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"That means nothing to me as a normal person who doesn't know about patents": Usability testing of Google Patents and Patent Public Search with undergraduate engineering students

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"That means nothing to me as a normal person who doesn't know about patents": Usability testing of Google Patents and Patent Public Search with undergraduate engineering students

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Abstract

Patent searching is an important research tool for undergraduate engineering students, yet it requires special topic knowledge to conduct successfully. Patent database websites have the ability to alleviate or add to the complexity of patent searching, depending on their usability. Prompted by the launch of the US Patent and Trademark Office's Patent Public Search (PPS) website in early 2022, the authors investigated the usability of PPS and Google Patents. The study's objective was to gain insights into the ways in which the websites of commonly-used patent databases support undergraduate students' patent searching activities. The study examined students' performance of typical tasks such as constructing search queries, filtering results, evaluating results, and interpreting classification and citation data. Data was collected via moderated in-person usability testing, following a think-aloud protocol. Usability issues were identified

in both websites, though participants unanimously preferred Google Patents due to their familiarity with other Google products and the "cleaner" design of the search interface. Based on the study's results, the authors offer recommendations for patent literacy instruction for undergraduate students.

Keywords

Introduction

Patent searching is an important learning experience and professional competency for students in many fields of engineering, as well as disciplines such as chemistry, computer science, life sciences, and agriculture. The information in patents, and the development of patent searching skills, can enrich their academic study, experiential learning, and professional success. Patent information offers students a technically detailed picture of how technologies have improved over time, the current state of development, and the current commercial opportunities for a new device. However, patent searching is complex and can be challenging even for experienced researchers. Patent language is highly technical and legal. Also, patent database websites may have unfamiliar layouts, structures, and functionalities. When assigned patent searching tasks, undergraduates may have limited previous knowledge or instruction in this area. They may consider themselves - like one of the students who participated in this study - "a normal person who doesn't know about patents".

Patent database websites have the ability to alleviate or add to the complexity of patent searching, depending on their usability. According to usability consultant Krug (2005), the first law of usability is "Don't make me think!" (11). A website with good usability imposes the least amount of cognitive load possible on the user who is trying to understand it; this means the website should be self-evident (no thought is required) or self-explanatory (minimal thought is required), such that anyone can understand how to use the website without prior experience or knowledge.

The International Standards Organization (ISO) provides a more formal definition of usability: "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (2018). Other aspects of usability are learnability, memorability, and minimal error rate (Nielsen, 2012, January 3). In sum, usability is a framework for evaluating the ease of use of a product, often applied to the assessment of a website's user experience (UX).

At the University of Vermont (UVM), library patent instruction and research assistance has in recent years prioritized two patent database websites: Google Patents and the US Patent and Trademark Office (USPTO)'s patent database websites. These databases have differing characteristics in terms of content, layout, search features, and analysis features. As a result, these tools support undergraduate patent searching in different ways and each provides unique value for student research.

Google launched Google Patents (shown in Fig. 1) in 2006, using "much of the same technology that powers Google Book Search, so you can scroll through pages and zoom in on text and illustrations just like you can with books" (Banks, 2006). Its homepage has a similar design to other Google interfaces, displaying a single search box on a page with a lot of white space and a very small number of links to other information or features. This is conducive to quickly running a search with one or more keywords. In terms of patent coverage, Google Patents contains "over 120 million patent publications from 100+ patent offices around the world, as well as many more technical documents and books indexed in Google Scholar and Google Books, and documents from the Prior Art Archive" (Google Help, n.d. a).

Figure 1. Screenshot of the Google Patents homepage.

In years up to 2022, the USPTO provided several patent database websites, including two for general public use: PatFT for issued patents and AppFT for patent applications. The USPTO also maintained two specialized "internal" database websites, PubEAST and PubWEST, which were public versions of the databases used by USPTO patent examiners. The UVM Libraries recommended PatFT and AppFT to undergraduates as the USPTO websites that were most appropriate for general purpose research. These websites were limited in scope to only patent documents (no other publications) and only US patent documents (no other jurisdictions). The USPTO's databases were also characterized by their advanced search features, such as the numerous fields available for field searching.

The USPTO's 2018-2022 Strategic Plan declared a commitment to "enhance customer experience programs and metrics and improvement of the customer experience for internal and external USPTO customers" (USPTO, n.d. c, p. 21). Thus, in 2022, the USPTO overhauled its public-facing web presence with the launch of Patent Public Search (PPS) (see Fig. 2). The release of PPS was intended to resolve several UX issues, especially the multiplicity of public-facing databases, the separation of patents and applications into separate databases, dated interfaces, and complicated clickpaths to patent documents and images.

PPS is designed to simplify patent searching by integrating issued patents and applications, and thus replacing both PatFT and AppFT. It also made it possible for the USPTO to retire PubEAST and PubWEST.
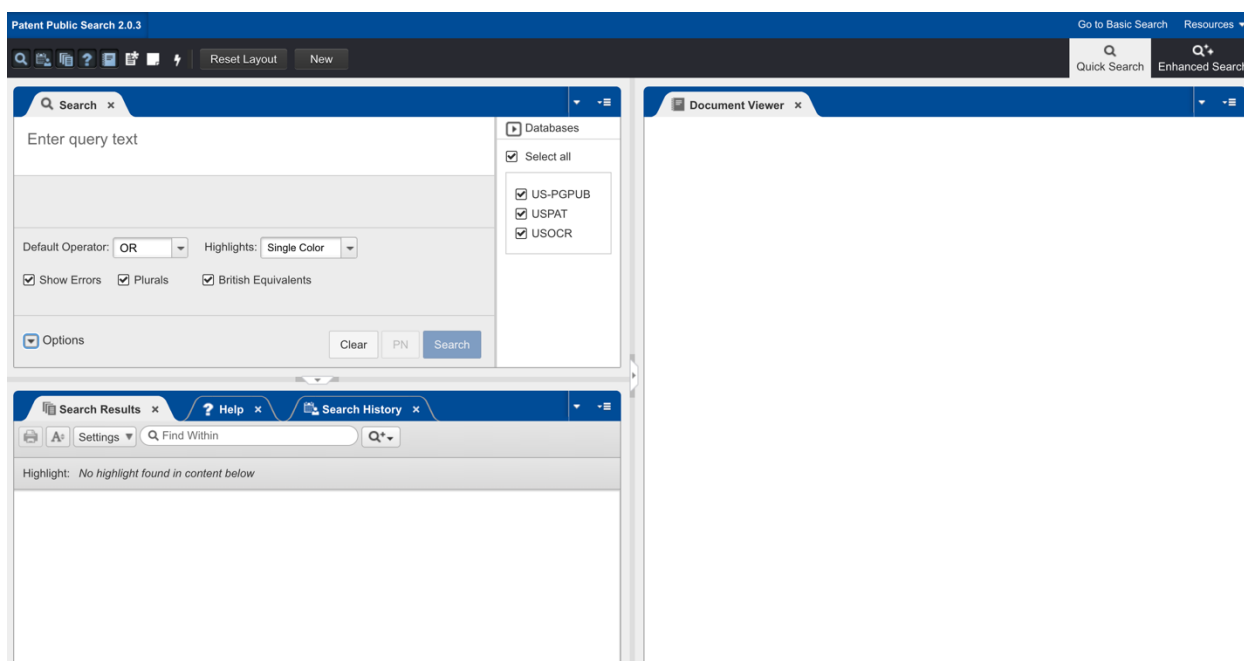

Figure 2. PPS's Advanced Search (version 2.0.3). This layout can be customized in a variety of ways to display information to match with the researcher's work style and screen size.

Figure 3 shows some more of the key differences between Google Patents and USPTO database websites (Sherriff, n.d.).

Google Patents	USPTO
All patent documents, except recent months	All patent documents, updated weekly
USPTO and 100+ other jurisdictions	USPTO patents only
Also contains non-patent literature (technical documents and books indexed in Google Scholar and Google Books)	Only patents
Simple interface designed for quick review of matches	Complex interface designed for precise searching
Searches full documents	Searches full documents 1970-present; searches classifications and patent numbers 1790-1970
Searches images with Optical Character Recognition	Searches text 1970-present (more reliable); searches with OCR 1790-1970
Default order of results is relevancy	Default order of results is reverse-chronological
Supports citation analysis across worldwide patents and other prior art	Supports citation analysis across US patents

Figure 3. Key differences between Google Patents and PPS, from the University of Vermont Libraries' patent searching guide.

The implementation of the new USPTO database website prompted us to reflect on the usability of both PPS and Google Patents. Both websites would continue to be essential for undergraduate patent learning and research due to the differences in their scope of content and search features. But how easy are these sites for students to use?

These websites make available extensive resources for learning how to use them. The footer of the Google Patents website has an "About" link that routes to an FAQ at https://support.google.com/faqs/answer/6390996 (Google Help, n.d. b), while PPS a "Help" tab in the search interface that describes several key features, as well as an FAQ at https://ppubs.uspto.gov/pubwebapp/static/pages/faq.html (USPTO, n.d. a) and a set of reference guides at https://ppubs.uspto.gov/pubwebapp/static/pages/quick-reference-guides.html (USPTO, n.d. b). These resources are no doubt useful for the patent searcher who is aware of them and inclined to consult them. But the fact that these guides are necessary underlines the complexity of these websites and heightens the

concern that their usability for the typical undergraduate student may be limited. Our hypothesis was that they do not meet Krug's standard of being self-evident or self-explanatory (2015).

