immersion in technology. Growing up in a globally connected world where the Internet has always been accessible (Seemiller & Grace, 2016), young generations tend to rely on digital media to search for information, stay up-to-date, and engage in social interactions through platforms like social networking services in their daily lives (Ng, 2012; Kennedy & Fox, 2013). In academic settings, the effective use of digital technologies includes the selection and use of mobile devices, software, and multimedia tools with a critical perspective by evaluating their contribution to academic work (Alexander et al., 2017). However, the unquestioned assumption that students already bring advanced technological skills due to prior use of digital technologies may have real implications for the learning practice by "*leaving learners unsupported and technologies inappropriately aligned with learning needs and contexts*" (Smith et al., 2020, p. 10).

Relevant studies indicate that university students are not aware of the enabling capabilities of digital technologies in learning (Ståhl, 2017; Leijon et al., 2022). Namely, previous research has shown that young people easily adapt to the use of the Internet at a technical level (e.g., accessing services, connecting to a WiFi network) (Ng, 2012; Kennedy & Fox, 2013), are very familiar with the use of technologies for communication purposes (Gosper et el., 2013; López-Meneses et al., 2020). However, they seem to experience difficulties

using tools and services for online information search and evaluation (Hargittai et al., 2010; Head, 2013; Neumann, 2016; Weber et al., 2018; Breakstone et al., 2018) and content creation (Ng, 2012; Kennedy & Fox, 2013; López-Meneses et al., 2020). In general, research indicates that informal experiences with digital technologies do not necessarily suggest that undergraduate students can use such technologies for academic purposes (Margaryan et al., 2011; Kennedy & Fox, 2013; Ståhl, 2017).

Another challenge that needs to be considered in the digital natives' dialogue and for which scholars have yet to reach a consensus refers to the development of new instructional strategies that educators can utilise to reach digital natives (Evans & Robertson, 2020). It is therefore essential to provide sound theoretical frameworks and assessment processes that will assist higher education institutions in forming policies and training resources for students (Litt, 2013). Several researchers suggested that learning through technology can be supported by the design of constructivist learning environments (Vannatta & Beyerbach, 2000; Jonassen, Mayes, & McAleese, 1993; Jonassen, 1999; Duffy, & Cunningham, 1996). Project-based learning is one of the most widely applied "*constructivist compatible instructional practices*" (Ravitz, Becker, & Wong, 2000) which has been used to transform teaching and learning in higher education (Gülbahar, & Tinmaz, 2006; Lasauskiene & Rauduvaite, 2015; Lee et al., 2014; Shpeizer, 2019; Guo et al., 2020). Taking into account the above, the present study reports on the effects of a project-based learning environment on undergraduate students' digital literacy skills in a university setting.

2. THEORETICAL FRAMEWORK

2.1 Conceptualization of Digital Literacy Skills

In recent decades, the ability to use digital tools has been associated with the term digital literacy, which was introduced by Paul Gilster in 1997 and has been linked to understanding and using information from a variety of digital sources (Bawden, 2008). Later conceptual investigations concluded that digital literacy is broad and includes various aspects of different concepts with a focus on different skills sets (Ala-Mutka, 2011). The present study focuses on the skills to use the Internet since the Internet is the primary medium that students use to access course materials and other information resources, communicate with their peers and professors, and conduct coursework (Kennedy & Fox, 2013; Gosper et al., 2013). Specifically, the study adopted the theoretical framework proposed by Van Dijk and Van Deursen (2014), which categorized digital literacy skills into six areas: Operational, Formal, Information, Communication, Content creation, and Strategic skills. Operational skills are basic technical skills required to use the Internet, such as using browsers to access web applications. Such skills allow a person to use digital tools to complete tasks, such as filling input information into fields or pages, and downloading and saving files. Formal skills relate to navigating the Internet hyperlinks, such as identifying where a website is located, and recognizing how to navigate to a website without feeling disoriented. Information skills refer to navigating various websites with different layouts and searching, selecting, and evaluating online information to achieve a specific objective. Communication skills relate to using online communication services to interact with others, construct, understand, and exchange meaning, create online profiles and identities, and engage in online collaboration. Content creation skills are the skills someone needs to create different types of good quality digital content, including text, images, and sound, in various formats, and, publish or share it with others on the Internet. Lastly, strategic skills relate to the fulfillment of personal goals through the use of the Internet, namely moving toward a specific goal, making the right decisions toward fulfilling a goal, and securing the benefits of using the Internet.

