education sciences

MDPI

Article

Study and Research Paths to Improve Web-Based Inquiry Learning: Study Case of an ICT Course in Engineering

Andreu Moreno and Elena Bartolomé *

Escola Universitària Salesiana de Sarrià (EUSS), 08017 Barcelona, Spain; amoreno@euss.es
* Correspondence: ebartolome@euss.es

Abstract: Many active, inquiry-based learning activities nowadays rely upon the students' capacity to perform efficient information research on the Internet. Study and Research Paths (SRPs) have been proposed to model inquiry learning, and successfully used as teaching formats in different areas. In an SRP the search for an answer to a generating question (Q_0) leads to a sequence of derived questions and answers, which are modeled using a Q–A map. We have investigated the benefits of using SRPs and Q–A maps to improve Web-based inquiry learning. We designed an SRP for a course on Information and Communication Technologies (ICT), belonging to an Engineering degree. The class-session SRPs revolved around Q_0 questions such as 'What is a «firewall»?', 'What are the main features of 5G?' etc. Our results, based on the analysis of six courses conducted between 2015/16–2020/21, show that the SRP is an enriching tool for learning ICT: content expands beyond that of the traditional course and is maintained up-to-date. Students are engaged and motivated by the active-search activity. In addition, the SRP helps in improving the students' skills in searching and selecting information on the Internet. The Q–A maps served both the students, to structure their Web inquiry, and the teacher, to monitor the learning study process.

Keywords: inquiry-learning; internet inquiry; digital skills; mobile learning; Study and Research Paths; ICP; engineering

Citation: Moreno, A.; Bartolomé, E. Study and Research Paths to Improve Web-Based Inquiry Learning: Study Case of an ICT Course in Engineering. *Educ. Sci.* **2021**, *11*, 772. https://doi.org/10.3390/educsci11120772

Academic Editors: Lucas F. M. da Silva and António Ferreira

Received: 23 October 2021
Accepted: 22 November 2021
Published: 29 November 2021

1. Introduction

Current trends in higher education (HE) emphasize the need for a progressive switch toward student-centered approaches, in which students participate actively in the learning processes [1,2]. Different from traditional teacher-led lecturing, active learning fosters the implication of students in different discovery, search and hands-on activities [3].

Many studies have shown the advantages of more "active" or "engaged" learning over direct, expository forms of instruction for acquiring deep conceptual knowledge [4], increasing students' involvement [5], motivation, and affective engagement [6].

Engaged learning is a rather open concept that embraces many different forms, including, for example, project and problem-based learning (PBL), computer aided learning (simulation environments and online labs), etc. [7,8]. The incorporation of ICTs in active learning activities has been found to increase the student's intrinsic motivation and promote participation [9,10].

Many of these active learning forms involve some type of inquiry activity, in which students must address a question, either proposed by the teacher or by themselves, by performing investigations. These may include searching background and literature information, collecting data, simulating, etc. [11]. Inquiry-based or research-based learning activities have been found to enhance deep learning among the students [12]. It has been pointed out that inquiry must be well planned, and the advances in the development of knowledge must be monitored, in order to lead to productive learning [13]. Moreover, inquiry learning must be well guided. As recently reviewed in [11], different ways have been proposed to provide students with guidance during inquiry learning, which include:

giving students the right level of control, e.g., by adjusting the degree of freedom or initiative, providing the students with scaffolds, i.e., a structure of the inquiry-cycle or sub-tasks to be done; and balancing instruction and inquiry.

Inquiry learning often demands searching for information over the Internet, whether that is for the purpose of knowing the state-of-the-art of a subject, collecting background information, further understanding a topic, etc. Internet research, understood as the practice of using the World Wide Web, has nowadays become the most common way of gathering formal and informal information. Moreover, learning using the Internet has become one of the most vital factors for academic success in HE [14–16].

In the twenty-first century, students increasingly rely on the Internet as their main information source. Today's students live digitally and they perform informal Internet research on a regular basis. However, this does not guarantee they have the skills to perform strategic, well-structured, and complete research. The overwhelming amount of information available can make it difficult for untrained students to select relevant information, and they can spend endless hours navigating through different web pages. Additionally, a critical sense towards the information found on the Internet must be developed [17,18]. It follows that some type of training is desirable to produce efficient and sound learning based on Web inquiry.

However, research on students' acquisition of research skills and students' learning using the Internet is still an emerging and highly fragmented field [19]. O. Zlatin-Troitschanskaia et al. [20] provided recently a comprehensive literature review on student learning vis-à-vis using the Internet, encompassing, (i) students' strategies for searching, (ii) the evaluation and selection of online information, (iii) the use of information for domain-specific learning, (iv) the influence of the characteristics of both online information sources, (v) learners on the Internet inquiry process, and (vi) the developing over time of online information use behavior.

Studies focused on HE students' strategies for searching online information have shown the search behavior of untrained students often tends to follow some general patterns [16,21–39]. These include [20]: i) 'foraging', i.e., there is no explicit research plan, and students base their task responses on the online material they come across in an arbitrary search, ii) 'Google dependence', i.e., students do not use any other search tools other than this search engine, iii) 'Rudimentary search heuristic', and iv) 'habitual topic changing' after rather superficial skimming.

All these studies indicate that there is a need to develop adequate teaching methods to develop the student's capacity to perform well-planed, strategic Internet inquiry.

Study and Research Paths (SRP) have emerged in recent years as interesting formats to shape different forms of active, inquiry-based learning. The SRP concept arose from the Anthropological Theory of the Didactic (ATD) in the context of the Didactics of Mathematics [40–42]. The SRP was first proposed to describe the actions performed by a community of study to answer a given question. Later on, SRPs developed as an interesting form of inquiry-based learning methodology.

The SRP begins by proposing the students an initial question (Q_0); the search for an answer leads to other sub-questions and partial answers, thus forming an arborescent scheme known as a Q–A map. The active search for answers leads students to study different notions and perform different inquiry activities using a variety of resources. As a result of this process, the knowledge of the community of study about the subject is expanded. The interactions between the students and the different information and validation resources are modeled by the media-milieu dialectics within ATD [43,44]. Recently, the variations and similarities in the development of the SRPs found as a function of the Q_0 generating question and the study-group have been discussed [45].

At present SRPs have been implemented in many different areas, ranging from Mathematics [46,47], Management, Epidemiology, and Sports [40–42]. In past years, we have shown the benefits of SRP methodology in the field of Engineering education. We reported the design and implementation of specific SRPs for courses of the Mechanical Engineering

curriculum, such as "Strength of Materials" [45,48], "Mechanics of the Continuous Media," [49] and "Theory of Machines and Mechanisms" [50,51]. Very recently, we showed the suitability of SRP for improving the learning of General Chemistry (submitted). The SRP methodology proved to be a motivating, active-learning format useful for the acquisition of both technical skills as well as other important soft skills such as teamwork, autonomous learning, critical thinking, and orientation to quality. All the above previously reported SRPs were project-based, i.e., the Q_0 questions were associated to real-world objects, and the SRPs were mainly designed to foster the integration of practical and theoretical learnings.

However, we consider that the SRP methodology may be an interesting approach to improve the learning of theoretical knowledge in an active way. Moreover, we consider that SRPs may be useful tools to enhance inquiry-based learning based on Internet search. The Q-A map management tool may serve both the students, to structure their Internet search, and the teacher, to monitor the online search study process.

This work represents a first evaluation of this hypothesis. We have analyzed, using a mixed quantitative-qualitative methodology, the SRPs implemented in an Information and Communication Technologies (ICT) course of an Engineering degree.