This study's objective was thus to gain insights into the ways in which Google Patents and PPS support undergraduate students' typical patent searching activities. We framed our research questions as follows:

- RQ1: To what extent are students able to accomplish typical undergraduate patent searching tasks in Google Patents and PPS, given a typical amount of prior instruction?

- RQ2: How do students perceive the usability of Google Patents and Patent Public Search?

- RQ3: Do undergraduate students have a preference for Google Patents or PPS for typical patent searching activities?

The study examined students' performance of tasks such as composing search queries, filtering results, evaluating results, and evaluating individual patents. At the undergraduate level, UVM students typically work with patents as "prior art" research. In other words, they explore the intellectual property (IP) literature in order to learn about a technology's development over time leading to its current "state of the art". Students therefore mostly need to do classification searching, using Cooperative Patent Classification (CPC) subclasses, which supports searching for patents by technological area. Occasionally, a student might find it useful to do field searching by assignee to browse the patents held by a known enterprise. Precision in these searches is more beneficial than recall, because overlooking a small number of relevant patents should not be problematic.

These typical undergraduate patent searching activities (CPC searches and assignee searches) differ from the rigorous and comprehensive searching required to establish patentability, of the kind undertaken by patent agents, patent attorneys, and patent examiners. Comprehensive searching places more emphasis on recall and requires a substantial investment of time. One definition of a "comprehensive" search is the review of approximately 500 relevant grants and applications identified through keyword, classification, and citation searches (Schox, 2015) - a scope of research that is well beyond the needs and the capacity of a typical undergraduate student or student team.

This study is intended to indicate the design elements and functionalities that students find helpful and ones they find unhelpful or confusing. Analysis will inform instructional design for undergraduates who need to use patent database websites, and may also inform the work of patent educators supporting graduate students, faculty and researchers, entrepreneurs, and small businesses.

Literature Review

Patent literacy skills have substantial value for engineering students. "Students who will never apply for their own patent still need to know what patents are, how they can be used, and what types of information they contain" (Zwicky, 2019, p. 1). The information in patents reveals a variety of possible design solutions, describes the underlying technologies, and clarifies what IP is currently protected and what is truly innovative (Clarke, 2014; Nazemetz et al., 2007; Phillips & Zwicky, 2017). Phillips and Zwicky observed that mechanical engineering students found patents useful for exploring both previous responses to technological problems and the current state of the art, inspiring design ideas, verifying the feasibility of those ideas, and assessing the patentability of their proposed design solutions. Brown (2016) notes that patent literacy skills help students to understand a technology's design "journey", as well as clarifying what makes their own design innovative. Significantly, the technical detail in patents is mostly unavailable from any other type of publication - possibly as much as 80% (Asche, 2018).

The value of patent literacy skills is also indicated by their alignment with standards for undergraduate learning. Meier (2012) mapped patent literacy instruction to several of the Association of College and Research Libraries (ACRL)'s "Information Literacy Standards for Science and Engineering/Technology" (2006), including:

- 1.3.d "The information literate student … is knowledgeable of sources that are specific to the field, e.g. … patents"

- 1.4.d "The information literate student … recognizes the importance of a variety of information research areas that can be used to gain competitive advantage, track new products, improve processes, and monitor competitors and their marketing strategies. Some examples would be … patent and intellectual property research."

- 3.2.c "The information literate student … uses other methods of search term input such as structure searching and image searching, specific to the discipline or information retrieval system."

- 4.1.d "The information literate student … understands many of the ethical, legal and socio-economic issues surrounding information and information technology [including demonstrating] an understanding of intellectual property".

The ACRL's "Framework for Information Literacy for Higher Education" (2016) is also relevant. Zwicky (2019) shows how patent literacy aligns with each of the Framework's six threshold concepts, while the ACRL's "Companion Document to the Framework for Information Literacy for Higher Education: Science, Technology, Engineering, and Mathematics" (2022) explicitly notes the relevance of patent literacy skills to several concepts. Among the "Companion Document"'s provisions, we would emphasize patent literacy's significance to the following:

- Information Creation as a Process "There are different kinds of organizations that create and disseminate STEM information … These organizations may rely on different kinds of information creation processes resulting in varying products that were created for different information needs" (p. 9).

- Information Has Value: Learners "understand that intellectual property is a legal and social construct", articulate the purpose and distinguishing characteristics of … the public domain", and "use discipline and culturally specific forms of information such as patents" (pp. 11-12).

- Searching as Strategic Exploration: Learners "understand how information systems … are organized in order to access relevant information; learners use critical thinking skills to navigate curated data information systems" (p. 19).

The acquisition of patent literacy skills also aligns with the student learning outcomes of the Accreditation Board for Engineering and Technology (ABET), especially "an ability to acquire and apply new knowledge as needed, using appropriate learning strategies" (2021, p. 9).

Beyond education, patent skills are valuable professional competencies that may be needed in the workplace (Jeffryes & Lafferty, 2012, Lutz & Paretti, 2017). Jeffryes and Lafferty found that 19% of a surveyed set of engineering students in work placements needed to work with patents, but that none of those students received any instruction in patent searching in those workplaces.

Despite the value of patent literacy skills, students may have low levels of familiarity with patents and patent searching, even in the later stages of their programs. A case study at UVM showed that Biomedical, Electrical and Mechanical Engineering students entering a capstone course in their senior year - in which they would need to do a significant amount of patent searching - averaged a score of 3.0/5 or 60% (N = 104) on a pre-test assessment of their knowledge of patent concepts (Sherriff & Rand, 2022). This low level of familiarity was likely due to a lack of instruction in their first-year, sophomore, and junior level courses. Curricular mapping by the UVM College of Engineering and Mathematical Sciences, in conjunction with the Libraries and Writing Center, has shown that information literacy skills are taught in only a small number of engineering courses and without a systematic or scaffolded approach. This lack of opportunities for students to develop patent searching skills over time underlines the importance of providing patent instruction and research assistance that are efficient and immediately effective.

A small number of evaluations of patent database websites and their relative usability are available in the scholarly literature. Noruzi and Abdekhoda (2014) proposed that Google Patents's international coverage, simplified search interface, speed of processing, and prominence of patent images are advantages over other patent websites. They also identified the following aspects as shortcomings:

- scanning errors
- the absence of recently published patents
- the need for patents from jurisdictions other than the USPTO and the EPO*
- the lack of an option for citation alerts
- the lack of a "Cited by" link to subsequent patents that reference it*
- the lack of patent classification indexing and searching*
- the need for disambiguation of inventors with the same name
- the lack of field searching for language and country*
- the absence of wildcard searching*

* Google Patents has added these features since this article was published.

However, their observations on the significance of these design elements, as well as their conclusions that "Google Patents is easy to use" (p. 2) and "an ideal example of simplicity" (p. 8), appear to be based on their own experiences of using the website and not on moderated user testing. Moreover, their article presents tips on effective searching that are not otherwise well-documented by Google Patents, tacitly acknowledging that some search features and techniques are not self-evident or

intuitive. These tips include guidance on using search operators, applying the date (or date range) filter, and combining search terms in multiple fields.

Meier (2015) makes recommendations for using USPTO (PatFT) effectively such as how to use the date range correctly. Similarly, for Google Patents, the "Search Tools" and "Advanced Search" interfaces should be used for more effective searching.

Jürgens and Clarke (2018) presented what they regard as the distinctive advantages of several free, non-patent office patent websites. For Google Patents, they considered the principal advantage to be the inclusion of non-patent literature from Google Scholar and Google books, which can be searched both by keyword searching and CPC field searching. They also regarded the features listed below as Google Patents' advantages compared with other evaluated websites:

- Full-text search in multiple patent authority collections
- The option to view search results in groupings by CPC class (the Group by: Classification feature)
- "Image thumbnails in result list helps to filter faster relevant from non-relevant patents" (p. 10)

The following disadvantages were also listed:

- No search history
- No option for saving searches
- No option for downloading full documents for non-US patents*

* Full documents are now available for patents from multiple jurisdictions.

Zwicky (2019) identifies the poor usability of government patent search tools as their foremost shortcoming, and observes that this is particularly true of the USPTO's database websites. "Government databases like USPTO's PatFT and AppFT are designed to be used by patent examiners and inventors rather than researchers, and their interfaces and search features reflect this" (p. 6). Useful results are only available to researchers who follow and understand search strategies oriented towards comprehensive patentability searching. Zwicky suggests Google Patents is more usable, given its similar design to the standard Google search engine.

As noted in the Introduction, the USPTO's new PPS website is designed to simplify searching and increase the ease of navigation and interaction. Therefore, it may be an improvement on PatFT and AppFT in terms of usability. Given its very recent

implementation in early 2022, we did not find any discussions of PPS in the scholarly literature.

These expert evaluations of patent websites are helpful for understanding their design and use, but this literature review did not find any usability study based on moderated in-person testing nor any study that investigated students' experiences or perspectives. This gap in the literature contrasts with the availability of usability studies on some of Google's other search interfaces. For example, Dudek et al. surveyed postgraduate students for their opinions on a variety of search engines - specifically, opinions on aspects labeled "usability", "visuals", "accessibility", "results", "precision" and "reliability" - and found that "the most popular search engine … was Google" (2007, p. 230).