2.2 Project-Based Learning in Higher Education

While higher education institutions have welcomed the integration of digital technologies in teaching and learning, the predominant approach for the selection and use of digital tools in teaching has been technology-led. This approach often neglects to assess whether these tools align with anticipated learning outcomes, despite students expressing a preference for digital technologies that add value to their learning process rather than being used merely because they are available (Gosper et al., 2013; Kirkwood & Price, 2014). Therefore, it is necessary for educators "*to have knowledge of the affordances the various technological*

tools offer that are beneficial for their own teaching and for their students' learning" (Ng, 2012). Additionally, while universities rarely make the necessary distinction between the individual needs of students (Jørgensen, 2019), although prior studies have shown that both the level of students' digital skills and their degree of familiarity with digital devices and tools vary (Selvyn, 2009; Helsper & Eynon, 2010; Hargittai, 2010; Corrin et al., 2010; Ståhl, 2017). To adequately address the instructional needs of digital natives, higher education institutions must invest in the deliberate design of learning experiences that consider the aforementioned factors.

In this context, integrating project-based learning approaches can offer distinct advantages. Project-based learning asserts that learning is an active process of building meaning through experiences (Gülbahar & Tinmaz, 2006; Leijon et al., 2022). This method promotes the combination of action and learning and encourages the transfer of prior knowledge during the project implementation process (Wobbe & Stoddard, 2023). Students have a central role in project-based learning, while the instructor is a facilitator (Shpeizer, 2019). The whole process of developing a project enhances autonomous learning, as the form of the final project is determined by the learners, who decide about what actions need to take to complete it (Lasauskiene & Rauduvaite, 2015). Such process makes engagement with the project attractive and feasible, especially at older ages where the acquired knowledge is somehow connected to the professional field and the project is developed individually (Larmer et al., 2015). Prior studies have documented the effectiveness of this method in enhancing skills in higher education (Lee et al., 2014; Guo et al., 2020). The framework for creating a project includes the central theme and goals of the project, which need to be attractive and feasible, the main products or deliverables that need to be produced and published, as well as an action plan of the process that learners need to follow to complete the project with success (Guo et al., 2020).

3. METHOD

3.1 Project-Based Learning Design

In this study, a 13-week project-based learning intervention was conducted as part of an elective course. The intervention consisted of three-hour weekly teaching sessions. The central focus of the project was the creation of a blog, with students having the freedom to choose their own topics. During the development of their projects, students were progressively engaged with digital technologies in a series of activities to enhance their digital literacy skills. The activities contributed to completing the final deliverable of the blog while enabling the transfer of knowledge to the academic environment. The digital technologies that supported the project's development were selected based on their affordances to enhance students' digital literacy skills. The affordances were considered based on the tools' potential to support access, retrieval, and evaluation of information (e.g., internet browsers, search engines, cloud services), communication and collaboration (e.g., social networking services, online content sharing), and content creation (e.g., multimedia, presentation software). The project design is presented in Table 1.