The research questions of the work are the following:

RQ1. In which ways could the SRP enrich the theoretical learning of an ICT course using the Internet?

RQ2. Would the SRP and Q–A maps help students improve their skills in the search of information on the Internet?

We discuss results based on SRP implementations carried out during six academic years (2015/16 to 2020/21).

2. Methodology

2.1. Didactic Engineering Methodology

We have used the Didactic Engineering (DE) methodology to design, experience, and analyze the SRP. It is structured in four phases [52]. The first phase helps to identify the possible existing problematic didactic phenomena [53]. It consists of a preliminary characterization of the initial study process in a given context, including the analysis of the epistemological, institutional, and ecological dimensions. The second phase concerns the design of the SRP to overcome the above detected problems by defining the structure and degree of openness of the SRP, choosing the generating questions, defining the deliverables, the assessment method, etc. The third phase covers the implementation and in vivo analysis of the SRP as well as the data collection for ulterior analysis. The fourth phase consists on the a posteriori analysis of the SRP, to check up to what extent the learning processes have been modified according to the expectations in the a priori phase. The DE methodology resembles the PDCA (Plan-Do-Check-Act) cycle quality tool often used in Engineering [54], and has been thus easily embraced by the research community working in Engineering education.

2.2. Course Context

The SRPs were implemented in a 6 ECTS, compulsory ICT course in the second year of a four-year degree in Industrial Management Engineering at EUSS School of Engineering in Barcelona (Spain). The course took place during the spring semester; it lasted 15 weeks, and consisted of two sessions per week of two hours. Teaching was structured in 9 theoretical sessions and 21 lab sessions. In each course edition, five SRPs were conducted in the theoretical sessions; each single-session SRP was initiated by a different Q_{0i} generating question and lasted 2 h.

The total number of participants in the six analyzed SRP-ICT editions was 352: 53 in 2015/16, 50 in 2016/17, 64 in 2017/18, 59 in 2018/19, 59 in 2019/20 and 57 in 2020/21. During the SRPs, the students worked in self-organized teams of six members. In the first four years, the SRP sessions took place in a traditional classroom, equipped with WIFI connection. Mobile phones, tablets, and portable PCs were provided by the students, who

commonly own these devices. However, in the last two years, SRPs were conducted online by video-conference due to COVID-19 pandemic constraints.

A single teacher conducted all the analyzed ICT-SRP courses. He had received a teacher training in SRP methodology, and was supported by an SRP researcher. The teacher had wide experience in ICT teaching and more than 10 years in conducting collaborative, PBL-based courses [55].

2.3. Data Collection

Firstly, we collected the students' productions in each SRP edition: the 'outputs', structured in the form of a list of questions-and-answers, written by each group summarizing the result of the inquiry work triggered by each Q_{0i}. We examined as well the graphical representations of the Q–A maps, collected since 2018/19. Second, we analyzed the students' exams, which included a question about one of the topics studied through the SRP. In the third place, we considered the teacher observations about the SRP dynamics and collective work during the sessions. Photos were taken, with the permission of the participants. Finally, we conducted a final survey to evaluate the students' adaptation to the SRP course and the use of Q–A maps in the two last editions (2019/20, 2020/21). The questionnaire included 19 structured questions to evaluate the student's opinions about the SRP duration, difficulty, structure, teamwork, Web search, and general aspects (S5.1). The questionnaire also collected students' qualitative opinions about the most positive and negative aspects of the SRP (S5.2).

3. DE Methodology Applied to ICT Course

3.1. DE First Phase: Preliminary Analysis

In this phase, we analyze the ICT course, attending to the epistemological, institutional, and ecological dimensions [53,56] to make explicit the problematic didactic phenomena in the traditional course.

ICT is an academic discipline aiming to offer services to access, store, transmit, and manipulate information. ICT has been relatively recently incorporated to the Engineering curriculum, but it is nowadays often present in the undergraduate program of Computer Science, Electronics and Telecommunication Engineering degrees, see, e.g., [57,58].

Given the recent establishment of ICT as academic subject and its rapid evolution, there are no classical undergraduate textbooks, unlike other more traditional courses. Instead, a variety of resources are used to teach the different parts of the subject, e.g., [59–61].

ICT is also often found in the curriculum of Industrial Engineering. A survey on different Industrial Engineering curricula shows that the common approach is to focus on a general-purpose programming language and computer architecture fundamentals, e.g., [62,63]. This can be considered the most dominant epistemology. However, at EUSS we considered that we needed to widen this scope because ICT technologies are currently playing an increasingly important role in engineering jobs. Therefore, the curriculum of Engineering degrees imparted at xxx includes a first-year course that covers the classical approach, but, in addition, a new subject named ICT was added in the second year, to include the following contents:

- Databases: data structure design and Structured Query Language (SQL).
- Web programming: HyperText Markup Language (HTML) and Hypertext Preprocessor (PHP) languages, static and dynamic web pages, and access to databases.
- Communication systems: transmission media, structured cabling, telephone systems, local area networks, wide band connections, wireless networks, TCP/IP protocols, and industrial communications.
- Communication services: Dynamic Host Configuration Protocol (DHCP), Domain Name System (DNS), Simple Mail Transfer Protocol (SMTP), and Internet Message Access Protocol (IMAP).

These contents were agreed at EUSS by a teachers' committee having professional expertise in ICT.

Before 2015/16, all the theoretical parts of the course were taught through master classes. One of the problems detected was that students perceived ICT as a peripheral subject in their Industrial Management Engineering degree, and they paid little attention to theoretical sessions; in spite of that, students were engaged in lab sessions. Moreover, the vast amount of descriptive contents, imparted through master classes, resulted as tedious, and the demotivated students spent part of the session using their mobiles.

Taking into account these problematic phenomena, we deemed it necessary to change this "monumentalistic" way of teaching. In the new conception of the theoretical sessions, it was considered important to implicate the students in the search of the topics, making them aware of changes in the field, and embracing the use of ICT devices. The redesign would also aim to develop other transversal skills associated to the course, such as capacity to use autonomous learning strategies, to search information on the Internet for the professional exercise, and to acquire new ideas (see S1). These transversal competences were described in the academic guide of the course, but were under-attended in the traditional organization.

3.2. DE Second Phase: SRP Design

This phase of the DE methodology includes the specific design of the SRP, oriented to circumvent the problems detected in the previous phase. It includes deciding the number and structure of the SRPs, selecting the question(s), planning the deliverables generated by the students and the assessment method.

The SRPs in the ICP course were introduced to replace part of the theoretical sessions. Every year five different, short SRPs were scheduled, each initiated by a different Q_{0i} question. Each SRP was designed to be completed within a 2-h session: in the first hour of class the teacher would introduce some theoretical notions, and in the second hour the students conducted the inquiry work about the Q_{0i}, working in groups of six students. We note that this type of SRP substantially differs from others previously reported, where a single generating Q_0 was utilized to develop a long-lasting course [45].

According to the first phase of the DE, we considered that the generating questions should lead the students to learn the proposed theoretical contents of the course, bearing in mind that this is not a "static monument" to be visited, but knowledge under construction, given continuous progress in ICT.

The five selected generating questions Q_{0i} are presented in Table 1. It is to be noted that question Q_{01} had to be adapted in the last courses, due to the fact that the Mobile World Congress (MWC) could not take place, owing to the COVID-19 pandemic. The contents of the theoretical class imparted during the first-hour of the SRP session are specified in the table.

To test the potentiality of the questions and foresee the possible development of the SRP, the teacher performed Internet research in advance. This preliminary research served the teacher to build an a priori Q-A map for each question and define a list of "milestones" that students should find to learn a minimum set of basic concepts (see S2).