We submitted a request to Google Patents for information about any in-house usability testing but received no response. We submitted the same request to the USPTO PTRC Office, which informed us that no usability testing of PPS had been recorded. During development of PPS, the USPTO solicited feedback on a pilot portion of PPS from a small group of invited Patent and Trademark Research Center (PTRC) librarians, but the content of this feedback was not available. (T. Turner, personal communication, September 28, 2022).

Comments on usability can be found online. For example, "the number of fields you can independently search with google patents is very limited and they are thought of as missing some recent documents... But google patents is always improving - I noticed a selection criteria today - "litigation" that I had not noticed before. And they are very forgiving of misspelled search terms, just like Google searching... Although it is only U.S. patents, the USPTO site has very fine grain searching of fields... no other site had the ability to narrow down by assignee city" (White, 2021). Again, self-reported user comments like these provide interesting insights, but do not necessarily represent the experiences of undergraduate students.

Methods

Recruitment

Participants in our study were undergraduate sophomore or junior engineering students enrolled as majors in the Biomedical Engineering, Electrical Engineering, and Mechanical Engineering programs at UVM, our home institution. UVM is a medium-sized research university, currently with the Carnegie classification "R2: Doctoral Universities – High research activity". The Biomedical, Electrical, and Mechanical Engineering programs are all accredited by ABET. In the Fall 2022 semester, student

enrollment totalled approximately 11,300 undergraduate students and 2,700 graduate and other students. The gender balance was approximately 63% female-37% male. Regarding race and ethnicity, approximately 81% of students identified as White and approximately 14% as Students of Color. (UVM Office of Institutional Research and Assessment, n.d.). Race and ethnicity data in the Biomedical, Electrical, and Mechanical Engineering programs are similar, whereas the gender balances in these programs are quite different from the overall undergraduate enrollment, with majority male enrollments, especially in the Electrical and Mechanical Engineering programs. (See Table 1.)

	All undergraduate majors	Biomedical Engineering	Electrical Engineering	Mechanical Engineering
Total students	11,326	159	79	316
Female:Male ratio	63:37	48:52	16:84	17:83
% International	1%	1%	1%	1%
% Students of Color	14%	18%	23%	7%
% White	81%	70%	70%	88%

Table 1. UVM enrollment statistics describing unique undergraduate majors in Fall 2022. Statistics for race/ethnicity do not include "unknown".

The study protocol, testing instrument, and all public-facing materials were piloted by a librarian colleague and approved by the UVM Institutional Review Board. It was categorized as "research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording)", and thus exempt from further review.

Participants were sophomores or juniors in the Biomedical, Electrical, and Mechanical Engineering programs – in other words, undergraduates with some technical learning and some knowledge of design principles. Seniors were excluded because in the Fall 2023 semester, Sherriff was grading assignments in a capstone design course in which

all Biomedical, Electrical, and Mechanical Engineering seniors were enrolled; excluding seniors avoided any conflict of interest.

We recruited participants in several ways. The most effective method was visiting engineering classes to speak briefly about the study. We also promoted the study with posters, digital displays, social media, emails, and outreach to course instructors, student clubs, and association chapters.

We were conscious of the need to seek out a demographically diverse set of participants, especially given the demographic profiles of UVM's engineering programs, which skew preponderantly male and preponderantly White. Our promotion of the study therefore included outreach to campus chapters of the National Society of Black Engineers (NSBE) and the Society of Women Engineers (SWE).

As incentives and compensation, we offered students a $50 retail gift card for participating, as well as some library and engineering database vendor items such as notebooks, mugs, t-shirts, and pens. The gift cards were obtained with funding from the UVM Libraries.

Regarding the number of users for testing, we followed the spirit of Nielsen's guideline that five is optimal for qualitative data that reveals most key issues: "As you add more and more users, you learn less and less because you will keep seeing the same things again and again" (2000, para. 7). We wanted to test an equal number of participants with Google Patents first, then PPS, as with PPS first, then Google Patents, in order to mitigate the risk of anchor bias (the cognitive bias whereby a person's evaluation of an object is influenced by their prior interaction with a different object). We therefore tested with six users, being the lowest even number that met the threshold of five.

Study design

Prior to the usability testing session, participants were required to take an online tutorial, estimated to take 30-45 minutes (https://uvm.libwizard.com/f/patentux-tutorial). The tutorial introduced the basics of patent searching including topics such as CPC classifications, searching by a particular date range and tips for handling the particularities of Google Patents and PPS. The tutorial was similar to one used to provide foundational patent literacy instruction to UVM students in their capstone design class. The intent of the tutorial was to provide the participants with enough background information to be able to successfully complete the tasks presented in the subsequent usability test. Participants could take the tutorial at the time and place of their choosing, and retake it as many times as they wanted.

Each participant participated in an in-person usability testing session, scheduled to last an hour. We conducted these sessions in December 2022-January 2023 in a group study room at UVM's main Howe Library. At that time, the live version of PPS was 2.0.3.

The usability testing in this study followed Krug's advice to focus on "key task testing", meaning asking the user to do things on the website and observing how they do it and with what degree of ease; and "get it" testing, meaning evaluating whether a website's purpose and organization makes sense to the user (2005, p. 144). Our testing sessions therefore comprised a combination of objective task accomplishment and gathering subjective, qualitative feedback. Participants were asked to rate their confidence in their patent searching abilities before starting the test. They completed a set of 13 tasks related to common patent searching information gathering needs, once for each tool - Google Patents and PPS. (See Table 2; see also Appendix for the full study instrument.)

1	Using simple keywords, run a query for patents relating to snowboard bindings.
2	Narrow your results to patents with the following characteristics: awarded grants (not applications).
3	Narrow your results to patents with the following characteristics: published in 2022.
4	Narrow your results to patents with the following characteristics: published in the United States.
5	Make sure that the sorting order for results is from newest to oldest.
6	Review the patents returned by your search and identify one patent that might be relevant to the development of snowboard bindings.
7	Save information about this patent offline, in any way that would enable you to return to its online information.
8	For this patent, locate and view the patent document (not the HTML version).
9	For the same patent, locate the numbers of its citations.
10	For the same patent, locate the numbers of its "cited by" citations.
11	For the same patent, locate its CPC classifications.
12	For the first CPC classification listed, is a definition available?
13	Run a search for this CPC classification.

Table 2. Study tasks.

After each set of 13 tasks, participants were asked to rate the effectiveness, intuitiveness and efficiency of the tool they had just used, with the following definitions:

- effectiveness - did the website successfully do what you needed it to?
- intuitiveness - was it readily apparent how to use the website?

- efficiency - did the website's design help you to work quickly or did it take more time than you would have liked?

Finally, we asked which tool they preferred and why.

Sherriff administered the test while Rogers recorded participants' comments, behaviors, and interactions with the computer screen. Participants were instructed to use Nielsen's think-aloud method to communicate their thought processes while completing the tasks (2012, January 15). Both of us asked clarifying questions as appropriate.

Data analysis

We started data analysis by coding our data into a rainbow sheet – a spreadsheet that uses colored cells to visualize the frequency of issues experienced in the course of each task performed by each participant (Sharon, 2013; Carleo, 2019). In our rainbow sheet, colors were assigned by task (rather than by participant) so the frequency of task difficulty can be tracked across both tools. (See Figure 7.) With our colleague librarian, we established guidelines for what constituted success and what constituted difficulty, then we each separately coded the data. For example, any situation where a participant needed guidance to complete a task was categorized as "difficulty", even if they accomplished the task quickly and easily after receiving that guidance. We discussed instances where our analysis varied, then settled on a group consensus for the completed rainbow sheet.