Table 1. Project-based learning design to support digital skills development in academic settings

Blog creation	Digital skills to support the creation of the blog (project)	Academic affordances
Topic selection Blog's title and purpose Registration to a blog service Poster creation and welcoming message Adjust the privacy settings	*Operational skills* The blog is stored in the bookmarks of the computer browser used by each student. Keyboard shortcuts are used to create hyperlinks embedded in the text, refresh the browser session to display changes, and split the screen, among other functionalities. Online forms are used to register for the blog's service or other tools' services. The blog includes multimedia content that the user has edited from ready-made images (posters). The blog includes a multimedia library (e.g., images, gifs). The blog's visibility settings (Public / Private) have been edited. Cookies are enabled so that the blog's address remains in the browser history and passwords are/are not stored.	Organize academic work using bookmarks (e.g., creation of course folders) Reduce the execution time of a task by using keyboard shortcuts (e.g., refresh, restore, open/close browser tabs). Efficient use of cloud technology services to organize and store work and other documents (e.g., collaborative editing and sharing of documents). Successful completion of a registration form in the online services of the University or other useful services which support academic work (e.g., verify registration, create a digital backup).

Blog creation	Digital skills to support the creation of the blog (project)	Academic affordances
		Protection of personal data and privacy in the academic environment (e.g., apply extra protection layers).
Create a list with future posts	*Information-Navigation skills* The blog is structured in Sections. There are tags for easy access to the blog's content.	Navigation to websites and databases with academic content (e.g., apply keyword search, use indexes/directories).
Create and upload the blog's logo Upload images, GIFs, banners, and videos free from copyright to the media library	The recent posts are displayed for easy access to the blog's content. There is a "Search" function. *Creative skills* The blog includes multimedia content that the user has edited from ready-made images (e.g., posters).	Use different search tools to meet specific information needs when performing a task (e.g., access open license content).
Upload relevant informational articles, digital resources, and other materials Use a reference system to cite the blog's material Use the tags and the recent posts function to organize the material	*Information-Navigation skills* There are keywords that describe the content of each blog post (tags). There are articles about the blog. The blog includes multimedia content that is not subject to copyright restrictions (e.g., copyright, citing or referencing omissions). *Critical skills* The articles include reliable information.	Optimization of the information search processes to find academic material (e.g., use of information retrieval strategies, such as filtering). Identify keywords to search for specific content (e.g., use synonyms). Use different search tools to meet specific information needs when performing a task (e.g., use multimedia databases). Evaluate the suitability of online resources for academic purposes (e.g., utilize checklists with evaluation criteria). Evaluate the suitability of online multimedia content for academic purposes (e.g., apply reverse image and video search strategies).
Upload a Creative Commons Licence	*Creative skills* The blog includes a license for copyright protection.	Securing the copyright of the author of an academic work/publication on the Internet (e.g., use online licenses).
Link the blog to personal and/or professional social network services Create links to other blogs	*Social skills* The information shared does not pose a risk to the blog owner.	Managing different digital identities and reputations in the internet environment (e.g., adjust profile settings).
Enable the basic functions for posts and follow	The language used respects the rules of netiquette in different online contexts (blog). There are comments from other users to which the blog owner responds in a way that respects the rules of netiquette. The blog includes a list of followers. The blog allows various sharing options (e.g., sharing via social media). The blog follows other blogs with reliable information.	Effective communication with the use of different digital media and environments (e.g., apply netiquette rules).
Embed flashcards and/or quizzes	*Creative skills* The blog includes multimedia content created by its owner (e.g., flashcards, quizzes, posters, presentations).	Support for learning during the studies (e.g., use flashcards, quizzes/questions for revision purposes)
Embed presentations	The blog includes a presentation created by its owner.	Development of academic work/publications and communication of the results.
Embed videos	The blog includes videos created by its owner.	Development of academic work/publications and communication of the results.
Presentation of the blog	The blog has been finalized, and it is a fully functional website.	Providing evidence for abilities/skills for the academic and professional career (e.g., create an e-portfolio showcasing examples of projects)

3.2 Participants

The research sample included 23 undergraduate students who were attending courses at a university. Their age range was 18-23 years. Approximately 40% of the students were males, and 60% were females. 52% were first-year students, 26% were second-year students, 4% were third-year students, and 18% were fourth-year students.