As a way to monitor the inquiry process and summarize the results of the search, we decided to ask the students to generate an 'output' report summarizing the list of tackled sub-questions (Q_{0ij}), arising from the initial question (Q_{0i}), the obtained answers (A_{ij}), and the utilized Internet sources. In order to help the students to structure the deliverable, a template was provided (see Figure 3). The suggested length was two pages, in order to put an indirect limit to the dedicated time. In the SRP editions from 2015–2019 the 'output' paper documents were delivered at the end of the session, whereas in 2019/20 and 2020/21 editions (carried on online due to COVID-19), the deliverables were presented the next day via Moodle.

Table 1. Questions Q_{0i} (i=1–5) proposed in the SRP imparted in ICT during academic years 2015/16 through 2020/21. The topic of the theoretical masterclass imparted prior to each SRP session is indicated.

Q_{0i}	Question	Course	Masterclass Theory
Q_{01}	What were the highlights of the last Mobile World Congress (MWC)?	2015/16–2018/19	Introduction to data communications, types of networks, brief history of Internet, standards in communications, transmission methods (wired and wireless), submarine cables
	What are the most outstanding news in mobile telephony this year?	2019/20	
	What is a submarine cable?	2020/21	
Q_{02}	What are the environmental and social costs of the mobile phone market?	2015/16–2019/20	Mobile communication: time and frequency domain, Generations: 1G (AMPS), 2G (GSM), 2.5G (GPRS, EDGE) 3G (UMTS), 4G (LTE), 5G
	What are the main features of 5G?	2020/21	
Q_{03}	What is a "firewall"?	2015/16–2020/21	Structured cabling, network devices, LANs, Ethernet
Q_{04}	What technologies are available to ensure security on a WiFi network?	2015/16–2020/21	Wideband connections, WiFi and Bluetooth: Digital Subscriber Line (DSL), Modem cable, FTTH, IEEE 802.11, Bluetooth
Q_{05}	What is Near field communication (NFC) technology?	2015/16–2020/21	Internet layer model, OSI layer model, industrial communication model, field buses, PROFIBUS, PROFINET

From 2018/19 onwards, we asked the students to deliver in addition a graphical representation of the Q–A map (see Figure 1), with the objective of improving the coverage of the topic by keeping in mind the conceptual map.

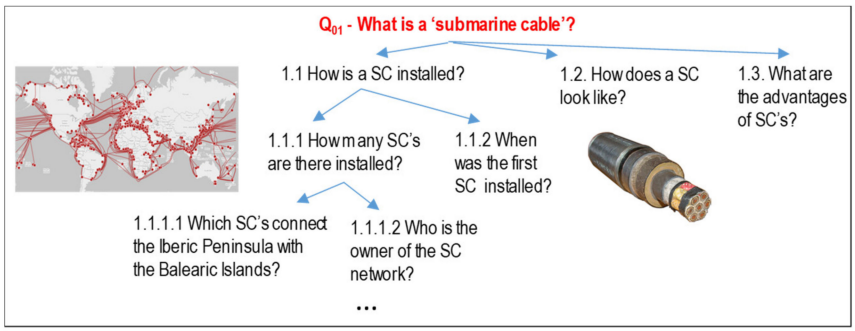

Figure 1. Graphical Q–A map: Arborescent scheme of sub-questions of different hierarchy triggered by the generating question *Q_{01}—What is a 'submarine cable'*?

The evaluation of each SRP was based on a rubric assessing (i) the quality of the tackled sub-questions and answers, (ii) the way the questions were posed and the depth of the investigation, in view of the richness (hierarchy and depth) of the generated Q–A map, and (iii) the completeness of the answers, by comparing the student's findings against the teacher's a priori Q–A map. The corrected 'outputs' were provided by the teacher before the beginning of the next Q_{0i}. The final written ICT exam included one of the questions treated in the SRPs. The SRP contributed a 20% to the total mark of the subject.

3.3. DE Third Phase: Implementation and 'In Vivo' Analysis

The SRP methodology was presented to the students at the beginning of the course, using an example ICT-Q_{0i}. The teacher provided in this case the complete Q–A map and instructed the students about how to write down the list of sequential questions, answers,

and resources in the 'output' sheet. An educational video was prepared in addition to support the explanation during the COVID-19 editions.

Typically, the SRP session dynamics in the class were the following. During the first hour of class the teacher imparted a theoretical class related to the question to be treated during the session (see Table 1). The exposition ended with the presentation of the new open question Q_{0i}. During the second hour the students, distributed in several groups, performed the inquiry work (see Figure 2a). Within each group, the students briefly discussed which sub-questions they would search, and wrote them down in the Q–A map sketch (Figure 2b). Immediately after, the students searched the information on the Internet, using their mobile phones, tables, or computers. Typically, one of the students of the team took the role of 'secretary', writing down the information in the report, while the other team members searched in parallel for information (see Figure 2b,c). Roles were interchanged in every SRP session. Within the group, students debated and decided which information was relevant to include in the report (Figure 2d). Inter-group interactions did not happen, given the short time available. As students deepened into the topic, new sub-questions arose, were tackled, and written down in the Q–A map. Thus, the arborescent scheme of questions and answers was progressively developed.

Figure 2. Active-learning during the SRP in ICT: (**a**) Overview of SRP class, showing different groups at work; (**b**) Intra-group discussion and collection of initial sub-questions; (**c**) Internet search using mobiles and laptops; and (**d**) annotation of answers and drawing of Q–A map.

Figure 3 shows an example of an 'output' structured in the form of questions and answers developed around question *"Q_{01}—What is a submarine cable?"*

During the SRP session, the teacher observed the group dynamics and answered any doubts the students had. Occasionally, he would suggest a team to investigate a relevant question that they had missed considering.

The work atmosphere during the whole session was very dynamic. The teacher observed that having a limited time was a determining, positive factor in the motivation of the teams. Mostly, good collaborative dynamics were observed, where all the members of the team actively collaborated towards the common goal of finishing the 'output' in time.