Next we did an affinity mapping exercise, following methods recommended by Priestner (2021). We broke down all of the participants' qualitative data into individual notes or phrases written on sticky notes. These were color-coded as positive comments, negative comments, behaviors, and ideas. With our colleague participating in order to provide validation of our coding, we sorted the sticky notes into categories based on the tasks, then re-sorted as necessary. (See Figure 4). This categorization was beneficial for identifying patterns, common themes, and outliers.
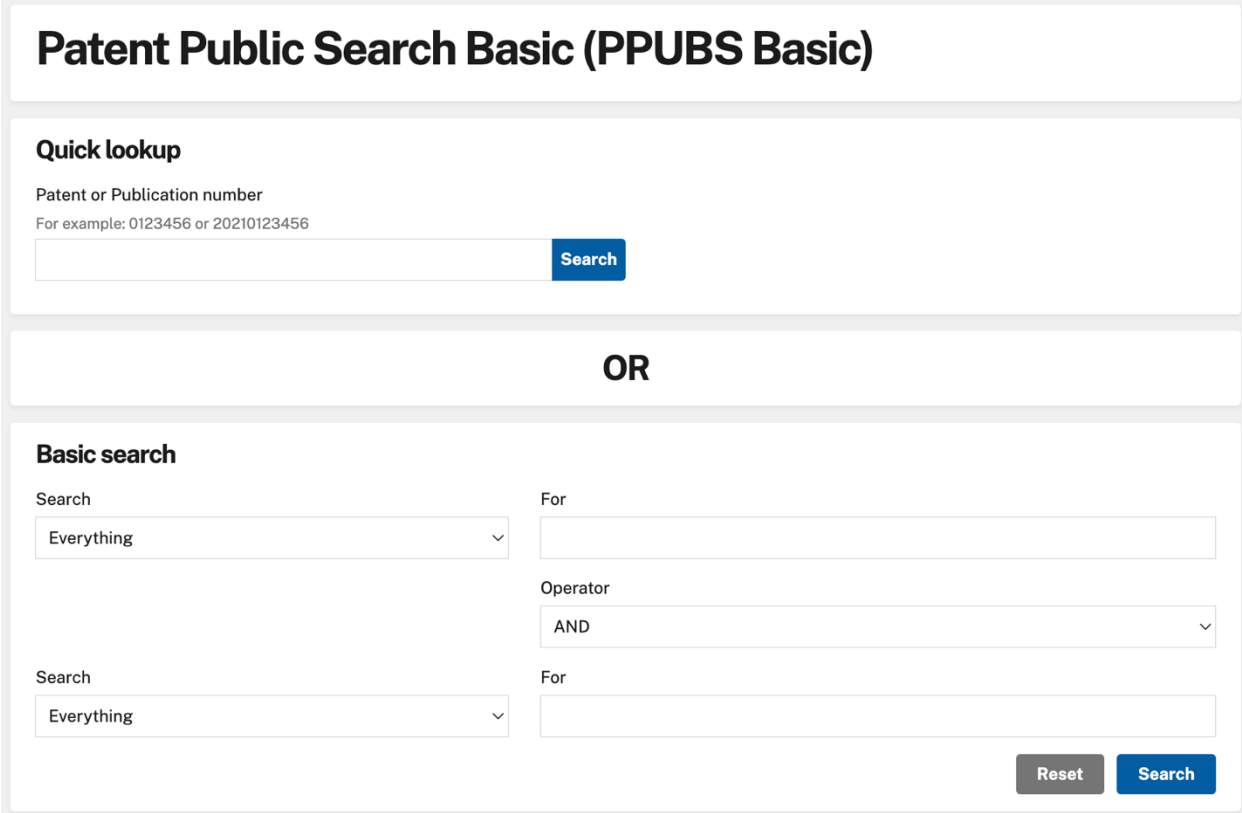
Figure 4. Affinity mapping example showing sticky notes pertaining to CPC classifications

A note on PPS Basic

During the course of our testing, the USPTO launched Patent Public Search Basic, a new basic search interface for patent research. The USPTO PTRC Office described it as an interface for "users who wanted a quicker way to conduct common searches using text query boxes and drop down menus for fields without having to use command language" (personal communication, December 16, 2022). It has a simplified search interface, with a "Quick Lookup" search box for patent numbers and another for keywords and some types of field searching. (See Figure 5). Search results also have a simplified display.

Patent Public Search Basic (PPUBS Basic)

Quick lookup

Patent or Publication number

For example: 0123456 or 20210123456

[   ] **Search**

OR

Basic search

Search

| Everything ⌄ |

For

[   ]

Operator

| AND ⌄ |

Search

| Everything ⌄ |

For

[   ]

Reset **Search**

Figure 5. Screenshot of PPS Basic.

The simplified layout and features of PPS Basic were intriguing to us, given our focus on usability. However, upon examination of this tool, we decided not to include it in this study. Our preliminary evaluation was that PPS Basic, in its current version, was overly simplified and would not support the types of patent searching activities that a student might undertake. Importantly, students need to search by Cooperative Patent Classification subclasses, which is not available in PPS Basic. We also considered it to be a major shortcoming that keyword searching was limited to a maximum of two fields and a single word or name in each, preventing phrase searching or precise combinations of multiple words. (The USPTO is working on continuing improvements to PPS, so it is possible in the future that PPS Basic could become a more useful tool for undergraduate students; USPTO PTRC Program Office, 2023).

Results

Participants are identified here as #2, #3, #4, #5, #6 and #7. (Our colleague was given the ID of #1 when she helped us prototype the test session.)

All participants completed the online tutorial before the in-person usability test. The amount of time that passed between tutorial completion and the test session varied from participant to participant. Our observations did not identify any patterns in retention of tutorial information related to the recency of the tutorial.

In the test session, our first question for the participants was, "What is your level of confidence in your ability to search for patents in a patents database website?" On a scale of 1-5, three participants chose 2, "slightly confident" and three participants chose 3, "moderately confident".

There was not a strong pattern between successful task completion and initial confidence level. Participant #4 completed the most tasks successfully with only 7/26 tasks flagged as difficult, after rating their confidence level as 2. Participant #3 rated their confidence as a 3, while they struggled with 10 of the 26 tasks (two sets of 13 tasks). Only one other participant (#5) struggled with more tasks (13/26). (See Figure 6.)
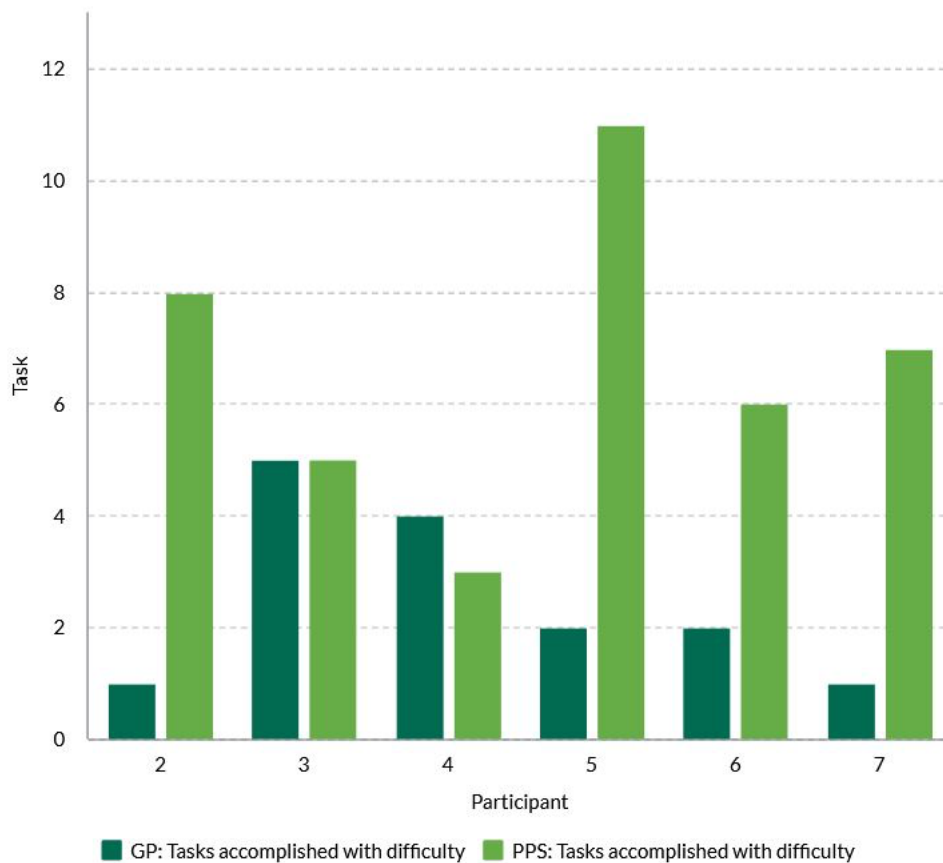
Figure 6. Each student's tasks accomplished with difficulty.

Task 1: keyword searching
The first task was "Using simple keywords, run a query for patents relating to snowboard bindings." As shown in the rainbow sheet, all participants accomplished this task easily using Google Patents. (See Figure 7.) Four participants mentioned this task when asked at the end of the set of Google Patent tasks, "Which tasks did you find easy?".

When the participants used PPS, only two participants mentioned that this task was easy - and one of them said that "searching" was one of the tasks they found easy in PPS, despite the fact that they did not complete the task correctly on the first try. PPS allows the user to select a "Default Operator" for combining keywords with one of the Boolean operators AND, OR, or NOT. (See Figure 8.) The default in Google Patents and most regular search engines is AND, but the default in PPS is OR in the tutorial, participants learned that they needed to change the operator to AND, but four of them did not remember to do this in the testing session, meaning that their results included matches for only one of the keywords "snowboard" or "bindings".

Task	Google Patents						Patent Public Search					
	#3	#4	#2	#5	#6	#7	#3	#4	#2	#5	#6	#7
1 (keyword search)							dark red		dark red	dark red		dark red
2 (filter by status)	red	red		red			red		red	red	red	red
3 (filter by year)	orange	orange	orange					dark gray	orange	orange	orange	orange
4 (filter by US)	dark gray	orange	dark gray	dark gray	orange			orange	orange	dark gray		orange
5 (sorting order)							gold			gold		
6 (review results)										yellow		
7 (save patent)										light green		light green
8 (view patent document)		green		green					green	green	green	
9 (find backwards citations)	green				green		green		green		green	green
10 (find forward citations)	dark gray	dark gray	dark gray	dark gray	dark gray		dark gray		dark gray	light blue		
11 (find CPC classes)						blue		blue	blue			
12 (find CPC definitions)	blue									blue	blue	blue
13 (search by CPC class)	purple						purple	purple	purple	purple	purple	purple

Figure 7. Rainbow chart showing tasks which students completed successfully (light gray) or completed with difficulty or with assistance (colored). The dark gray squares indicate no data was collected because a task was not asked (for example, the first participant was not asked to limit by only US patents), the answer was irrelevant (for example, in Tasks 9 and 10, some patents did not have any citations), or there was a notetaking error.

