

UNVEILING THE IMPACT OF DIGITAL READING AND RESEARCH ON PRODUCT DESIGN: EMPOWERING TECHNOLOGY AND ENGINEERING EDUCATION THROUGH NEW LITERACIES

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Abstract

The technology and engineering curriculum emphasizes the importance of developing students' abilities to find and design new solutions, be creative, and make decisions while building structures. In this exploratory experiment, this research aimed to deepen the design and planning of engineering and technology problems online and encourage creativity among students in their free time. The intervention was curriculum-based and involved sixteen groups of 4-5 students. The project task was structured in two steps, with the first step in a classical format, while the second step was to be completed in an online learning environment using the reciprocal teaching method. Qualitative and quantitative research methods were used to collect data, including a comparison of project assignments produced in steps 1 and 2, an unstructured interview with the teacher and students, and a rating scale for students. Results showed that students improved their products by reading and researching online. The use of online resources was particularly relevant in the problem design and planning phase, where students were able to fill gaps in their knowledge and improve their products.

KEYWORDS: *online reading to learn, online research, product design process, technical product, technology and engineering*

Introduction

Despite more than 30 years of research in the field of online reading and learning (Mayer, 2018), the most intensive research on online reading in the educational en-

environment began more than a decade ago. Even before the internet reached its current ubiquity, there was recognition of its transformative potential for literacy education, offering unprecedented access to information and new models of learning (Leu, Coiro, Castek, and Hartman, 2008). The complexity of navigating and evaluating information online underscores the necessity for a structured approach to inquiry. The notion aligns with the principles outlined by Kuhlthau, Maniotes, and Caspari (2015), who advocate for a guided inquiry process that equips students with the tools to critically assess sources and construct knowledge effectively. Such structured approach is instrumental in developing the advanced information literacy skills required in today's digital landscape. Generation Alpha is considered the most technologically driven demographic (McCrinkle and Fell, 2020), and their lives are defined by the fact that information is available to them anytime, anywhere (Nagy and Kölcsey, 2017). Children are taught to read and practice reading comprehension with offline texts. However, they are rarely taught how to read and research online, highlighting the gap in digital literacy skills. According to UNESCO (n. d.), digital literacy involves the confident and critical use of digital technologies for learning, working, and for participation in society. Reading is increasingly moving to online environments, which brings a new context to reading (Forzani, Leu, Li, Rhoads, Guthrie, and McCoach, 2020). Reading and writing in online environments are different because students must find the information they need among a multitude of other information that is not relevant to them. They are not readily available in a book or textbook provided by the library or selected by the teacher, but are part of a problem-solving task that requires higher-level thinking than offline reading (Coiro and Castek, 2010). Not only children but also adults face difficulties in reading online (Tighe, Kaldes, Talwar, Crossley, Greenberg, and Skalicky, 2023). The process of constructing meaning from online text involves abilities, techniques, attitudes, and social practices that occur in the process of using the internet for research, problem-solving, and finding answers to questions, underscoring the importance of information literacy. Information literacy refers to a collection of integrated skills that include the ability to find information in a thoughtful manner, comprehend the production and value of information, and use information to create new knowledge and engage ethically in learning communities (Framework for Information Literacy for Higher Education, 2015). Moreover, constructing meaning from text in critical online reading is particularly pressing in the post-truth era, where not all information offered on the internet is necessarily true and relevant (Nash, 2021), which requires thoughtful and critical use of sources that students encounter online, and is most critical for younger students (Kingsley, Cassady, and Tancock, 2015).

The data that students can obtain online can significantly enrich learning and ex-

pand the knowledge that students can acquire. There are many possibilities for incorporating online research and reading into the primary school curriculum, with much already written about it, mostly in the context of online reading in teaching and learning the native language (e.g., Coiro, 2012; Leu et al., 2008; Tseng, 2010), mathematics (e.g., Quellmalt and Haertel, 2008), science (e.g., Kennedy, Rhoads, and Leu, 2016; Quellmalt and Haertel, 2008), history (e.g., Malysheva, Tokareva, Orchakova, and Smirnova, 2002), and many others, as well as studies related to children with learning difficulties (Castek et al., 2010). What they all have in common is the recognition of the need to develop new literacies, a concept closely intertwined with digital and information literacy. Despite students having acquired reading skills and many of them being proficient in technology, reading on the internet is somewhat different. The reader must independently choose which websites to visit, often jumping from one site to another; within the selected websites for detailed reading, the reader must decide how and in what way to read or review the multitude of information contained on the chosen webpage, which embedded links to choose (Cho and Afflerbach, 2015), and they have to be able to resist being drawn away from their reading goal by other information. The work method automatically stimulates students to higher taxonomic levels of analysis, synthesis, and evaluation, as described by Bloom (1956) and the two-dimensional taxonomy table by Krathwohl (2002). Readers require new literacies to assist them in online research and comprehension (Leu, Coiro, Castek, and Henry, 2013), which involve a mixture of multiple processing practices that demand new skills and strategies, laying the foundation for digital and information literacy. These include reading to identify important questions, reading to locate information, reading to evaluate information critically, reading to synthesize information, and reading and writing to communicate information, as listed by Zawilinski, Forzani, Timbrell, and Leu (2019, p. 339). They add that new literacies are crucial to learning and they focus directly on information use and learning; and the ability to read and use online information effectively to solve problems defines an individual's success in both personal and professional life. Zawilinski et al. (2019, p. 343) also address the difference between reading analog and digital texts. While reading printed text relies on the use of narrative texts, using inferential reasoning about setting, events, problems, solutions, characters, etc., comprehension activities are based on typical discussion questions - reading digital texts, however, changes this. Informational texts such as search engine results are used, and it is necessary to be able to infer information from search lists, with questions focused more on the characteristics and content of websites. Of course, both types of questions are important and necessary, but a combination of both is needed, rather than just using traditional texts with traditional forms of questions and answers, for which knowledge and treatment of literacies is required.