Q_{01} – What is a submarine cable?		
Q / A	#	**Question (Q)** / Answer (A)
Q A	**1.1** 1.1	**How to install a submarine cable?** When installing a submarine cable, four main steps must be followed: 1- Select a provisional route. 2- Obtain the permits from the competent authorities, both national and international. 3- Complete and thorough sound the route, to select the one that minimizes the environmental impact and maximizes the protection of the cable. Studies are needed to define the layout of the cable between the two earth stations to which it will be connected. For example, bathymetry studies can be performed to have a 3D image of the seabed. 4- Extend the cable. This includes burying of the agreed areas. Laying the cable is the last part in the installation. It must be carried out accurately to minimize impact of the seabed. To do this, specially designed ships are used. Divers manage these operations in the case of surface waters, whereas for deep waters remote operation vehicles must be used. To bury a cable, a one-meter-wide corridor is bult using pressurized water or using a plow. Cables are normally buried to a depth of one meter, and exceptionally, ten meters below the seabed to protect of the anchorage of the boats and in the trawl fishing. A submarine cable requires frequent maintenance. Repairing the cable is impossible, or at least, very complicated, therefore cables are currently fixed to the surface. Damaged ends are rescued with a robot and damage is repaired aboard a ship. When a submarine cable ceases to be operational, it is up to its owner to remove or leave it at the bottom of the sea. Some companies withdraw them to reuse materials, following the principles of circular economy, or reuse them on another route.
Q A	**1.1.1** 1.1.1	**How many cables are there installed?** Today there are more than 420 submarine cables operating, approximately 1.1 million kilometers surrounding the world. These cables have been funded by companies such as Google, Facebook or Microsoft, which are within the realm of communications and need a large, fast and secure efficient data transport channel. Currently, almost all of our communications are transmitted through these cables.
Q A	**1.1.1.1** 1.1.1.1	**Which submarine cables connect the Balearic Islands with the peninsula?** Currently, there are different wiring that connect the Balearic Islands and the Iberian Peninsula. These different connections are called the Rómulo project, the Balalink project and the Penbal-5 project. The Romulo project connects Santa Ponca and Sagunto and is characterized by being the first submarine interconnection of the Balearic Islands and the Peninsula to carry direct current. We have the Balalink Project that connects Palma de Mallorca with Valencia. Unlike the previous one, this project serves to supply optical fiber without repeaters. Finally, and no less important, we have the Penbal-5 project, which connects Ses Covetes and Gavà. This project is managed by Telefonica and is therefore a communications cable.
Q A	**1.1.2** 1.1.2	**When was the first submarine cable installed?** With the advent of the telegraph in the world, there was a need to expand communications. For this reason, in 1847 the German Werner von Siemens invented the gutta-percha, a more resistant type of rubber, and it was used to coat the threads of copper (before that cables could not be successfully isolated). In August 1850 the Englishman Jacob Brett used the gutta-percha to build the first cable, which connected Southerland (UK) and Gris-Nez (France). Shortly afterwards this cable was cut by some fishermen, however, it proved the concept was possible
Q A	**1.2** 1.2	**How does a submarine cable look like?** They are fibre optic cables, intended for telecommunications services or, to a lesser extent, the transport of electrical energy. Inside they contain fibre optic filaments that carry light signals from a transmitter to a receiver. Its diameter is about the same width as a human hair. This fibre is surrounded by several layers of insulation and protection. The total thickness of the cable changes along its length, but most is the size of a garden hose. As for its capacity, it also varies. When measuring it, both its potential capacity (the one that could reach its maximum level) and the service capacity (the one that is actually executed) are taken into account. Marea (the cable shared by Facebook and Microsoft) is capable of carrying 160 terabits (one million megabits) per second.
Q A	**1.3** 1.3	**Why are submarine cables useful?** Submarine cables are used as a communications vehicle. One may think that most communications of this type are made via satellite, as it seems the option is economical, but it is certainly not. More than 99% of these communications are made through submarine cables. This system is cheaper and it can carry much higher quality data.
Web sources		
https://blogthinkbig.com/cable-submarino https://www.neoteo.com/como-se-instalan-los-cables-submarinos/ https://blog.cnmc.es/2017/09/05/que-cables-submarinos-conectan-el-territorio-espanol-enganchados-a-los-cables-submarinos-ii/ https://mnactec.cat/blog/del-telegraf-a-internet/2020/09/21/xarxa-de-comunicacio-global-cables-de-comunicacio-submarina/ http://www.islalink.com/portfolio/balearic-islands-balalink/ https://www.icesi.edu.co/blogs_estudiantes/lawebdemafer/2009/01/14/4/ https://cnnespanol.cnn.com/2019/07/26/internet-global-es-alimentado-por-vastos-cables-submarinos-pero-estos-son-vulnerables/		

Figure 3. Example of Q-A map triggered by the SRP question: *"Q_{01}—What is a submarine cable?"*

In the last two editions, the SRP sessions were carried out online due to COVID-19. In this case, the teams communicated through a private teleconference session and the teacher was available in another session to attend the students' questions. In addition, the delivery period was extended until the next day. Under these different conditions, the dynamism of the students was much lower, and some procrastination was observed. On the positive side, the extended deadline led to higher quality responses.

3.4. DE Fourth Phase: 'A Posteriori' Analysis

In this phase we analyze whether the SRP helped to solve the didactic problems detected in the preliminary DE phase.

In the first place, we conclude the SRP was successful in solving the lack of motivation of students for the ICT classes. In the final survey, the great majority of students (90.7% in 2019/20 course and 85.7% in 2020/21) agreed that SRP is more motivating than traditional classes. A large percentage (62.5% in 2019/20, 88.1% in 2020/21) found that the SRP methodology is more attractive than masterclasses for learning the theoretical contents of ICT. Thanks to the active-learning character of the SRPs, the students were engaged in the search for answers, as annotated by the teacher during the sessions. The students enjoyed the dynamism of the proposal and the opportunity to learn with colleagues, as they declare in the questionnaire answers:

> *"It is an interesting approach, as we learn concepts by developing activities with our classmates, and the truth is that they are very interesting"*
>
> *"It's a much more dynamic way of working on a topic and that makes it not hard to pay attention to"*
>
> *"It is an activity that brings dynamism to the subject"*
>
> "*This self-learning system is attractive"*

Additionally, the proposed questions, related to actual topics, attracted the interest of students and provided the subject with a 'sense'. The majority of students (96.9% in 2019/20, 85.7% in 2020/21) perceived that what they learned was useful. In their comments, they state:

> *"I think it is great to be (learning) about current issues"*
>
> "*You investigate topics you didn't know about*"

The second problematic issue detected in the previous course was that students were distracted by mobile phones during the masterclasses but did not use them for academic purposes. In the SRP we have addressed this problem by asking the students to use their phones to search the Internet. Due to the time constraint, students were not distracted.

Finally, the SRP helped the students to develop the soft skills associated to the course, as desired. Indeed, the SRP helped students acquiring autonomous learning strategies (competence C02). In the survey most students (90.6% in 2019/20, 78.6% in 2020/21) agreed the methodology stimulated self-learning. In the qualitative comments, the students expressed in the following terms:

> *"(The SRP) encourages self-learning, so it helps you stay with the concepts faster"*
>
> *"You learn autonomously with the support of the teacher, through Meet and e-mail*"
>
> *"It encourages autonomous thinking*"
>
> "*You look for the information yourself"*

By design, the SRP promoted the use tools and media provided by ICT technologies, such as cell phones, tablets, and computers. Moreover, in the last two courses a video-communication service was used for the online classes (T05). In addition, the SRP design fostered the search of information on the Internet (competence T03), and provided tools to learn how to perform a structured search, as discussed in detail in Section 4, RQ2. Finally,

in the questionnaires, the students emphasized the SRP had helped them to acquire other soft skills, such as "teamwork" and "organization".

The majority of students adapted well and enjoyed the SRP methodology, as evidenced by the results of the final survey (see S5). Nevertheless, a few participants (<10%) expressed negative comments, related to "unbalanced workload within the teamwork", "too much workload," and perception of "not reaching the desired depth in concepts". Further, some students commented that, depending on the topic, they found it difficult to "distinguish between relevant and superfluous information".

The pass rates in the six courses where the SRP was implemented were 92.5% (2015/16), 92.3% (2016/17), 96.3% (2017/18), 88.0% (2018/19), 100% (2019/20), and 100% (2020/21), which is 94.8% on average, slightly above the average mark (94.2%) in the previous six years taught with the traditional methodology.

4. Results and Discussion

In the following section, we provide an answer to our research questions regarding the capacity of the SRP to construct the theory of the ICP course and the use of the Q–A maps to improve Internet searches, based on the information provided by the mixed quantitative and qualitative information provided by all collected data: Q–A maps, 'outputs', the teacher class observations, and the survey. Finally, we discuss the results of our work in the context of previous research on learning through Internet searches.

4.1. RQ1. In Which Ways Could the SRP Enrich the Theoretical Learning of an ICT Course Using Internet?

In the first place, the implementation of the SRP brought an extension of the theoretical knowledge of students about ICT. The fundamentals of the subject were still imparted through the initial masterclass at the beginning of the class, but in addition, the different questions led students to deepen in some topics that were either treated very superficially (case of questions Q_{02}–Q_{04}), or not at all (Q_{01}), in the previous course. In the case of question Q_{05}, the SRP was meant to replace the theoretical class about NFC, but the inquiry approach brought about an enrichment of the topic, thanks to the many examples of use found by the students.