Tasks 2, 3, and 4: combining search fields
Task 2, 3, and 4 asked participants to narrow their results to patents with certain characteristics. (See Table 2.)

Task 2: searching by status
Participants found narrowing by status (grant or application) difficult with both tools. (See Figure 7.) This function is sufficiently different between Google Patents and PPS that the cause of the participants' struggles was different for each. It may not be

immediately obvious how to accomplish this task so this specialized knowledge was presented to the participants in the online tutorial.

Google Patents has a stylus icon above the search results (see Figure 8). This icon reveals a menu of "Search Fields" on the left with many options for narrowing results by adding metadata terms to the search, including "Status" with a dropdown arrow. Clicking on "Status" presents the options "Grant" and "Application" (see Figure 9). This set-up poses three barriers: users need to know to click on the stylus icon, which is not labeled and does not display a tooltip when hovered over; they need to know that "Status" is the control they are looking for; and they need to understand the wording of "grant" versus "application".
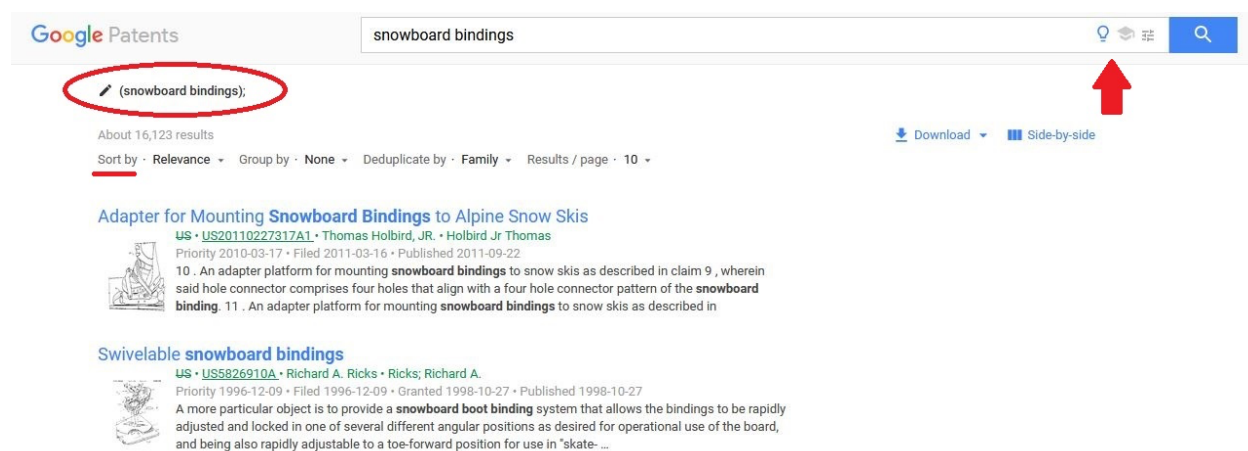
Figure 8. Screenshot of the Google Patents search results page with the stylus icon circled. The icons in the search bar appear above the arrow. The "Sort by" heading is underlined.

The participants found the stylus button to be the most confusing component of Google Patents. Four participants struggled to find and identify the stylus icon as the path to the menu they were looking for. As participants explored the screen, they looked at the icons in the search bar and the "Sort by" menu options (see Figure 8) instead of the stylus icon. Half the participants mentioned the stylus button when asked about tasks they found difficult to complete. One participant commented that "the one thing that was a little difficult [in Google Patents] is the little pencil button up top that doesn't look like it does anything but then it was where most of the things I was searching for were".

Once they had opened the menu, two participants did not remember what the word "Status" referred to. Some participants said it was "not intuitive" and "hard" to accomplish this task. One participant easily understood the status dropdown menu, and the last two participants found both the stylus button and the dropdown easily.

Figure 9. Screenshot of Google Patents showing the "Search Fields" menu expanded with the Status menu open.

To complete this task in PPS, there is a menu to the right of the search box (in the default view) labeled "Databases" (see Figure 10). There are three options:

- US-PGPUB: published US patent applications since 2001
- USPAT: full-text US patent grants since 1970; and patent grant number and classification searching for 1790-1970
- USOCR: OCR scanned US patent grants up to 1970

These acronyms are not self-explanatory, nor are they described, so a user needs to know that these database options control which patent documents will be searched, and what is included in each of the databases.
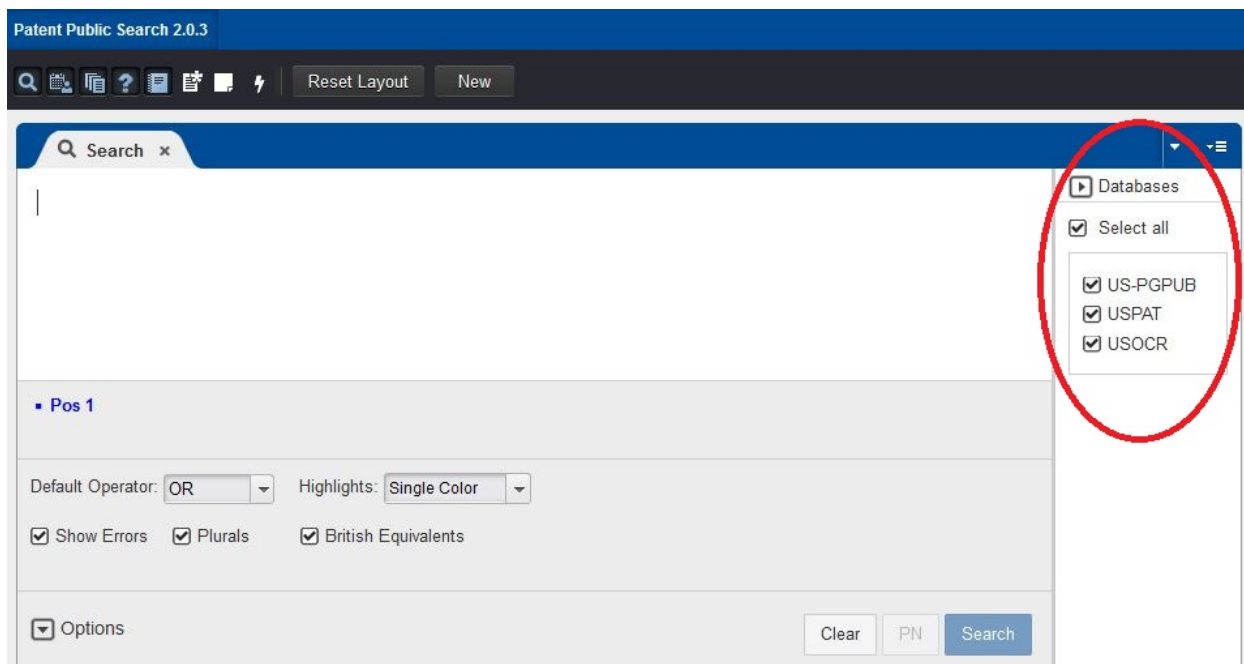
Figure 10. Partial screenshot from PPS, with "Databases" checkboxes highlighted.

Five of the six participants struggled to narrow their search by grants using PPS. In the "Search" box, there is a dropdown menu called "Options" (also visible in Figure 10). Three of the participants looked here first as they tried to complete the task. Participants also scrolled through the search results table looking for a way to limit by status. One participant characterized their search, "I'm furiously searching…" Only one participant remembered the database options from the tutorial and completed this task easily. Another participant remembered that the database section is where this information is controlled, but they unchecked the wrong database. One participant reflected, "Those abbreviations meant nothing to me." When asked which tasks were hard, two participants referenced this one.

Task 3: searching by date
The rainbow sheet shows that most participants experienced difficulty on this task in PPS, as did several in Google Patents. (See Figure 7.)

In Google Patents, three participants were easily able to limit their results to patents from 2022 by using the date range option in the left-side options. The menu containing this setting has already been expanded to complete the previous task, so it was easy for most participants to see how to complete this task. (The task asked participants to search for patents published in 2022, but they were considered successful if they found the date range option and applied the necessary dates, even if they neglected to toggle the dropdown from "priority" to "published".)

Two other participants expressed uncertainty or hesitation about completing this task. One sorted newest to oldest instead of limiting to just 2022 patents. Another thought about this task more deeply than the others and expressed curiosity about the multiple dates presented by Google Patents. Google Patents uses priority dates for sorting by date, but information in the results list may also display "Filed", "Granted" and "Published" dates. No explanation of these different dates is available within Google Patents, so this required some explanation from the engineering librarian.

Five of six participants struggled with this task using PPS. To complete this task successfully in PPS, it is necessary to run a command language query with a specific syntax that includes what PPS calls a "field code." To search for patents from 2022, the correct query would be: "2022.py." This is explained in PPS's "Help" documentation and reference materials (https://ppubs.uspto.gov/pubwebapp/static/pages/searchable-indexes.html), but these can be difficult to locate. This syntax for a "patent issue query" was covered in the tutorial, but only one participant remembered the correct query syntax. None of the other participants remembered that special syntax was needed at all. Instead, they looked in places such as "Options", "Settings", and the search results table as they worked to accomplish this task.