But before acquiring new literacies, students need a foundation. The foundation for developing new literacies are, of course, digital literacy competences, as basic use and mastery of a computer, tablet, or other device is essential for successful learning, reading, and online research (Legvart, Kordigel Aberšek, and Kerneža, 2022), which secondary level students have mostly acquired (Kerneža and Kordigel Aberšek, 2023; Kordigel Aberšek and Kerneža, 2023), meaning there are no barriers to acquiring and utilizing the advantages of reading an online research. Forzani and Leu (2012) particularly emphasize that new literacies need to be integrated into teaching as soon as students begin to receive their literacy education, which a critical step in fostering both digital and information literacy.

To further elaborate, the interconnections between information literacy, digital literacy, and new literacies reveal significant overlaps and synergies, especially pertinent in the STEM and STEAM education areas. Information literacy and digital literacy form the foundational blocks upon which new literacies are built, incorporating critical evaluation of information, ethical use of digital content, and practical application of this knowledge in creating new understandings. This multidisciplinary approach is essential in STEM education, where problem-solving, critical thinking, and the ability to navigate vast amounts of digital information efficiently are key (Perignat & Katz-Buonincontro, 2019). By framing this research with the contest of information literacy alongside digital literacy, and extending it to the STEM or STEAM areas, the importance of these literacies in preparing students not just for academic sources, but for lifelong learning and adaptability in a rapidly changing digital world is underscored.

Research Problem

Zemljak, Aberšek, and Dolenc (2021) explored the adoption of modern processing technologies in the Technology and Engineering classes, focusing on the usage and perceived importance of computers and related technologies in teaching. Their study revealed a consensus among teachers on the significance of utilizing computers, especially for presentations, but a more varied stance on computer applications and e-textbooks. While contemporary technologies are highly valued for making lessons more engaging and relevant to students' everyday lives, their actual application in classrooms is not as widespread. The results of the study suggest that teachers of technology and engineering recognize computers primarily as a support for their work rather than as a means of supporting students and developing and deepening their knowledge.

Technology and Engineering is one of the most practical, if not the most practical, subject in the school curriculum, where children acquire knowledge and skills in an area that is also one of the fastest developing fields, as technology advances daily. So fast, in fact, that curricula and educational content cannot keep up, as progress in the field is happening at the speed of progress of society. All of the above speaks in favor of providing students with authentic learning that includes problems based on real situations, and that represents one of the most effective ways to encourage students' online research and academic growth and development (Britt, Goon, and Timmerman, 2015). The proposed research aims to investigate one of the effective approaches to teaching Technology and Engineering, which would involve the latest technological achievements and would encourage students to research, analyze, and solve problems. The study also examines the impact of incorporating technology into the learning process and how it affects student engagement and academic performance. One of the general goals in the curriculum (Program osnovna šola tehnika in tehnologija. Učni načrt., 2011) is for students to understand and explore simple technical objects (while also constructing and building them, which was not the subject of the study). The curriculum also stipulates that when designing, planning, analyzing, and manufacturing or building, students, together with the teacher, evaluate the products, using sketching, reading, drawing technical and technological documentation, and oral and written communication to express their ideas, with a preference for manual and computer graphic tools for presentation. Additionally, the curriculum recommends that students become familiar with the real world, discovering questions for which they seek solutions, acquiring new knowledge and skills, and discovering and developing their abilities. This could also be extended beyond the current definition of information technology in the curriculum, through interdisciplinary connections, including developing digital capabilities. The curriculum suggests that students use information technology primarily when working with computer programs for learning, designing technical documentation, 3D modelling, calculating the cost of the product, using online classrooms, recording events for computer presentations, and searching for information on the internet. However, if we connect this with the data presented by Zemljak et al. (2021), which shows that only a quarter of technology teachers are aware of the opportunity to use computers to achieve higher taxonomic levels, we can see that there is not enough emphasis on using computers to achieve higher taxonomic levels, and that there is not enough emphasis on using computers to search for information online, which could deepen and expand the content context beyond the classroom walls. The reasons for this may lie in the fact that other forms and methods of using information technology are more researched and emphasized.

Research Focus

The interdisciplinary connection between the school subject of Technology and Engineering and the subject of the native language (in the case of this research, the subject of Slovene language) is instrumental in promoting critical thinking, writing skills, and the development of reading and online research skills. This integration enhances students' abilities to recognize, analyze, and interpret technological and scientific information, while also articulating their ideas clearly and effectively in written form. Specifically, this research underscores the critical role of information literacy and digital literacy within STEM education, as these competencies are essential for students to navigate, evaluate, and create information in the realm of technology and engineering. The proposed research intervention focuses on leveraging online research skills to achieve the selected subject goals, where students learn various aspects of technology, engineering, and practical skills necessary for the design, operation, and maintenance of various products and systems. The IRT method, which has proven effective for online reading (Kerneža and Kordigel, 2022), is employed. This integration not only fosters students' interest in an engagement with technology and engineering, but may also encourage them to pursue careers in these fields.

Research Aim and Research Questions

The research aim was to explore the impact of online research resources on the design and planning of problems presented in the Technology and Engineering class, and to explore new literacy skills of students in grades 6 to 8, with a special focus on how information literacy and digital literacy contribute to their understanding and application of STEM concepts.

- RQ1: What are the new literacy skills of students in grades 6 to 8?
- RQ2: What is the impact of online reading and research on the product design in Technology and Engineering class?
- RQ3: Can Technology and Engineering teachers effectively integrate online reading and research into their teaching?

Research Methodology

General Background

Rojc and Dolenc (2021) have found out that nearly half of the lessons are dedicated to the product production, with students often utilizing work materials containing all necessary materials for their construction. In selecting appropriate products, teachers adhere to the contents and objectives of the curriculum, drawing from prior knowledge, desires, and ideas for the products. For this reason, an exploratory experiment was planned to examine the effects of online reading and research on the performance of the technical product design process in primary school, within the framework of the Technology and Engineering subject segment in which students design practical products. This research emphasizes not only the practical aspects of product design, but also aims to foster students' information literacy and digital literacy skills that are pivotal in enabling students to efficiently locate, evaluate, and utilize digital information during the product design process, thereby enriching their learning experience and outcomes.