The analysis of the SRP answers shows that often the new knowledge was connected with real-world applications and examples. As an example, in the case of question "*Q_{01}—submarine cable*", the students found out specific, updated values about the kilometers of cable installed at present in the world, the cabling projects between the Iberian Peninsula and the Balearic Islands; in question *Q_{05}–NFC*, students learned that this technology is the base of contactless payment systems we use in our daily lives, etc.

In the second place, the SRP proved to be a useful approach to collectively gain knowledge about a subject, such as ICT, in rapid evolution. The Q_{0i} questions had to be adapted through time to follow ICT technological developments. For instance, in 2020/21 question Q_{05} was changed to focus on the recently emerging 5G mobile-phone technology. Moreover, the analysis of the 'outputs' provided for every Q_{0i} question shows the SRP answers evolved through time, following the progress of ICT technologies. For example, Table S6 summarizes the results of the inquiry triggered by the question "*Q_{01}—What are the main novelties of mobile telephony this year?*" through years 2015–2020. The SRP allowed students to be updated about the new cell phones, industry trends, new technologies and gadgets etc. In the case of "*Q_{04}—What technologies are available to ensure security on a WiFi network?*" students could follow the evolution of different security measures, such as new encryption methods. In another example, during the research of question "*Q_{05}—What is NFC technology?*" students learned about the rapid expansion of NFC technology, which was only used in a few applications in the beginning and is nowadays embedded in all credits cards. In the final survey, the majority of students declared the SRPs had been a useful methodology for learning a rapidly evolving subject such as ICT (93.8% in 2019/20 and 90.5% in 2020/21).

In the third place, the SRP prompted students to reflect about the impact of ICT technologies on society and their own lives. As an example, during the study of *"Q_{02}—What are the environmental and social costs of the mobile phone market?"* students found out about minerals such as COLTAN, whose extraction implies complex social and political problems. In addition, students increased their awareness about addiction to the use of technologies, a matter of critical importance for youth nowadays. Through the study of the question *"Q_{02}—What is a 'firewall'?"* students were prompted to consider the importance of securing access to personal information; question Q_{03}(WIFI) led students to reflect about the importance of passwords, etc. The teacher expressed that the students' critical spirit and sense of ethical responsibility was developed "through the process of making themselves questions".

To evaluate to what extent the students assimilated the topics studied through the SRP, we analyzed the results of exams. Each exam included 20 multiple-choice questions about topics taught in masterclasses, and a last, open question coinciding with one of the Q_{0i}'s. The degree of difficulty of the SRP-linked question and the rest of questions in the exam was comparable. As an example, the batch of questions posed in course 2020/21 is presented in S7. The rubric of correction of the SRP-linked open question required the same level of detail and depth as the non-SRP test questions. Qualitatively speaking, the exam answers show that students acquired a good general knowledge about the topics covered by the Q_{0i}'s, although sometimes they had difficulties remembering specific data, such as protocol names, data rates, frequencies or dates. We compared the average marks obtained in the part of the exam associated to theory learned through SRP and classical sessions. The mark in the SRP part of the exam was always higher. For example, the average score in the SRP-linked part of the exam was 9.2 (7.6) out of 10 in 2015/16 (2018/19), which is 43% (58%) higher than in the rest of the exam. In the last course, 2020/21, the average mark in the SRP-question decreased, due to the fact that this year the teacher required students to include specific data in the exam-answers, but the mark was still 5% larger than in the rest of the exam.

4.2. RQ2. Would the SRP and Q–A Maps Help Students Improve Their Skills in the Search of Information on the Internet?

The SRP produced an enrichment of the *media-milieu*: different from the traditional organization, where theoretical information was mainly provided by the teacher and textbooks, during the SRP students learned through collaborative Web inquiry. The analysis of the sources of information, reported in the 'outputs', reveals that students used a variety of web sources, mainly in Spanish language, including generalist webs (e.g., 'wikipedia'), digital journals (e.g., 'el pais', 'la vanguardia', 'el economista') and ICT-specific pages. It is to be emphasized that the teacher imposed no restriction on the types of sources. Each group consulted an average of five web pages per Q_{0i}.

In the last two SRP editions, the 'output' was prepared and delivered digitally. The students included the list of web-page links consulted in the report, making it easier for the teacher to monitor the inquiry work. Moreover, the average number of sources increased slightly with online working. For example, in question *Q_{05} (NFC)* the number of sources increased from an average of four links in 2018/19 (presential) to 6.2 in 2019/20-2020/21 (online). We associate this increase to the extended time granted to deliver the 'outputs'. In addition, the majority of links were from specialized web-pages, and only 10% of the answers came from 'Wikipedia'.

Notably, the use of Q–A maps helped students to structure the inquiry activity performed using Internet and organize their findings. Indeed, the results of the survey evidence students found Q–A maps very useful. The majority agreed that 'Q–A maps had helped them to structure the search for information on the Internet' (81.3% in 2019/20 and 83.3% in 2020/21). Moreover, most students considered that Q–A maps helped them to find the fundamental concepts of the generating question (87.6% in 2019/20 and 80.9% in 2020/21).

In the qualitative answers of the survey, students expressed in terms such as:

"(The SRP) *encourages your creativity in the search for information*"

They also emphasized that Q-A maps were a useful tool for organizing the information found on the Internet:

"*It is a very good method to synthesize the concepts risen*"

"*It facilitates the drawing of conclusions*"

The analysis of the five SRP 'outputs' presented by each group sheds light on how the use of the Q–A maps helped students to improve web search. In the majority of cases, a positive evolution with time is observed, which can be described in the following terms:

A large increase in the quality of the Q–A maps is observed from the first Q_{01} to the second Q_{02}, whereas improvements in the successive Q_{0i} are more gradual. Qualitatively, the number of sub-questions tackled by each group increased a 28% from Q_{01} to Q_{02}. The number of questions included in the Q–A map of Q_{02} was 6.8 in average. The marks increased by 20% from the first to the second 'output'.

Qualitatively, significant differences can be observed by comparing the first and subsequent Q–A maps. At first, some groups of students did not clearly distinguish between "questions" and "answers". Some Q–A maps included very general or few questions, and answers were presented in the form of single, long paragraphs. In a few cases, the answers were distributed over the 'output' sheet instead of successively listed (Figure S3.1a).

Generally, these initial problems were solved from the second Q_{02} onwards. The delivered 'output' contained an ordered list of numbered questions and sub-questions of different hierarchy (1, 1.1, 1.1.1, etc.), and their corresponding answers (Figure S3.1b). In the majority of cases, questions and answers were presented in alternating sequence (Figure S3.2a), although in a few cases (5%), all the questions were written at the beginning of the report and answers were grouped at the end (Figure S3.2b). The handwritten 'outputs' presented some typical characteristics, as illustrated by the Q–A maps instances shown in Figure S3.3. For clarity, some groups used a different color code for questions and answers (Figure S3.3a). Often, the answers were short and contained lists of items ordered with numbers and bullets (Figure S3.3b). Occasionally, schematic drawings were included (Figure S3.3c).