Task 4: searching by country/office
In the rainbow sheet (Figure 7), this task has more black squares than other tasks. In this case, the black squares indicate a combination of not initially posing this task to participants and notetaking error.

Some participants struggled to limit their search results to US patents in Google Patents. While it is an option in the "Search Fields" menu they already had open from previous tasks, the dropdown menu is labeled "Patent Office"; it is necessary to know that the country data is related to patent office data to be able to accomplish the task. Again, the tutorial had explained how to narrow by country in Google Patents, but several participants did not remember this. One particularly struggled even after they found the "Patent Office" menu. They quickly skipped over the top of the list, where "US" is located, because they were looking for US in alphabetical order. As they scrolled back up to the top, they were confused by the unfamiliar abbreviations, expecting to see US state abbreviations rather than two-letter codes for countries/offices. One participant was able to easily complete this task using Google Patents.

Perhaps due to the wording of the question "make sure you are looking at only US patents," many participants forgot that PPS only includes US patents. Only one participant remembered this fact. Two other participants saw that the Document IDs of

their search results started with the letters "US" and used this as evidence to support their guess that the patents were US-only. One participant misunderstood PPS's command-language syntax and tried searching "US.py." (drawing on Task 3). This participant did not understand that .py. stands for "patent issue year" and is not just a system-wide code used for all command language queries. This same participant also tried searching in the "Find Within" search box in the search results table. (See Figure 11.)

Figure 11. PPS "Search Results" table. Note the vertical and horizontal scroll bars that allow users to see more information and the carat next to "Date Publish…" which allows users to sort this column in the reverse order.

Task 5: sorting results by date
Task 5 asked participants to "make sure that the sorting order for results is from newest to oldest." All participants completed this task easily using Google Patents. One participant mentioned it when asked which tasks in Google Patents were the easiest.

As the rainbow sheet shows, only PPS presented difficulties for this task. Half the participants struggled with the task using PPS, while two participants mentioned this task when asked which tasks were the easiest. For the participants who had more difficulty, there were two problem areas. Some participants were overwhelmed by the number of columns in the "Search Results" table, so needed to scroll around to find the "Date Published" column (see Figure 11). Other participants were confused by the sort functionality. In PPS, it is necessary to click twice on the top of the column to change the sort order. One participant only clicked once, while others were confused by the arrow/caret icon. One participant expected this icon to indicate a dropdown menu rather than the ability to change the sort order.

Task 6: evaluating results
Task 6 asked participants to "review the patents returned by your search and identify one patent that might be relevant to the development of snowboard bindings." We wanted to understand how participants judged relevancy.

When using Google Patents, all but one participant used the title to determine relevancy. Four participants used Google's description on the search results page or the abstract (inside the patent document). Four participants used images in the search results or individual patents. All the participants had good things to say about the ways in which Google Patents makes it easy to scan patent information. One participant noted that it was easy to look at the figures and read the abstract compared with PPS. Other participants commented on the images, noting their utility.

Since this task is hypothetical, we assessed participants' judgments quite generously, although we noted that two participants focused on patents that we judged to be not relevant at all. For at least one participant, this was because they were overly focused on the first result. Sometimes it felt like the participants were trying to convince themselves of the relevancy of a patent while they explained to us the different features they were evaluating. In each website, one participant found the highlighted keywords particularly useful.

When using PPS, title was also the most common attribute used to determine relevancy, mentioned by all but one participant. Three participants used the blue highlighted keywords to help with their determination. (See Figure 12.) Two participants consulted the abstract available in the HTML view. One participant mentioned that they were looking for images to help them determine the relevancy, but they were unable to find them (since PPS does not display images in the results list or a patent's HTML view, as Google Patents does). Another participant put a lot of emphasis on the first result, trying to convince themselves that it was very relevant to their search since it appeared first in the list of results. Participants differed in how they looked at the PPS screen. One participant clicked through the search results, looking at the "Document Viewer" tab to see the detailed information about each new patent. Another participant clicked through the titles in the search results but did not notice the information in the "Document Viewer" changing. Finally, two participants mentioned the highlighted keywords as an effective tool for determining if a patent fit their research interests.

This task demonstrated that participants found the search results table in PPS challenging to navigate. The table was described as "small", "confusing", and "hard to

see." This table can be adjusted in size, but none of the participants explored that possibility.

Another web design issue was highlighted in this task as participants clicked in and out of different patents. When working with Google Patents, users can use the browser's back button to easily return to the list of search results. In PPS, the back button takes the user out of PPS altogether and returning to the site presents a new search interface, which caused confusion for the participants. PPS has a "Search History" tab, but participants were not aware of this and did not notice it.
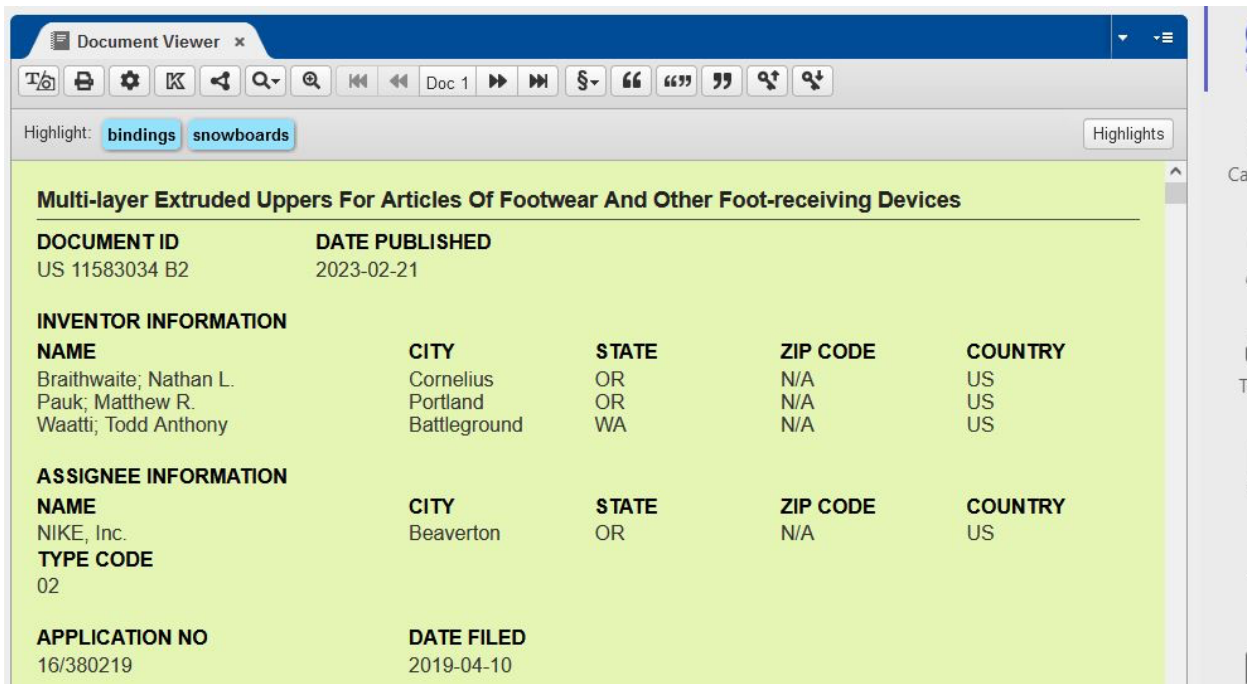

Figure 12. Screenshot of PPS showing the "Document Viewer" tab. Note the blue keywords at the top of the screen.

Task 7: saving a patent
Task 7 directed participants to "Save information about this patent offline, in any way that would enable you to return to its online information". All of the participants easily downloaded the patent document using the "Download PDF" button in Google Patents. However, many participants suggested an alternate way that they could accomplish this task. One participant mentioned bookmarking the URL to return to the page later - something that is possible in Google Patents but not PPS. Other participants suggested taking a screenshot, saving patent IDs in a file, and simply leaving their browser tab open.

Again, only PPS presented difficulties on this task. (See Figure 7.) PPS does not have a download feature. Instead, it is necessary to use the print feature to "Save to PDF". All the participants explored the "Document Viewer" buttons as they worked to figure out this task. One participant mentioned they found this task easy but two other participants had a very hard time completing this task. One did not know it was possible to "Save to PDF" via the print feature. Another participant (who did the same in Google Patents) wanted to save the patent ID number in another document. However, in the case of PPS, this participant initially tried to save the CPC code, before realizing that this was not specific enough, then settled on the document ID.

Task 8: accessing the patent document
Task 8 asked participants to "locate and view the patent document (not the HTML version)." Task 7 set up participants to succeed at this task since they should have already saved or downloaded the PDF document. But for both Google Patents and PPS, we observed participants who did not fully understand the directions because they did not understand the difference between an HTML version and the official patent document.

Two participants struggled with this task in Google Patents. One of the participants did not understand the task and looked in many places before conceding, "I'm not aware of that." We observed that the labeling in Google Patents did not match the wording that the participant was expecting. Three of the participants quickly located the patent document with little trial and error. Some of the same three participants expressed confusion about the difference between the HTML version and the patent document.