During the process of designing a practical product, teachers can take advantage of the opportunity to expand students' knowledge, seek new additional information that may not have been obtained in class, and discover more similarities. In this manner, the online reciprocal learning method and problem-based learning (Zemljak and Kerneža, 2023) are integrated, not only as instructional strategies but also as means to cultivate critical information and digital literacy skills. This integration is proposed as the cornerstone of the 21st-century learning (Tan, 2003). The study is based on qualitative methodology (Denzin and Lincoln, 2015), grounded in theoretical frameworks. A qualitative study design with a quasi-experimental approach (Cooper, 2009) was selected, as the main goal was to explore benefits of online learning through reading and research on how well technical product design processes operate in primary schools, albeit on a smaller sample size, but covering all segments of the research questions posed, with a particular focus on how the enhancement of information literacy and digital literacy can impact the design process and outcomes in the context of Technology and Engineering education.

Sample

The study utilized a convenience non-probability sample of students enrolled in the 6th, 7th, and 8th grades of Slovenian primary schools. The sample consisted of 21 students in the sixth grade (divided in 5 groups), 23 students in the seventh grade (divided in 6 groups), and 19 students in the eighth grade (divided in 5 groups). In align-

ment with the internet reciprocal teaching method, students engaged in the process of learning new literacy skills as they progressed through the curriculum, with a teacher modeling those skills not yet acquired by students. This approach allowed students to acquire previously unmastered skills in real-time, fostering an environment of active and interactive learning. It is important to note that while students typically do not use computers during these specific lessons, for the purposes of this study, they utilized them within the context of the research activities. All groups were instructed by the same Technology and Engineering teacher, thereby eliminating variations in teaching methodologies as a confounding variable in the study's outcomes.

Instruments and Procedures

Within the subject of Technology and Engineering, the students designed a product, specifically, the sixth grade designed a paper product, the seventh grade a product made of synthetic material, and the eighth grade a product made of metal. The work was differentiated by grade according to the objectives in the curriculum. The IRT method was presented to the implementing teacher, along with the lesson plans for teaching, designed to include all necessary theoretical principles. The teacher was provided with answers to all the posed questions.

In the introductory part of the lesson, the teacher presented a product to the students, where the students thought about the suitability of the use and the properties of materials for such a product, considering various criteria. They looked at some other product made from the mentioned materials. Prior to planning, the teacher and the students justified the importance of technical communication and the need for standardized technical drawing, and then established planning criteria: autonomy in work, technical solutions, quality of execution, various improvements and additions, functionality. The teacher then divided the students into groups to engage in collaborative online reading to foster the co-construction of meaning and knowledge so as to reach positive outcomes (Kiili et al., 2012), and told them that they would receive a problem task, in the planning of which they would form a mind map, and work would take place in four steps. (1) First, they would search for ideas to solve the problem. (2) Then, they would form an idea to solve the problem. (3) They would draw a sketch of the product network. (4) They would justify the sketch of the idea. They had 20 minutes for the task, and the teacher told them that they would be able to supplement the idea with research. Group work was deliberately chosen for its positive effects on the quality of the discussion and on the individual's cognitive development (Mercer and Littleton, 2007), and it is also part of reciprocal teaching (Palinscar and Brown, 1984).

The students then worked in groups for 20 minutes to plan their product. Within the

group, they created a mind map on a poster, noting down their ideas for problem-solving (brainstorming), formulated their ideas for solving the problem, and drew a schematic network of the product, which they then presented and justified. This step is particularly important because background knowledge we bring to a text significantly shapes our information retrieval and interpretation (Leu, Zawilinski et al., 2008).

In the next step, the teacher informed the students that they would further improve their planned product by exploring their notes, ideas, sketches, etc. – everything they wrote down in the first part of the lesson – online, for which they had 35 minutes. He emphasized that they should also pay attention to quality, innovativeness, usability, functionality, and sustainability. The students were asked to take a different colored pen, and complete the mind map created in the previous part of the lesson by now researching online. The students monitored their work and evaluated it on an ongoing basis using a worksheet, which guided them in their reading and research online, broadening and deepening their knowledge and understanding of the topic. The worksheet, following the Castek and the New Literacies Research Team (n.d.), addressed the issues of the *search design* (What are the key words related to this topic? Who could write about this topic? What organizations could provide information on this topic?), *search* (What new key words did I notice while searching? What types of authors write or publish about this topic? What are the most interesting sources that write about this topic? Why did I choose these sources?), *evaluation* (What professional knowledge about the topic do authors most often have? What were the most common motivations for authors to publish their text? What is the main claim that authors most often wanted to convey to readers? How well did authors justify their writing? What evidence did authors use (e.g., research, experience...)? How did authors' professional knowledge most often reflect in the way they supported their claims?), and *knowledge building* (How did the views of different sources differ from each other? What was common to the sources? What can explain differences in sources (e.g., motivations, professional knowledge...)?). These records were reviewed and evaluated by the researchers, who rated on a 3-point scale whether the learning groups did not demonstrate the skill, or the skill was not detected (not detected), if it was emerging (emerging), or it was acquired (acquired). The measure “not detected” allows the possibility that the skill is acquired, but not demonstrated by the students on a given task. In this study, the internet reciprocal teaching method was adopted to evaluate digital skills at the group level, aligning with the collaborative learning approach that is facilitated by the IRT method (Leu et al., 2008). This approach, aimed at secondary school students, aligning with the age of students participating in this study, supports collective exploration and evaluation of digital information, fostering critical thinking and shared decision-making. Emphasizing the use of common digital

tools like Google or any other, depending on students' decision, the study also seeks to broaden students' digital research capabilities.

This was followed by a presentation in which the students presented their product design process to other groups, and, after the presentation, the students evaluated their work in groups using the four study activities, defined by Palincsar and Brown (1984), further developed by Castek and the New Literacies Research Team (n. d., p. 6) in the context of the Internet Reciprocal Teaching Dialogue Rubric. Using a 4-point scale, the students assessed their abilities in *questioning* (1 – asking simple questions whose answers could be found on the first page of a website; 2 – finding answers to questions on one or more websites; 3 – asking more complex questions and using prior knowledge to answer; 4 – adjusting questions based on what was read and what interested them), *explaining information* (1 – improving understanding by explaining information in a group when necessary; 2 – using the knowledge of all members of the group to understand something not understood; 3 – using context clues to explain unknown words or information; 4 – using more advanced strategies to explain more difficult information), *using information* (1 – combining website information to improve the product without hesitation; 2 – improving the product based on multiple main ideas and numerous details; 3 – improving the product based on logically connected ideas from different websites; 4 – being complete and accurate with the information used for product improvement, and learning a lot of new information while searching for information), and *predicting* (1 – before reading, we tried to predict what the content on the website would be about; 2 – to say what the text will be about, we have clearly stated the purpose of the reading; 3 – adjusting predictions and expectations based on information obtained while reading; 4 – we formed predictions about the text as we received information in real time).