The initial battery of proposed questions was usually proposed by the students within the group. The comparison of the Q–A maps developed by the different groups, triggered by the same question (Q_{0i}) reveals many trees coincide in the general 'skeleton' (first-order questions), but are more or less elaborated depending on the capacity and interest of the group to perform the inquiry. As an example, Figure S3.4a,b compares the Q–A maps developed by two different groups of the same course, revolving about the question "Q_{0i}—*What are the social and environmental costs of mobile phones?*"

We would like to mention that Google introduced the "People Also Ask" (PAA) feature at the beginning of 2018 [64] and at the end of that year it was shown in the 80% of the web queries. The operation of this new feature is that when we are searching, Google proposes a list of related questions with a short answer. This feature is very helpful at the beginning of the searching process, because it allows the searcher to obtain a general overview in a few minutes, and then pass to deeper web pages. However, we analyzed the Q–A maps before and after the introduction of PAA, and we did not appreciate significant differences in the developed schemes.

The introduction in 2018/19 of a rubric that valued the inclusion of higher-order sub-questions (see S4) had a positive impact on the structure of the produced Q–A maps. Some of the arborescent schemes of questions presented in the first editions were quite "horizontal," i.e., they consisted of an enumeration of first-order level questions (Figure S3.1a). The inclusion of the rubric led students to deepen in the inquiry, and find correlations between questions, which generally resulted in richer, more elaborated Q–A maps, as illustrated in the examples shown in Figure S3.5a,b).

The imposed length limit of two-pages per 'output' obliged students to select only the most relevant information and condense answers. Students could not merely "copy-paste" the information found in the web pages, but were forced to read, select the information and include only relevant answers. The analysis of the reports shows that answers were short (2–5 lines), to the point, and sometimes presented as a bulleted list. It must be noted that in the last two SRP editions (2019/20 and 2020/21), carried Online, answers tended to be longer (see, e.g., Figure 3); the 'outputs' extended to 2–4 pages, but "copy-pasting" was usually not observed.

The list of questions and answers written down in the 'output' was corrected by the teacher, who indicated in the feedback the missing relevant questions in the search. Thus, the corrected Q–A map was the tool to institutionalize the knowledge in the ICP-SRP. The information collected in this document was considered as correct, and students used it to prepare the exam.

In the future, other options may be considered to institutionalize the common knowledge, such as i) to *"do a joint talk after every SRP*", as suggested by one of the students in the survey, or ii) to gather in a final, common 'output' of the information found by the whole community of study.

4.3. Discussion and Further Work

Learning using the Internet is a crucial factors for academic success in HE [14,15]. Prior research has shown that each student's Internet-based learning includes diverse requirements with regard to planning the search, collecting, comparing, evaluating, selecting, and applying information in a critical manner [19,65]. In the vast majority of reported studies, carried on in very different academic disciplines, untrained participants demonstrated rather rudimentary search strategies and showed systematic deficits in their search behavior [30,39].

One of the highlighted problems was the lack of a research plan; students showed incapacity to articulate the specific research goals and plunged into database searching without any sort of strategic approach. In our work we have shown the Q–A maps used during the SRPs were a valuable tool for planning the Internet search. The conceptual maps helped students to make questions explicit, think about the correlation between questions, and organize the information they found in databases.

Another problematic behavior mentioned in previous studies was the students' tendency to change topic after rather superficial research [20]. Although this search behavior was also observed in our students at the beginning, the introduction of a rubric giving importance to Q–A map hierarchy prompted students to conduct deeper research.

It is noted that the research methodology used by the majority of previous studies on Internet strategies so far was based on the self-reports of students and, in some cases, on direct observation and recording techniques used to capture and analyze students' search strategies [20]. In our work, we have shown that Q–A maps represent a different, powerful methodological tool. They offer the researcher the possibility of tracking the results of the Internet search process, to monitor the evolution of the Q–A maps as search skills are developed, and to investigate the structure of the Q–A structure as a function of different factors, such as the initial question, or the collective performing the search. The advantages of Q–A maps for monitoring inquiry had been signaled in previous works reporting project-based-like SRP implementations [48–50]; however, this is the first time this methodological tool is employed to investigate Internet search strategies and the development of the associated skills.

A limitation of the actual 1 h-SRP design was the relatively short time the students had to evaluate the quality of the sources. The teacher's a posteriori inspection of the utilized websites proved no unaccredited sources were used to answer the questions, as sometimes reported in other studies [37,66], but certainly students had not the time to explore search engines other than Google, or study highly qualified articles. The present SRP design was

a 'compromise solution', stemming from the DE design, aiming to increase the students' motivation for ICP theory while developing Internet research planning skills.

Finally, previous works reported the assessed level of search skills seemed to increase over the course of studies, and students seemed to be able to transfer their search skills across search environments and contexts [32,35]. In our work, students developed search strategies through time, as shown by the evolution of the Q–A maps. In the future, it would be interesting to study whether the search skills developed during the ICT-SRP course transfer to other courses and higher levels of study.

5. Conclusions

SRPs are demonstrating to be interesting inquiry-based formats for teaching a variety of subjects in different areas. The associated DE methodology allows the design of specific SRPs oriented to reach particular learning goals in every context. The SRP designed and implemented in the ICP course in Engineering was successful at overcoming the didactic problems identified in the previous organization. Indeed, the introduction of short SRPs that required collaborative searching of information on the Internet about ICP hot topics was successful in increasing the students' motivation during the theoretical classes. The SRP promoted the use of ICT technologies, which were used in a didactic context, instead of being elements of distraction. Moreover, the SRP brought along the development of other important transversal competences, such as autonomous learning and Internet search skills.

The analysis of the delivered Q–A maps and 'outputs' has been very useful for monitoring the students' progress and investigating the potential of the SRP methodology to improve ICT learning and Internet search skills.

Our results show the SRP is an enriching tool for learning the theoretical contents of an ICT course. The *media-milieu* is expanded thanks to the use of Internet sources, and the knowledge about ICP is extended in the SRP compared to the traditional course. Students are not mere receptacles of information, but, on the contrary, they participate actively in the construction of the subject. The SRP helps keeping the contents up-to-date, something essential in ICT. In addition, the 'questioning about the world' method associated to SRP epistemological approach leads students to reflect about the impact of ICT technologies in their lives and society.

On the other hand, the use of Q–A maps helps students to structure the inquiry performed using the Internet and organize their findings. The arborescent schemes of questions and answers of different hierarchies are useful to deepen in the search, and to show the interconnection between topics. A positive evolution in the quality of the delivered 'outputs' was observed through the course, demonstrating that SRP is a useful methodology to improve the students' competence in searching and selecting information from the Internet.

To summarize, the SRP methodology based on web-based inquiry emerges as a very interesting format to learn subjects in rapid evolution, such as ICT, and develop Internet-search skills.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/educsci11120772/s1, S1. List of Competences and Learning outcomes, S2. A priori Q–A maps, S3. Examples of 'outputs' structured as Q–A maps, S4. Rubric for assessment of Q–A maps, S5. Results of Questionnaire: S5.1 Quantitative results, S5.2 Qualitative results, S6. Time evolution of questions and answers, S7. Examples of ICT exam questions.