Two participants struggled with this task in PPS. Most participants were looking within the "Document Viewer" buttons to complete this task, where they successfully found the T/camera button which toggles between the HTML version and the patent document PDF. (See Figure 13). One participant mentioned this task when asked which tasks were easy to complete in PPS. Multiple participants eventually located the T/camera button but did not find it self-explanatory. The participants would often mouse over this button while exploring various buttons, then return to it and complete the task.
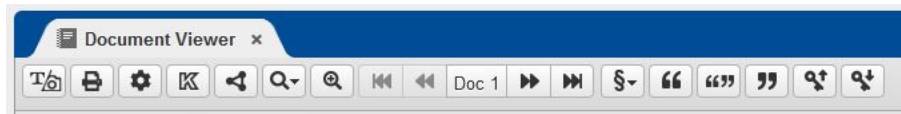

Figure 13. Screenshot from PPS showing a close-up view of the "Document Viewer" buttons. The T/camera button at far-left helps participants accomplish Task 8.

Task 9: backwards citations

Task 9 prompted participants, "For the same patent, locate the numbers of its citations." Both websites presented difficulties for a small number of participants. (See Figure 7.)

Two participants mentioned this task when asked about difficult tasks while using Google Patents. Two other participants had the opposite opinion, mentioning this task when asked about easy tasks. This task could range in difficulty depending on whether the participant was already looking at the HTML view or the patent document. All six participants scrolled down to look for citations, perhaps influenced by the layout of journal articles. Most participants who were already looking at the HTML version of the patent found the citations easily. Three participants started in the patent document view and were not able to find citations there. One participant mistook CPC classifications for citations.

For participants using PPS, two participants noted this task when asked which tasks were difficult. Four of the six participants encountered some degree of difficulty. Participants looked for this information in a variety of places, including scrolling down towards the bottom of the screen and looking in the "Search Results" table. One participant used Control + F to try to find the word "citation." PPS provides three quotation mark buttons in the document viewer that allow you to search for forward citations, backward citations and both at the same time (see Figure 13). For the two participants who did find the quotation buttons without help, the path to success was still not clear.

Participants' comments show how much this task could range in difficulty. One participant said, "I don't know where else to start searching" after exploring the screen extensively, while another called this task "pretty self-explanatory because of the quote mark," referring to the citation buttons.

Task 10: forwards citations
Participants were then directed to locate the patent's forward citations. One participant noted that finding forwards citations was difficult using Google Patents. In PPS, participants were sometimes confused by the fact that clicking on one of these buttons returned zero results. Due to the newest-to-oldest sorting of results, participants were mostly looking at patents that did not yet have any forwards citations. Participants found this confusing.

Task 11: locating CPC classifications
Tasks 11, 12, and 13 pertain to CPC classifications. Similarly to Tasks 9 and 10, these tasks can be completed differently depending on whether the participant is starting in the HTML version or using the patent document.

Task 11 directed participants, "For the same patent, locate its CPC classifications." Most participants successfully completed the task, though some participants encountered difficulties in each website. (See Figure 7.)

Three participants mentioned this task when asked which tasks were easy when working with Google Patents. Three participants found the CPC classifications very quickly when using Google Patents, and only one participant did not accomplish the task. The participant who struggled with the task mistook the patent's Int. Cl. (International Classification) classifications for CPC classifications. This participant was using the patent document rather than the HTML version, whereas other participants appeared to find it easier to locate the CPC classifications in Google Patents's HTML view. One participant used Control + F to find "CPC." Another participant noted, "I just remembered that it was right up front and center."

When asked which tasks were hard, one participant mentioned this task when using PPS. In contrast, three participants found the CPC classes quickly using PPS. In the HTML version of PPS, each section of the CPC code has its own hyperlink, leading to a description of that classification (see Figure 14). Participants were confused when presented with the multiple links. One participant looked through the search results table and settled on the CPCI column as the answer to this question. After guidance from the engineering librarian, they found the correct heading while using the patent document view. Another participant completely forgot what CPC codes are, asking if the blue highlighted keywords were the CPC classifications.
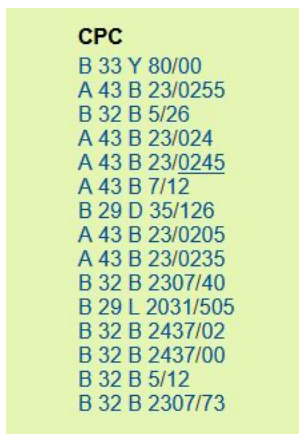
CPC
B 33 Y 80/00
A 43 B 23/0255
B 32 B 5/26
A 43 B 23/024
A 43 B 23/0245
A 43 B 7/12
B 29 D 35/126
A 43 B 23/0205
A 43 B 23/0235
B 32 B 2307/40
B 29 L 2031/505
B 32 B 2437/02
B 32 B 2437/00
B 32 B 5/12
B 32 B 2307/73

Figure 14. Screenshot of PPS showing CPC classifications made up of multiple hyperlinks

Task 12: locating CPC definitions

Task 12 asked participants, "For the first CPC classification listed, is a definition available?" Using Google Patents, three participants found the CPC definition easily. One participant knew that the USPTO has a list of CPC definitions, but they did not proceed to find Google's definitions. A few participants encountered some unexpected behavior as they explored to find the answer to this question. Clicking on a CPC classification in Google Patents loads the relevant classification search. Two participants stumbled upon this feature as they looked for a definition. Hovering over the CPC code opens a pop-up that provides more information. Two participants encountered this behavior and were mildly surprised, clearly not expecting the pop-up (see Figure 15).
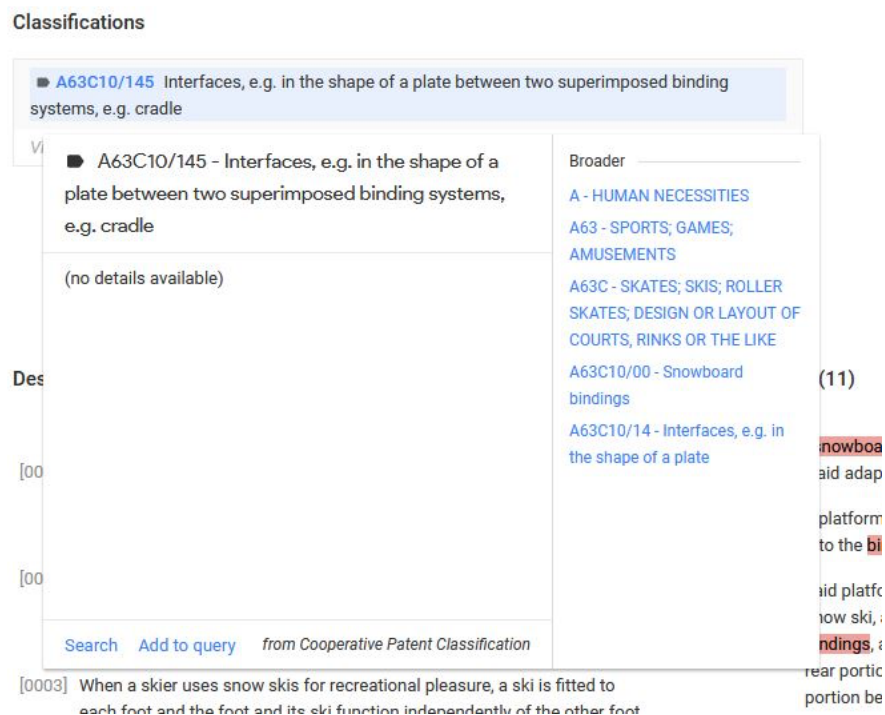

Figure 15. Screenshot from Google Patents showing the pop-up display with more information on CPC classifications.

In PPS, three participants did not complete this task easily. (See Figure 7.) One participant did not see a definition on the page, so answered the question, "No, a definition is not available" and did not explore further. Another participant tried to search using the CPC classification, expecting that PPS would return both patents that pertain to that classification (which it did) and a definition (which is not functionality that PPS has). When prompted to look in the HTML version of the document, participants were able to find the links quickly. Two participants were confused by the multiple links for each section of the CPC classification, but in general, were able to click on these links and figure it out (see Figure 14).

Task 13: searching by CPC classification

Task 13 asked participants to "run a search for this CPC classification." Our rainbow sheet showed a clear disparity between participants' performances in each website. (See Figure 7.)

Unexpectedly, in Google Patents almost every participant completed it differently. Two participants copied and pasted the CPC code into the search bar, though one participant's entry had spaces and therefore failed. Two participants encountered the pop-up box (see Figure 14) and clicked on the "Search" link at the bottom of the box which performs a new search for just that classification. Another participant clicked on the box's "Add to Query" button. A last participant clicked directly on the CPC code then edited the search query to remove the original keywords. The participant who copied and pasted the code with the spaces classified this task as difficult, due to the fact that the classification search requires a certain format.

Task 13 is difficult in PPS because it again requires knowledge of the syntax for a command language query. A successful CPC classification search consists of the CPC classification with no spaces followed by ".cpc." No participants remembered this syntax from the tutorial without the engineering librarian's prompting. One participant searched for only a portion of the classification, while one searched for the full classification but with spaces and without the syntax. Two participants typed in the CPC classification without spaces, but needed assistance to remember to add .cpc. One participant had no idea how to complete the task and another participant did not remember the command language at all.