The students engaged in product design using a mind mapping technique, where they recorded ideas for problem-solving, developed design concepts, created product network sketches, and presented and justified their design ideas. The product design was evaluated by the teacher. The evaluation took place both before and after the incorporation of online reading and research into the design process. The criteria used for evaluation were specifically designed for this study, and included quality, innovativeness, usability, functionality, and sustainability (Table 1).

A semi-structured interview was conducted with the teacher, in which the general structure of the interview was based on a few basic open-ended questions, while other questions were formulated during the interview (Vogrinc, 2008). In this way, answers were obtained to the research questions focusing on the effects of online reading and research on the performance of the technical product design process from the perspective of the technical aspects of the process, the teacher's instructional experiences, and

TABLE 1. Evaluation Criteria for Mind Mapping

	1 – Poor	2 – Fair	3 – Good	4 – Excellent
Quality	The design is incomplete, inconsistent, and of low quality. It has numerous flaws and deficiencies that diminish its integrity and usability.	The design is mostly of good quality, with some minor shortcomings or errors that do not significantly affect its functionality or aesthetics.	The design is of high quality, without significant errors or deficiencies. It is well-thought-out, consistent, and fulfills its purpose.	The design is flawless, of exceptional quality, and without errors. It is exceptionally well-conceived, refined, and meets the highest standards.
Innovativeness	Design does not include any new or innovative elements. It is based on existing ideas or solutions without any improvements or advancements.	The design incorporates some innovative elements, but their use is limited or unoriginal. It presents some new ideas, but not entirely innovative.	The design incorporates several new and innovative elements that add value to the product. It includes creative and original solutions that stand out.	The design is exceptionally innovative. It incorporates entirely new and unique concepts.
Usability	The design has limited utility and fails to meet expectations. It does not effectively address the problem at hand.	The design possesses some useful characteristics; however, there are certain deficiencies or limitations that restrict its usability.	The design is highly functional and effectively addresses and operates in line with the defined problem.	The design is exceptionally practical and efficiently solves the problem. It brings innovative solutions and surpasses expectations.
Functionality	The design exhibits deficient or inadequate functionality. It fails to meet the basic requirements or purpose of the product and does not enable effective use.	The design predominantly possesses appropriate functionality; however, there are certain deficiencies or limitations that restrict its operation or usability.	The design demonstrates high functionality and effectively fulfills its purpose. It enables easy use and meets key requirements.	The design showcases exceptional functionality and surpasses expectations. It accomplishes its purpose in an innovative manner, offering additional features or use benefits, and allows for easy and intuitive use.
Sustainability	The design lacks sustainability and does not consider environmental aspects. It is constructed from poor materials, lacks durability, and does not provide a long lifespan.	The design has some aspects of sustainability, but there are limitations or shortcomings that reduce its resistance to handling or environmental impact.	The design is sustainable and made of high-quality materials. It is hard-wearing, durable and has a low environmental impact during its life cycle.	The design is highly sustainable, taking into account the principles of the circular economy and incorporating environmentally friendly materials and production processes. It ensures a long service life, easy repair and recyclability.

the students' learning experiences. The interview was conducted immediately after the research was completed in all classes, ensuring consistency and uniformity. The teacher's answers are included in the research results on an ongoing basis.

Data Analysis

The data analysis in this study is based on qualitative methodology that has guided the evaluation and interpretation of findings. The validity and reliability of the research were ensured through regular checks and necessary corrections. The instrument underwent preliminary validation in a classroom setting at a smaller primary school, encompassing a cohort of nine students, to ensure the age-appropriateness of the task assigned to students; these findings were integral to the conceptualization of the current studies. Potential biases that could have influenced the findings were considered during analysis, ensuring appropriate data collection and analysis. The traceability of the research process was documented with detailed evidence, ensuring consistency and transparency on interpretation. The entire research process was clearly described, from the initial idea to the development of methods and reporting of findings. Instructions were clear, precise, and unambiguous. Data were processed using descriptive statistics, analyzed and interpreted. Initially, the data were carefully examined and read multiple times, providing a comprehensive understanding of the research area. Data synthesis and analysis were then conducted, allowing for a cross-sectional examination of the data to develop conceptual structures and understand causal relationships among themes. The final conclusions were drawn based on the entire body of evidence, with results thoroughly examined multiple times. The conclusions were supported by the collected data. Such an approach facilitated a deep understanding of the data, revealing patterns, trends, and interpretations that supported the final conclusions and findings.

Research Results

The research results were analyzed in-depth and comprehensively to define the field and problem in the most detailed and thorough manner. The interpretation of the results is based on the outcomes of the measurement instrument and is supported by the data obtained from the interview with the teacher.

New Literacies Skills of Students in grades 6 to 8

The results presented in Table 2 demonstrate the extent to which students have acquired the skills of new literacies necessary for successful web search planning.

TABLE 2. Acquisition of New Literacy Skills Required for Successful Web Search Planning

		Grade 6	Grade 7	Grade 8
Keyword identification	Group 1	emerging	acquired	acquired
	Group 2	emerging	acquired	acquired
	Group 3	acquired	acquired	acquired
	Group 4	acquired	acquired	acquired
	Group 5	acquired	acquired	acquired
	Group 6	-	acquired	-
Relevant authors	Group 1	emerging	emerging	emerging
	Group 2	emerging	emerging	emerging
	Group 3	emerging	emerging	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	acquired
	Group 6	-	acquired	-
Organization search	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	not detected
	Group 4	not detected	not detected	emerging
	Group 5	not detected	not detected	acquired
	Group 6	-	emerging	-

Note. *Keyword identification* – The skill of identifying key words related to the topic. *Relevant authors* – The skill of recognizing relevant authors and their contributions in the field under consideration. *Organization search* – The skill of searching for organizations that provide information on the topic being discussed.