Author Contributions: Conceptualization, E.B.; methodology, E.B.; formal analysis, E.B., investigation, E.B., A.M.; resources, A.M.; writing—original draft preparation, visualization, E.B.; supervision, E.B.; project administration, E.B.; funding acquisition, A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval was not necessary for this study, because every teaching and research activity at EUSS is guided by the Salesian values of the institution, and the study did not involve risks of any type for students.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Owing to length restrictions, the data presented in this study is only partially available in the article and Supplementary Material. Further data is available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Price, A.; Rimington, R.; Chew, M.-T.; Demidenko, S. Project based learning in robotics and electronics in undergraduate engineering program setting. *Fifth IEEE Int. Symp. Electron. Des. Test Appl.* **2010**, 188–193.
2. Altbach, P.G.; Reisberg, L.; Rumbley, L. Trends in global higher education: Tracking an academic revolution. In Proceedings of the Report for the UNESCO 2009 World Conference on Higher Education, Paris, France, 5–8 July 2009; pp. 113–121.
3. Shuell, T.J. Learning theories and educational paradigms. In *International Encyclopedia of the Social and Behavioural Sciences*; Baltes, P.B., Ed.; Elsevier: Amsterdam, The Netherlands, 2001; pp. 8613–8620.
4. Hake, R.H. Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics course. *Am. J. Phys.* **1998**, *66*, 64–74. [CrossRef]
5. Hughes, P.W.; Ellefson, M.R. Inquiry-based training improves teaching effectiveness of biology teaching assistants. *PLoS ONE* **2013**, *8*, e78540.
6. Lee, Y.; Capraro, R.M.; Bicer, A. Affective Mathematics Engagement: A Comparison of STEM PBL Versus Non-STEM PBL Instruction. *Can. J. Sci. Mathematics Technol. Educ.* **2019**, *19*, 270–289. [CrossRef]
7. Bellomonte , L.; Persano Adorno, D. Active learning in a real-world bioengineering problem: A pilot-study on ophthalmologic data processing. *Comput. Appl. Eng. Educ.* **2019**, *27*, 485–499. [CrossRef]
8. Auerbach, J.E.; Concordel, A.; Kornatowski, P.M.; Floreano, D. Inquiry-Based Learning with RoboGen: An Open-Source Software and Hardware Platform for Robotics and Artificial Intelligence. *IEEE Trans. Learn. Technol.* **2019**, *12*, 356–369. [CrossRef]
9. Kaewunruen, S. Enhancing Railway Engineering Student Engagement Using Interactive Technology Embedded with Infotainmen. *Educ. Sci.* **2019**, *9*, 136. [CrossRef]
10. Guthrie, R.; Carlin, A. Waking the Dead: Using interactive technology to engage passive listeners in the classroom. In Proceedings of the 10th Americas Conference on Information Systems, New York, NY, USA, 6–8 August 2004; pp. 2952–2959.
11. De Jongh, T. Moving towards engaged learning in STEM domains; there is no simple answer, but clearly a road ahead. *J. Comput. Aided Learn.* **2019**, *35*, 153–167. [CrossRef]
12. Altimira, M.; Prahl-Wittberg, L. Teaching Research Methodologies. In Proceedings of the 10th International Technology, Education and Development Conference, Valencia, Spain, 7–9 March 2016; pp. 3019–3027.
13. Mayer, R.E. Should there be a three-strikes rule against pure discovery learning? *Am. Psychol.* **2004**, *59*, 14–19. [CrossRef] [PubMed]
14. Muralidharan, L.; Gaur, S.; Menon, V. A Study on Internet Use by Students and Their Academic Achievements in the Present Education System. *Int. J. Innov. Res. Adv. Stud.* **2018**, *5*, 175–178.
15. Torres, J.; Duart, J.; Gómez-Alvarado, H.F.; Marín-Gutiérrez, I.; Faggioni, V.S. Internet Use and Academic Success in University Students. *Comunicar* **2016**, *24*, 61–70. [CrossRef]
16. Weber, H.; Becker, D.; Hilmert, S. Information Seeking Behaviour and Academic Success in HE: Which Search Strategies Matter for Grade Differences Among University Students and How Does this Relevance Differ by Field of Study? *High. Educ. Int. J. High. Educ. Res.* **2018**, *77*, 657–678.
17. Downes, P. Power searching. *Br. Dent. J.* **2007**, *202*, 657–667. [CrossRef] [PubMed]
18. Mavridis, A.; Tzimkas, L.; Ztoupas, D. Do we teach our students how to search over the Internet? A paradox of the Greek educational system. In Proceedings of the 10th Annual International Conference of Education, Research and Innovation (ICERI), Seville, Spain, 16–18 November 2017; pp. 7066–7069.
19. Goldman, S.R.; Braasch, J.L.; Wiley, J.; Graesser, A.C.; Brodowinska, K. Comprehending and Learning from Internet Sources: Processing Patterns of Better and Poorer Learners. *Read. Res. Q* **2012**, *47*, 356–381.
20. Zlatkin-Troitschanskaia, O.; Hartig, J.; Goldhammer, F.; Krstev, J. Students' online information use and learning progress in higher education–A critical literature review. *Stud. High. Educ.* **2021**, *46*, 1996–2021. [CrossRef]
21. Bloom, B.; Deyrup, M.M. The SHU Research Logs: Student Online Search Behaviors Trans-scripted. *J. Acad. Librariansh.* **2015**, *41*, 593–601. [CrossRef]
22. Nagel, M.T.; Schäfer, S.; Zlatkin-Troitschanskaia, O.; Schemer, C.; Maurer, M.; Molerov, D.; Schmidt, S.; Brückner, S. How Do University Students' Web Search Behavior, Website Characteristics, and the Interaction of Both Influence Students' Critical Online Reasoning? *Front. Educ.* **2020**, *5*. [CrossRef]