3.3 Research Instrument

The data were gathered using the self-assessment questionnaire *Internet Skills Scale* by Van Deursen, Helsper, and Eynon (2014, 2016) which was based on Van Dijk and Van Deursen's (2014) conceptualization of digital literacy skills and was administered to evaluate students' skills before and after the intervention. The authors validated the Scale for the context of higher education, and the results from the reliability analysis indicated high internal reliability across all five scales (Cronbach's alpha is 0.90 for the Information Navigation skills, 0.89 for the Social skills, 0.91 for the Creative skills, 0.84 for the Operational skills, and 0.87 for the Critical skills) (Miliou & Angeli, 2021). The questionnaire was structured on a five-point Likert scale ranging from "Not at all true of me" to "Very true of me." The collected data were used to determine differences in students' skills based on the project-based learning design before and after the intervention. The authors used the non-parametric Wilcoxon Signed Rank test, which was applied with the statistical package SPSS, and the effect sizes for the Wilcoxon's signed-rank tests were calculated as $r = z/\sqrt{N}$ with the following thresholds: significant effect is .5, a medium effect is .3, and a small effect is .1 (Fritz et al., 2012).

4. RESULTS

4.1 Operational Skills

The scores for this dimension were calculated as the sum of the ratings for the four items. As shown in Table 2, a Wilcoxon Signed Rank Test revealed a statistically significant increase in Operational Skills following participation in the project-based learning intervention, $z=-4.114$, $p=.001$ with a large effect size, $r=.60$. The median score on the Operational Skills increased from pre-intervention (Md=14) to post-intervention (Md=19).

Table 2. Wilcoxon Signed Rank Test for Students' Self-Assessment of Operational Skills (N=23)

	Median Pre-questionnaire	Median Post-questionnaire	Z	p
Operational Skills	14	19	-4.114	.001

4.2 Information-Navigation Skills

The scores for this dimension were calculated as the sum of ratings for the seven items, which were reversed because they were negatively stated. A Wilcoxon Signed Rank Test revealed a statistically significant increase in information-navigation skills following participation in the project-based learning intervention, $z=-4.205$, $p=.001$ with a large effect size, $r=.62$. The median score on the information navigation skills increased from pre-intervention (Md=24) to post-intervention (Md=32). Table 3 shows the results of the Wilcoxon Signed Rank Test from students' self-assessment of their information navigation skills.

Table 3. Wilcoxon Signed Rank Test for Students' Self-Assessment of Information-Navigation Skills (N=23)

	Median Pre-questionnaire	Median Post-questionnaire	Z	p
Information-Navigation Skills	24	32	-4.205	.001

4.3 Social Skills

The scores for this dimension were calculated as the sum of the ratings for the seven items. A Wilcoxon Signed Rank Test revealed a statistically significant increase in social skills following participation in the project-based learning intervention, z=-3.849, p=.001 with a large effect size, r=.57. The median score on the Operational Skills increased from pre-intervention (Md=28) to post-intervention (Md=34). Table 4 shows the results of the Wilcoxon Signed Rank Test from students' self-assessment of their social skills.

Table 4. Wilcoxon Signed Rank Test for Students' Self-Assessment of Social Skills (N=23)

	Median Pre-questionnaire	Median Post-questionnaire	Z	p
Social Skills	28	34	-3.849	.001

4.4 Creative Skills

The scores for this dimension were calculated as the sum of the ratings for the five items. A Wilcoxon Signed Rank Test revealed a statistically significant increase in creative skills following participation in the project-based learning intervention, z=-4.208, p=.001 with a large effect size, r=.62. The median score on the creative Skills increased from pre-intervention (Md=12) to post-intervention (Md=25). Table 5 shows the results of the Wilcoxon Signed Rank Test from students' self-assessment of their creative skills.

Table 5. Wilcoxon Signed Rank Test for Students' Self-Assessment of Creative Skills (N=23)

	Median Pre-questionnaire	Median Post-questionnaire	Z	p
Creative Skills	12	25	-4.208	.001

4.5 Critical Skills

The scores for this dimension were calculated as the sum of the ratings for the four items. One item was reversed because it was negatively stated. A Wilcoxon Signed Rank Test revealed a statistically significant increase in critical skills following participation in the project-based learning intervention, z=-4.125, p=.001 with a large effect size, r=.61. The median score on the critical skills increased from pre-intervention (Md=13) to post-intervention (Md=19). Table 6 shows the results of the Wilcoxon Signed Rank Test from students' self-assessment of their critical skills.