The results (Table 2) indicate that the majority of students have adequately acquired the skill of *keyword identification*, as only 12.50 % of participating groups demonstrated an emerging level of proficiency. The remaining proportion of groups (87.50 %) have fully acquired the skill, indicating that students can recognize key terms and use them for effective online information retrieval. The skill is crucial for successful navigation of the contemporary information environment. The teacher supported this finding by highlighting that students begin

learning keyword identification, essential information retrieval skills, and other reading-learning strategies early in their elementary education, suggesting that the skill is largely well-acquired by the target grade level. Regarding the ability to *identify relevant authors* who could write about the topic at hand, some difficulties were observed. Only 12.00 % of groups had fully acquired this skill, while in 87.50 % of participating groups it was still emerging. Thus, the majority of students still struggle with identifying appropriate authors who could write about a specific topic, indicating a lack of knowledge about experts and their work in the given field. The teacher emphasized the importance of fostering students' exploration of diverse sources and providing guidance and direction in understanding different authors and their contribution. Similarly, it was found that several groups faced challenges in *searching for organizations* that provide information on the topic at hand. The skill was fully acquired by 12.50 % of groups, emerging in 6.25 % of groups, and not acquired by 81.25 % of students. This highlights the need for the development of instructional strategies that can help students improve these skills. The teacher once again expressed the belief that searching in English, where more resources on the researched topics can be found, could assist students. Students would also benefit from new discoveries they would make during their research. Similar findings were reported by the teacher regarding the ability to search for organizations that provide information on the topic. The teacher believed that searching in English would also aid students in this regard, as more records on the researched topics are available.

The step following web search planning is web searching itself (Table 3).

The Impact of Online Research on the Design of Products in Engineering and Technology

TABLE 3. Acquisition of New Literacy Skills Required for Successful Web Search

		Grade 6	Grade 7	Grade 8
New keywords	Group 1	not detected	not detected	not detected
	Group 2	not detected	emerging	emerging
	Group 3	emerging	emerging	emerging
	Group 4	emerging	emerging	acquired
	Group 5	acquired	acquired	acquired
	Group 6	-	acquired	-

		Grade 6	Grade 7	Grade 8
Different types of authors	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	not detected
	Group 4	not detected	not detected	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Most interesting sources	Group 1	emerging	emerging	emerging
	Group 2	emerging	emerging	emerging
	Group 3	emerging	emerging	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Reasons for choosing	Group 1	emerging	emerging	emerging
	Group 2	emerging	emerging	emerging
	Group 3	emerging	emerging	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-

Note. New keywords – The skill of perceiving new keywords during the search process. *Different types of authors* – The skill of recognizing different types of authors who write or publish on the topic under consideration. *Most interesting sources* – The skill of identifying the most interesting sources that address the topic. *Reasons for choosing* – The skill of understanding the reasons for selecting specific sources.

The data presented in Table 3 indicate that the ability to perceive *new keywords* during the search process is emerging, with students still needing practice and experience. 25.00 % of the groups did not demonstrate the skill and the same percentage had no difficulties with the skill, while the skill was emerging in 50.00 % participants. Regarding the ability to recognize *different types of authors*, the results show that 31.25 % of students demonstrated emerging abilities, while the remaining students (68.75 %) did not demonstrate the targeted skill. The interview with the teacher revealed that the main issue stems from a lack of knowledge about professions and fields related to the topics being addressed. The ability to identify the *most interesting sources* that address the topic is emerging in all students (100.00 %), but according to the teachers' report, students are unable to adequately justify their *reasons for choosing*, i.e., this skill is also emerging in all observed cases.

After conducting online search planning and engaging in information retrieval on the internet, the acquired information was evaluated by students to determine the appropriateness of the information found (Table 4).

Integrating Online Research and Reading into Teaching Technology and Engineering

TABLE 4. Acquisition of New Literacy Skills Required for Successful Evaluation of Online Information

		Grade 6	Grade 7	Grade 8
Domain-specific knowledge	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Motives identification	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Main arguments	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	emerging	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Substantiation of the claims	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	emerging
	Group 4	not detected	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-

		Grade 6	Grade 7	Grade 8
Types of evidence	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	emerging	emerging	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Justification of claims	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	emerging
	Group 4	emerging	emerging	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-

Note. Expertise – The skill of recognizing the domain-specific knowledge possessed by the authors most commonly addressing the topic at hand. *Motives identification* – The skill of identifying the most prevalent motives of authors for providing the text. *Main arguments* – The skill of recognizing the primary claim that authors most frequently intend to convey to readers. *Substantiation of the claims* – The skill of evaluating the justification provided by authors for their statements. *Types of evidence* – The skill of identifying the various forms of evidence employed by authors. *Justification of claims* – The skill of observing how authors' expertise is reflected in the manner they substantiate their claims.

From Table 4, it is evident that none of the skills required for successful evaluation of online information have been acquired. In terms of the ability to recognize *domain-specific knowledge*, *authors' motives*, *main arguments*, and the *justification of claims*, half of students did not demonstrate the skill, while it was emerging in half of participants. This indicates the need for further development of critical thinking and the ability to understand authors' intentions, to identify key elements of the text, highlighting the necessity to enhance the capacity for critical assessment of information and verification of its reliability and credibility. Regarding the ability to evaluate the *justification of authors' statements*, a larger proportion of participants (56.25 %) did not acquire the skill, while it was emerging in 47.75 % of participants. In terms of the ability to identify types of *evidence* used by authors, 37.50 % of students did not acquire the skill, while it was emerging in 62.50 % of students. These results indicate that none of the skills required for successful evaluation of online information were fully acquired, emphasizing the need for additional teaching and guidance to develop these skills. The teacher highlighted students' need for support and recognized the necessity for further guidance and instruction in the evaluation of online information. The importance of developing the ability to understand context, engage in critical

thinking, and apply criteria for assessing the reliability and credibility of information sources was also identified. The teacher acknowledged the role of teachers in promoting these skills, providing leadership and guidance to develop students as independent and responsible users of online resources.