23. Powers, E.M. How Students Access, Filter and Evaluate Digital News: Choices That Shape What They Consume and the Implications for News Literacy Education. *J. Lit. Technol.* **2019**, *20*, 2–44.
24. Raido, V.E. Investigating the Web Search Behaviors of Translation Students: An Exploratory and Multiple-Case Study. Ph.D. Thesis, Universitat Ramon Llull, Barcelona, Spain, September 2013.
25. Rosman, T.; Mayer, A.-K.; Krampen, G. Combining Self-Assessments and Achievement Tests in Information Literacy Assessment: Empirical Results and Recommendations for Practice. *Assess. Eval. High. Educ.* **2015**, *40*, 740–754. [CrossRef]
26. Salehi, S.; Du, J.T.; Ashman, H. Use of Web Search Engines and Personalization in Information Searching for Educational Purposes. *Inf. Res. An Int. Electron. J.* **2018**, *23*, 7882018.
27. Sendurur, E. Students as Information Consumers: A Focus on Online Decision Making Process. *Educ. Inf. Technol.* **2018**, *23*, 3007–30272018. [CrossRef]
28. Togia, A.; Korobili, S. Information Seeking Behavior of LIS Students: The Case of Greece. In Proceedings of the BOBCATSSS 2014 Proceedings, Barcelona, Spain, 29–31 January 2014; pp. 245–252.
29. Tsai, M.-J.; Liang, J.-C.; Hou, H.-T.; Tsai, C.-C. University Students' Online Information Searching Strategies in Different Search Contexts. *Australas. J. Educ. Test.* **2012**, *28*. [CrossRef]
30. Tylor, J. An Examination of How Student Journalists Seek Information and Evaluate Online Sources During the Newsgathering Process. *New Media Soc.* **2015**, *17*, 1277–1298. [CrossRef]
31. Weber, H.; Hillmert, S.; Rott, K.J. Can Digital Information Literacy Among Undergraduates Be Improved? Evidence from an Experimental Study. *Teach. High. Educ.* **2018**, *23*, 909–926. [CrossRef]
32. Dahlen, S.P.; Haeger, H.; Hanson, K.; Montellano, M. Almost in the wild: Student Search Behaviors when Librarians Aren't Looking. *J. Acad. Librariansh.* **2020**, *46*, 102096. [CrossRef]
33. Furi, I.; Balog, K. P Information Seeking Behaviour in the Digital Environment: Information Science vs. Non-Information Science Students. *Knjižnica* **2016**, *60*, 61–82.
34. Georgas, H. Google vs. the Library (Part II): Student Search Patterns and Behaviors when Using Google and a Federated Search Tool. *Portal Libr. Acad.* **2014**, *14*, 503–532. [CrossRef]
35. Hahnel, C.; Goldhammer, F.; Kröhne, U.; Naumann, J. The Role of Reading Skills in the Evaluation of Online Information Gathered from Search Engine Environments. *Comput. Human Behav.* **2018**, *78*, 223–234. [CrossRef]
36. Holman, L. Millennial Students' Mental Models of Search: Implications for Academic Librarians and Database Developers. *J. Acad. Librariansh.* **2011**, *37*, 19–27. [CrossRef]
37. Judd, T.; Kennedy, G. Expediency-Based Practice? Medical Students' Reliance on Google and Wikipedia for Biomedical Inquiries. *Br. J. Educ. Technol.* **2011**, *42*, 351–360. [CrossRef]
38. Lee, J.Y.; Paik, W.; Joo, S. Information Resource Selection of Undergraduate Students in Academic Search Tasks. *Inf. Res. An Int. Electron. J.* **2012**, *17*, 511.
39. Leeder, C.; Shah, C. Practicing Critical Evaluation of Online Sources Improves Student Search Behavior. *J. Acad. Librariansh.* **2016**, *42*, 459–468. [CrossRef]
40. Barquero, B.; Bosch, M.; Gascon, J. Using Research and Study Courses for Teaching Mathematical Modelling at University Level. In Proceedings of the 5th Congress of the European Society for Research in Mathematics Education, Larnaca, Cyprus, 22–26 February 2007; pp. 2050–2059.
41. Barquero, B.; Bosch, M.; Romo, A. An online course for inservice mathematics teachers at secondary level about mathematical modeling. In Proceedings of the 13th International Conference in Mathematics Education, Hamburg, Germany, 24–31 July 2016.
42. Fonseca, C.; Gascón, J.; Lucas, C. Desarrollo de un modelo epistemologico de referencia en torno a la mode.lizacion functional. *Revista Latinoamericana de Investigación en Matemática Educativa* **2014**, *17*, 289–318. [CrossRef]
43. Kidron, I.; Artigue, M.; Bosch, M.; Dreyfus, T.; Haspekian, M. Context, milieu, and media-milieus dialectic: A case study on networking of AiX, TDS and ATD. In *Networking of Theories as a Research Practice in Mathematics Education*; Bikner Ahsbahs, A., Prediger, S., Eds.; Springer International Publishing: New York, NY, USA, 2014; pp. 153–177.
44. Winsløw, C.; Matheron, Y.; Mercier, A. Study and research courses as an epistemological model for didactics. *Educ. Stud. Math.* **2013**, *83*, 267–284. [CrossRef]
45. Bartolomé, E.; Florensa, I.; Bosch, M. Teaching Strength of Materials through Study and Research Paths: Invariants and Differences. *Int. J. Eng. Educ.* **2021**, *37*, 446–460.
46. Florensa, I.; García, F.J.; Sala, G. Condiciones para la enseñanza de la modelización matemática: Estudios de caso en distintos niveles educativos. *Avances de Investigación en Educación Matemática* **2020**, *17*, 21–37. [CrossRef]
47. Florensa, G.; Barquero, B.; Bosch, M.; Gascón, J. Study and research paths at university level managing, analysing and institutionalizing knowledge. In Proceedings of the 11th Congress of the European Society for Research in Mathematics Education, Utrecht, The Netherlands, 6–10 February 2019; p. hal-02422617.
48. Bartolomé, E.; Florensa, I.; Bosch, M.; Gascón, J. A 'study and research path' enriching the learning of mechanical engineering. *Eur. J. Eng. Educ.* **2019**, *44*, 330–346. [CrossRef]
49. Florensa, I.; Bosch, M.; Gascón, J. Question-answer maps as an epistemological tool in teacher education. *J. Math. Teach. Educ.* **2020**, *24*, 203–225. [CrossRef]
50. Bartolomé, E.; Ruete, R. 'Study and Research Path' multi-approach learning of Theory of Machines and Mechanisms. *Eur. J. Eng. Educ.* **2021**, *45*, 985–1001.

51. Bartolomé, E.; Benítez, P. Failure mode and effect analysis (FMEA) to improve collaborative project-based learning: Case study of a Study and Research Path in mechanical engineering. *Int. J. Mech. Eng. Educ.* **2021**, 0306419021999046. [CrossRef]
52. Artigue, M. Didactic engineering in mathematics education. In *Encyclopedia of Mathematics Education*; Lerman, S., Ed.; Springer: Dordrecht, The Netherlands, 2014; pp. 159–162.
53. Gascón, J. The three fundamental problems of a didactic problem: The case of analytical algebra. *Revista Latinoamericana de Investigación en Matemática Educativa* **2011**, *14*, 203–231.
54. Deming, W.E. *Elementary Principles of the Statistical Control of Quality*; JUSE: Tokyo, Japan, 1950; Available online: https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1269107 (accessed on 22 October 2021).
55. Amer, M.A.; Bernadàs, S.; Moreno, A. Proyecto integrado: Una alternativa metodológica para las asignaturas de tipo teórico-práctico [Integrated project: A methodological alternative to courses of theoretical-practical type]. In Proceedings of the 20th Congress on Educative Innovation in Technical Education, Gran Canaria, Spain, 18–22 July 2012.
56. Barquero, B.; Bosch, M.; Gascón, J. The ecological dimension in teaching of mathematical modelling at university. *Recherches en didactique des mathématiques* **2013**, *33*, 307–338.
57. Bachelor Computer Science-and Engineering at TU Eindhoven. 2021. Available online: https://www.tue.nl/en/education/bachelor-college/bachelor-computer-science-and-engineering/ (accessed on 25 September 2021).
58. ICT at University of Kentucky. 2021. Available online: https://www.uky.edu/academics/bachelors/information-communication-technology-ict (accessed on 25 September 2021).
59. Chen, S.P. *Fundamentals of Information and Communication Technologies*; Cambridge Scholars Publishing: Newcastle upon Tyne, UK, 2020.
60. Stallings, W. *Data and Computer Communications*, 10th ed.; Pearson: New York, NY, USA, 2014.
61. Betjlich, R. *El Tao de la Monitorización de Seguridad en Redes: Más allá de la Detección de Intrusions*; Pearson Educación: Madrid, España, 2005.
62. Industrial Technical Engineering at ETSEIB. 2021. Available online: https://www.upc.edu/es/grados/ingenieria-en-tecnologias-industriales-barcelona-etseib (accessed on 3 September 2021).
63. Engineering at Tecnologico de Monterey. 2021. Available online: https://tec.mx/es/areas/ingenieria-y-ciencias (accessed on 3 September 2021).
64. Johnson, R. The explosion of paa answering questions is the new way to dominate-search. 2019. Available online: https://searchengineland.com/the-explosion-of-paa-answering-questions-is-the-new-way-to-dominate-search-310409 (accessed on 25 September 2021).
65. Pifarré, M.; Jarodzka, H.M.; Brand-Gruwel, S.; Argelagós, E. Unpacking Cognitive Skills Engaged in Web-Search: How Can Log F Miles, Eye Movements, and Cued-Retrospective Reports Help? An In-Depth Qualitative Case Study International Journal of Innovation and Learning. *Int. J. Innov. Learn.* **2018**, *24*, 152–175. [CrossRef]
66. Kingsley, T.L. *Integrating New Literacies Instruction to Support Online Reading Comprehension: An Examination of Online Literacy Performance in 5th Grade Classrooms*; Ball State University: Muncie, IN, USA, 2011.