Table 6. Wilcoxon Signed Rank Test for Students' Self-Assessment of Critical Skills (N=23)

	Median Pre-questionnaire	Median Post-questionnaire	Z	p
Critical Skills	13	19	-4.125	.001

5. DISCUSSION

Following the results analysis, the authors assert that the project-based learning intervention significantly contributed to the improvement of operational, information-navigation, social, creative, and critical skills among undergraduate students. This conclusion is supported by the substantial effect size observed in each of these skill areas, underscoring the intervention's effectiveness in enhancing digital literacy skills among undergraduates.

The approach's success could be attributed to several design elements that aimed to enhance the project-based learning experience. Specifically, to combat the lack of students' awareness about the use of technologies for academic purposes (Kennedy & Fox, 2013; Ståhl, 2017), the authors highlighted the added value of the tools they were using beyond the context of the intervention, and prompted students to identify the affordances of each tool for future use in academic or professional environments. Such practice was based on the results of previous research, which showed that students found added value in learning activities with the

use of digital tools that support their study and work at an academic or professional level (Ng, 2012; Hall et al., 2013).

Additionally, the authors sought to address the differences in students' digital literacy skills levels and their familiarity with digital devices and tools (Helsper & Eynon, 2010; Hargittai, 2010; Corrin et al., 2010; Ståhl, 2017) by following a holistic approach to learning. Namely, each project enabled students to experiment with various tools and develop various skills in different areas by working on a unique project on a topic of interest. Thus, the design addressed the need for more personalized learning experiences that allowed students to use tools based on the needs of their work (Jørgensen, 2019).

In summary, the acknowledgment of a large effect size suggests that the project-based learning approach is educationally impactful, with broad implications for enhancing digital literacy skills in academic settings. This is noteworthy for educators, institutions, and policymakers, as it underscores the effectiveness of project-based learning in fostering crucial skills that are essential for students' success in academic settings and beyond. Furthermore, the discussion sheds light on the success factors of the project-based learning approach, such as highlighting the added value of digital tools, prompting students to identify tool affordances, and addressing differences in students' digital literacy skills levels through a holistic learning approach. These design elements not only contribute to the effectiveness of the intervention but also provide practical insights for educators seeking to implement similar strategies.

6. CONCLUSION

The discourse around The Digital Natives Debate has often made presumptions about younger generations' inherent technological prowess, especially within the confines of higher education. However, this paper sheds light on the overlooked gaps and nuances in their digital literacy, emphasizing the need for targeted interventions. Through a focused exploration of project-based learning's efficacy in enhancing digital literacy skills, this research has bridged a critical knowledge gap. The robust positive outcomes across various facets of digital literacy, ranging from operational to critical skills, underscore the potential of project-based learning in molding digitally competent scholars.

However, it is essential to acknowledge certain limitations that may impact the generalizability of our findings. One notable limitation is that the study relied on a relatively small sample size, which may limit the extent to which our results can be applied to broader populations. However, it is essential to note that the primary aim of this research was not to achieve broad generalizability but to focus on a comprehensive exploration of a project-based learning intervention within the context of digital literacy education.

Another limitation stems from the self-selection bias among participants which could introduce a degree of subjectivity into our findings, as individuals with a heightened interest may have been more inclined to participate. Future research should aim to address these limitations by employing larger and more diverse samples, as well as considering alternative recruitment strategies.

As higher education continues to evolve in the digital age, it is imperative that institutions recognize and harness such pedagogical strategies not merely to keep pace with technology, but to leverage it in cultivating holistic, future-ready learners. This study lays the groundwork for future endeavors seeking to refine and implement project-based learning interventions seamlessly integrated with digital literacy training in academic settings emphasizing the added value that technology can bring to educational settings.

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