In the final stage of improving the product design using the steps of the IRT method, there was one last step – the students had to apply the knowledge they had acquired (Table 5).

TABLE 5. Acquisition of New Literacy Skills Required to Successfully Build Knowledge Online

		Grade 6	Grade 7	Grade 8
Observing the differences	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	not detected
	Group 4	not detected	not detected	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Identifying common elements	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	not detected
	Group 4	emerging	not detected	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-
Explaining differences	Group 1	not detected	not detected	not detected
	Group 2	not detected	not detected	not detected
	Group 3	not detected	not detected	not detected
	Group 4	not detected	not detected	emerging
	Group 5	emerging	emerging	emerging
	Group 6	-	emerging	-

Note. *Observing the differences* – The skill of observing differences between the views of different sources. *Identifying common elements* – The skill of identifying to identify common elements between sources. *Explaining differences* – The skill of explaining differences between sources.

The results presented in Table 5 demonstrate a strong correlation among individual skills, as they show the same level of acquisition. Specifically, 68.75 % of participants did not exhibit developed skills in *observing differences* between perspectives

from different sources, recognizing *common elements* across sources, and *explaining differences* between sources. Meanwhile, these skills were emerging in 31.25 % of participants. In the interview, the teacher stated that students were not accustomed to this approach, leading to incomplete tasks or a lack of demonstrated skills that went unnoticed. The results highlight a significant interconnection among skills in building knowledge online, indicating the importance of teaching and developing abilities for analyzing and comparing different sources and fostering critical thinking in online learning. The teacher's observation that students were not familiar with this mode of work suggests the need to adapt the instructional process, introduce and gradually develop new literacies, and provide appropriate support to students in developing these skills.

After completing the online search, students filled out a questionnaire to evaluate their use of online reading strategies (Table 6).

TABLE 6. Group Work Evaluation of the Use of Online Reading Strategies

		Grade 6	Grade 7	Grade 8
Questioning	Group 1	1	1	1
	Group 2	1	1	2
	Group 3	1	2	2
	Group 4	2	2	2
	Group 5	2	2	3
	Group 6	-	3	-
Clarifying	Group 1	2	2	2
	Group 2	2	2	2
	Group 3	2	2	3
	Group 4	2	2	3
	Group 5	2	2	3
	Group 6	-	3	-
Summarizing	Group 1	2	2	2
	Group 2	2	2	3
	Group 3	2	2	3
	Group 4	2	2	4
	Group 5	2	3	4
	Group 6	-	3	-

		Grade 6	Grade 7	Grade 8
Predicting	Group 1	1	1	1
	Group 2	1	1	1
	Group 3	1	1	1
	Group 4	1	1	4
	Group 5	4	4	4
	Group 6	-	4	-

Note. See Chapter *Instruments and Procedures* for an explanation of the individual values.

Table 6 indicates that students evaluated their work differently. Regarding question formulation, 37.50 % of participants believed that the *questions asked* were straightforward and that they found appropriate answers on the first page, 50.00 % of participants identified their questioning as having answered the questions by searching for information on one or more websites, and the remaining participants (12.50 %) considered that they asked more difficult questions and that they related the information from the websites to their prior knowledge when answering. Students also rated their ability to *explain information* by group. 75.00 % of students said that if they did not understand something, they used the knowledge of all the group members to help them, while the remaining 25.00 % said that they used clues in the text to help them explain unfamiliar words and information. In terms of the *use of information*, the majority of students (62.50 %) felt that the improvement of their product was based on several main ideas and many details, 25.00 % of students felt that the improvement of their product was based on meaningful connected ideas from different websites, was complete and accurate, and 12.50 % of participants felt that the improvement of their product was based on complete and accurate information and that they had learned a lot by searching for information. In anticipation, students rated themselves within two options. The first part of students (68.75 %) estimated that they tried to predict what the content on the website would be about before reading, while the second half of students (31.25 %) estimated that they kept their predictions and forecasts up-to-date with the information they got from reading online. In the interview, the teacher also complemented the data with his own observations, pointing out that students showed different levels of skills in using online reading strategies in group work. He notes that students should be encouraged to be more critical to information, to evaluate the reliability of sources, and to think in multiple ways when using and interpreting information. He also adds the importance of identifying reading styles in advance and adjusting predictions according to the information obtained.

TABLE 7. Impact of Online Reading and Research on the Product Design in Technology and Engineering Class

		Grade 6		Grade 7		Grade 8	
		Before	After	Before	After	Before	After
Quality	Group 1	2	2	2	3	3	4
	Group 2	2	3	3	3	3	4
	Group 3	3	4	3	4	4	4
	Group 4	3	4	3	4	4	5
	Group 5	4	4	4	4	4	5
	Group 6	-	-	4	5	-	-
Innovation	Group 1	2	4	2	4	2	5
	Group 2	3	3	3	4	3	4
	Group 3	3	4	3	3	3	4
	Group 4	4	4	4	4	4	4
	Group 5	4	5	4	5	4	5
	Group 6	-	-	4	5	-	-
Usability	Group 1	2	3	2	4	3	4
	Group 2	2	4	3	5	3	5
	Group 3	2	3	3	3	3	5
	Group 4	3	4	4	5	4	5
	Group 5	4	5	4	5	4	5
	Group 6	-	-	3	5	-	-
Functionality	Group 1	2	4	2	3	2	3
	Group 2	2	3	2	4	2	4
	Group 3	2	3	2	3	3	5
	Group 4	2	4	3	4	3	5
	Group 5	3	4	3	5	4	4
	Group 6	-	-	4	5	-	-
Sustainability	Group 1	1	2	1	1	1	2
	Group 2	1	3	2	3	2	3
	Group 3	2	2	2	2	2	4
	Group 4	2	3	2	4	2	3
	Group 5	2	4	2	3	3	4
	Group 6	-	-	3	4	-	-

Note. See Table 1 for an explanation of the individual values.

The results presented in Table 7 indicate that, in most cases, there was an increase in ratings for the assessed items. Regarding *quality*, the results show that there was no increase in ratings for 5 groups (31.25 %), while 11 groups (68.75 %) showed an increase of one rating. In most cases, the ratings thus improved by one level, indicating that online reading and research contributed to the improvement of product design quality. With respect to *innovation* ratings, it is observed that the ratings also mostly improved after the use of online reading and research. There were no changes for 5 groups (31.25 %), while the rating increased by one level for 8 groups (50.00 %), by two levels for 2 groups (12.50 %), and by three levels for 1 group (6.25 %). The results indicate that students' products became more creative, incorporating more innovative elements and improvements compared to existing ideas and solutions. The *usability* of the product also improved after online research. Most groups achieved higher ratings, with one group not improving usability (6.25 %), 9 groups increasing the usability rating by one level (56.25 %), and 6 groups increasing it by two levels (37.50 %). The results indicate that students responded better to the identified problem with the improvements made to the products, receiving support through online research to design more usable products. One group did not improve the functionality of the product (6.25 %), while the rating increased by one level for 8 groups (50.00 %) and by two levels for 7 groups (43.75 %). Despite the online inquiry, the sustainability rating remained unchanged for 3 groups (18.75 %), increased by one level for 9 groups (56.25 %), and increased by two levels for 4 groups (25.00 %). Although the sustainability rating improved for the majority of groups by one or two levels, it should be emphasized that some groups did not achieve an improvement in the sustainability rating, which is an important aspect in product design. This highlights the need to continue promoting understanding and utilization of environmentally friendly materials and processes.

Discussion

The results of the research provide valuable insight into the skills of new literacies among students in grades 6 to 8, specifically focusing on web search planning, web searching, evaluation of online information, and the application of acquired knowledge. These skills are integral components of digital literacy and information literacy, foundational for navigating the complex information landscape inherent in STEM and STEAM education. The findings shed light on the extent to which students have acquired these skills and highlight areas that require further attention and instructional support. The findings indicate that the participating students have not sufficiently

acquired the new literacies described by Leu, Coiro, Castek, and Henry (2013) to engage in independent online reading, researching, and learning. This observation underscores the need for a more integrated approach to teach digital and information literacy within the context of STEAM education, where technology and engineering play crucial roles.

Difficulties were observed in all areas mentioned by Zawilinski, Forzani, Timbrell, and Leu (2019), namely, in identifying important questions, reading to locate information, reading to evaluate information critically, and reading to synthesize information (the ability to communicate information was not assessed). This aligns with the essential skills of information literacy, particularly critical in the context of STEM/STEAM, where students are often required to engage with complex, interdisciplinary content. The ability to communicate information was not assessed, but is also a critical aspect of literacy in digital contexts, especially for students working on projects that intersect technology, engineering, and other STEAM areas.

Two main findings are highlighted. Participating students were most successful in the keyword information area, as confirmed by the participating teacher. The curriculum for Slovene class (Program osnovna šola slovenščina, učni načrt, 2018) already anticipates the acquisition of reading learning strategies from the early stages of education. Students start acquiring these strategies even when they are just learning basic reading skills, and one of the strategies they learn includes keyword identification. This is the only skill of new literacies that can be considered well-acquired by students. However, difficulties arose in perceiving new keywords during the search process, not because students were unable to recognize new keywords, but due to the lack of familiarity with the possibility of determining new keywords while reading. This result is also associated with the self-evaluation of students' group work. A significant proportion of the group was satisfied with the data obtained from the first page, while only one group integrated information from different web pages. Another important aspect to highlight the frequency of the occurrence of non-evaluated skills, indicating that some specific aspects of online reading require special attention. Students are not aware that they should be particularly attentive to them because no one has taught them about web searches or they have insufficiently learned it on their own through independent web usage. The teacher elaborated that the deficiency in using online reading and search strategies stems from a broader educational context, wherein there is insufficient emphasis on such skills within the school curriculum, limiting opportunities for students to acquire these skills both within and outside the school environment, including at home. The broader context of digital literacy among educators and families suggests a need for ongoing research and development in this area to ensure effective teaching of dig-

ital skills. According to Eurostat (2023), more than just basic overall digital skills are possessed by only 26.49 % individuals aged 16 to 74 in the EU and 19.72 % of individuals in Slovenia, where the study was conducted. Additionally, only 27.46 % of individuals in the EU and 29.95 % of individuals in Slovenia in the mentioned age group have basic digital skills, making a total of 53.95 % of EU residents and 49.67 % of Slovenian residents lacking basic digital literacy skills (information and data literacy skills, communication and collaboration skills, digital content creation skills, safety skills, and problem-solving skills were evaluated). Therefore, the data from this case study indicate that new literacy skills among students aged 11 to 14 are not sufficiently developed. Considering Eurostat data, which provides information starting from the age of 16, it is not expected that the new literacy skills will significantly progress. This is further supported by the recent study by Tighe et al. (2023), which found that adults also encounter difficulties in online reading. There is a clear need for education in new literacies among primary school students, as it is an area that seems to be somewhat neglected despite being essential for safe and successful engagement in modern digital society.

Regarding the impact of online reading and research on product design in the Technology and Engineering class, the results indicate that web-based inquiry and research have positively influenced all assessed aspects of the technical product. This suggests that digital literacy and information literacy are not just supplementary skills but central to the innovative and practical application of knowledge in STEAM disciplines. The use of online reading and research contributed to the improvement of product design quality, innovation, usability, functionality, and sustainability. However, not all groups showed improvement in their products. While most groups improved their product design scores, some did not make progress in the monitored area or the progress was less than it could have been. The planning and evaluation by students and the teacher's feedback reveal that the reasons for the lack of progress in some groups do not stem from the inadequacy of online reading and research to enhance product design, but rather from deficiencies in digital literacy skills. It became apparent that students lack the necessary skills to transition from an environment where information is provided to them in the form of books, textbooks, or other formats to an environment where they engage in problem-solving tasks that require higher-level thinking than offline reading (Coiro and Castek, 2010). The online environment itself proved to be a meaningful and effective setting in which children can progress and further develop their knowledge. Furthermore, the results indicate that promoting understanding and the use of environmentally friendly materials and processes is crucial for the continued success and improvement in technical design. Additionally, there is a reiterated need for appropriate education of students in digital skills, which will

indirectly enhance the effectiveness of using online resources in product design. This finding supports the theoretical premises of researchers Cho and Afflerbach (2015), who suggest that the reader must make decisions about which websites to visit, how to read them, how to integrate information from different websites, and similar tasks, but these skills were not sufficiently developed in the participating students. But learners can make progress if the skills are developed in the right way, as reported by Kerneža and Kordigel (2022). In the future, it would be interesting and meaningful to compare the improvements in students' products using non-digital sources (books, magazines, textbooks, etc.) with the improvements in students' products complemented with digital sources.

Overall, it is evident that Technology and Engineering teachers could effectively incorporate online reading and research into their instruction. The examined intervention had a positive impact on product design improvement, indicating that online reading and research can be successfully integrated into the teaching of Technology and Engineering. However, challenges arise due to students' insufficient digital literacy, which hindered the progress of some groups in improving their design ratings. This highlights the importance of digital education and teacher support in developing students' digital skills, enabling them to better utilize the potential of online reading and research in teaching technology and engineering. It has been revealed that this approach can stimulate creativity, innovation, usability, and sustainability in product design, while providing a richer learning experience for students. However, it is important to note that this conclusion is based on observations in a singular context, involving a small sample of student taught by a single teacher. Consequently, the findings should be interpreted with caution, and there is a pressing need for further research employing a representative sample to validate these initial insights comprehensively. With modern processing technologies, computers have become essential tools in computer classrooms (Zemljak et al., 2021). Nevertheless, teachers must also be competent in teaching new literacies (Kordigel, Dolenc, and Kovačič, 2015). Another limitation of this study is that while the IRT method was utilized for the acquisition of new literacy skills, with the teacher modeling those not yet mastered, students typically do not use computers during these lessons, though they were employed specifically for this research.

Overall, the study underscores the critical role of digital and information literacy in enhancing the effectiveness of STEAM education, particularly in the technology and engineering fields. It highlights the need for structured educational interventions that not only improve digital and information literacy skills but also integrate these literacies seamlessly into STEAM curricula, thus preparing students for the multifaceted challenges of the 21st century. The need for teacher competence in new literacies, es-

pecially within the STEAM context, is more pressing than ever, suggesting a direction for future professional development and curriculum design.

Conclusions

The research results provide valuable insight into the skills of new literacies among students in grades 6 to 8, specifically focusing on web search planning, web searching, evaluation of online information, and the application of acquired knowledge. These findings shed light on the extent to which students have acquired these skills and highlight areas that require further attention and instructional support. It is evident that the students who participated in the study have not sufficiently mastered the new literacies to engage in independent online reading, research and learning. New literacies, also known as digital literacies, represent a modern understanding of literacy that encompasses the skills and knowledge necessary for successful navigation in the digital world. The needs for reading, writing, critical thinking, and information literacy skills have changed in digital environments, and require development of effective and efficient functioning in contemporary society. New literacies involve abilities such as searching, evaluating, and utilizing information online, participating in digital communities, and comprehending multimedia texts. As new technologies continue to evolve, so do the ways in which people communicate, create, and share content, making new literacies an important concept in the development of educational strategies and preparing students for an ever-changing world. This research contributes to a better understanding of effective approaches to teaching and learning with help of online learning environments and improving STEM education for all students.

The positive impact of online reading and research on product design in Technology and Engineering class is evident in the improved quality, innovation, usability, functionality, and sustainability of the designed products. However, the limited progress in some groups indicates inadequate digital literacy skills rather than the suitability of online reading and research for enhancing product design. Therefore, the integration of online reading and research into technology and engineering education is recommended, but it is crucial to provide digital education and support for teachers to develop students' digital skills. By addressing these challenges and investing in digital literacy education, students can effectively utilize the potential of online reading and research, develop their new literacies, and thrive in the digital age.

The present study is significant as it sheds light on the shortcomings in developing new literacies among students. The findings provide a better understanding of the extent to which students have acquired these skills and identify areas that require further

attention and support. Future research could focus on the development of self-reflective practices, in which students are encouraged to engage in self-reflection to enhance their awareness of their own limitations and progress, as well as foster autonomy in online reading and research. The starting points and research already carried out offer the opportunity of conducting comparative research among countries. It would be meaningful in order to identify best practices and understand the factors that influence success in acquiring these skills. Additionally, it would be valuable to examine the influence of the family environment on the development of digital skills in children.

By addressing these recommendations and advancing our understanding of new literacies, we can ensure that students are well-prepared to thrive in a digital society and actively contribute to its advancement. Digital education is the key to empowering students for success in the digital age.

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RAZOTKRIVANJE UTJECAJA DIGITALNOG ČITANJA I ISTRAŽIVANJA NA DIZAJN PROIZVODA: OSNAŽIVANJE TEHNOLOŠKOG I INŽENJERSKOG OBRAZOVANJA KROZ NOVE PISMENOSTI

Sažetak

Kurikul tehnologije i inženjerstva naglašava važnost razvoja sposobnosti studenata za pronalaženje i dizajniranje novih rješenja, kreativnost i donošenje odluka pri izgradnji struktura. U ovome istraživačkom eksperimentu cilj istraživanja bio je probuditi dizajn i planiranje inženjerskih i tehnoloških problema na internetu te potaknuti kreativnost među studentima u slobodno vrijeme. Intervencija se temeljila na kurikulu i uključivala je šesnaest grupa od 4-5 studenata. Zadatak projekta bio je strukturiran u dva koraka, pri čemu je prvi korak bio u klasičnom formatu, a drugi korak izveden u okruženju za online učenje koristeći se metodom uzajamnog poučavanja. Korištene su kvalitativne i kvantitativne metode istraživanja za prikupljanje podataka, uključujući usporedbu projektnih zadataka izrađenih u koracima 1 i 2, nestrukturirani intervju s učiteljem i studentima te ljestvicu ocjenjivanja za studente. Rezultati su pokazali da su studenti poboljšali svoje proizvode čitanjem i istraživanjem na internetu. Korištenje online resursa bilo je posebno relevantno u fazi dizajniranja i planiranja problema, gdje su studenti mogli popuniti praznine u znanju i poboljšati svoje proizvode.

KLJUČNE RIJEČI: *online čitanje za učenje, online istraživanje, proces dizajna proizvoda, tehnički proizvod, tehnologija i inženjerstvo*