Effectiveness

Participants' ratings for each tool's effectiveness (did it successfully do what you needed it to?) are displayed in Figure 16.
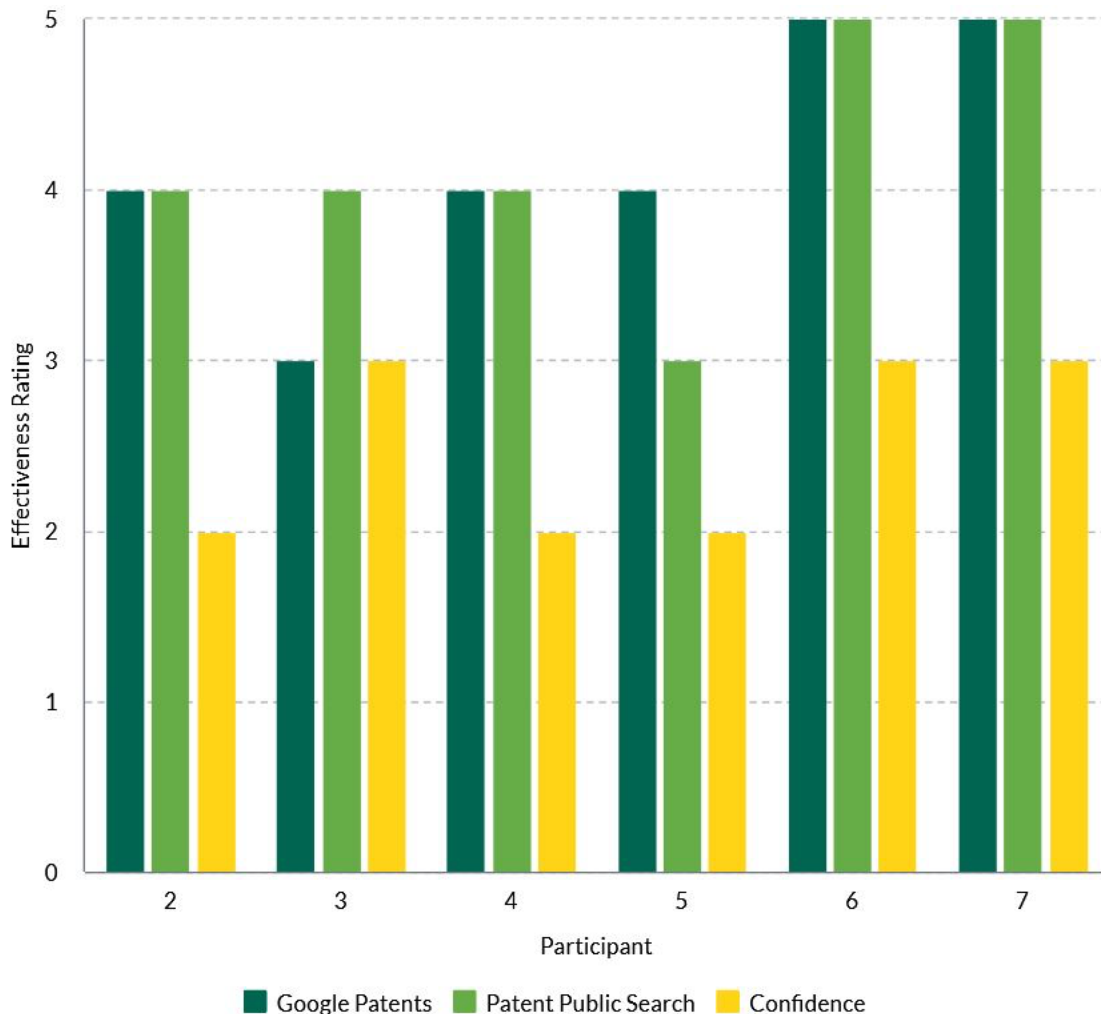
Figure 16. Participants' effectiveness ratings, including their original confidence rating.

Google Patents' lowest effectiveness score was a 3. The participant remarked, "It did give us snowboard bindings but there was also some stuff that wasn't relevant." Three participants gave Google Patents a rating of 4, mentioning, "everything was pretty easy to find" and "it seems user friendly." Two participants gave Google Patents a rating of 5. One participant discussed the "familiarity" of the site; "it looks like Google and all the buttons are sort of in the same place so it's easy to figure out what you're looking for." They also mentioned that narrowing a search was similar to what they are used to doing when using Google or online shopping. Another participant had similar comments, "I use Google a lot so it feels natural to me to use the interface… it's very easy to draw your eye towards the right section".

PPS received the same set of ratings for effectiveness, though not from exactly the same participants, including one rating of 3. The participant reported, "it did complete all of the tasks that I wanted it to, but not in an effortless way." PPS got two ratings of 4.

One participant observed, "I think it can be super effective if you knew how to use it better." Three participants gave PPS a rating of 5. One participant noted "once I figured out how to do everything it had everything I needed, but it wasn't necessarily easy to get." Another participant relayed, "when you know where all the buttons are it works good."

Intuitiveness

Participants' ratings for intuitiveness (was it readily apparent how to use it?), compared with their original confidence rating, are displayed in Figure 17.
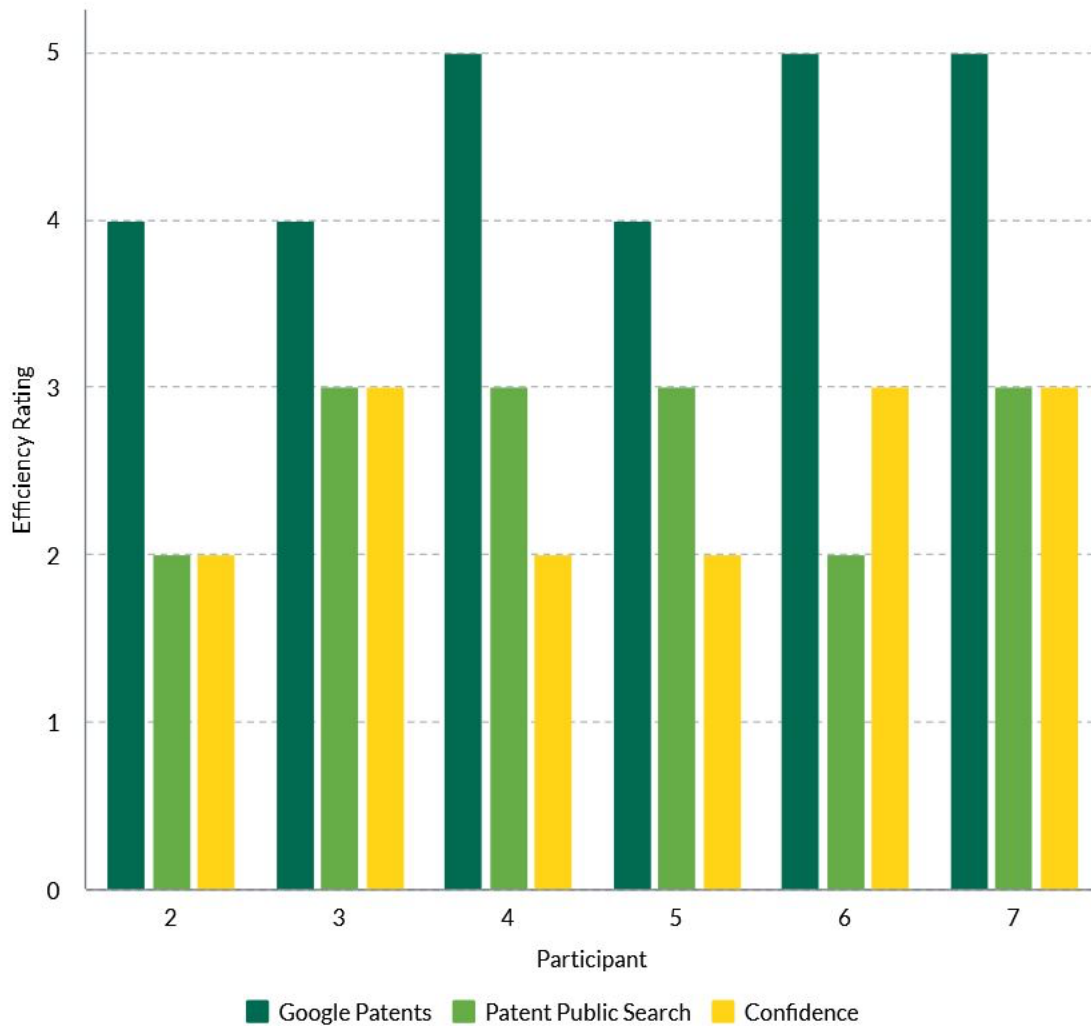

Figure 17. Intuitiveness ratings, with participants' initial confidence ratings.

There was a clear pattern of higher ratings of intuitiveness for Google Patents. One participant gave a 3 for intuitiveness. They commented, "Training yesterday [referring to the tutorial] made it easier." The other 5 participants ranked Google Patents as a 4 or 5.

Comments included, "Because I'm familiar with Google, I think most people are, it was easy to navigate based on familiarity." They described the ease of using Google Patents's search results to determine if a patent fits your research interests. By looking at the title, the description and the "small picture," you can scan "bing, bing, bing, right down it to see if something is relevant to your search." Multiple participants compared the two tools in their comments about intuitiveness. One participant said, "Unlike the US Patent Public Search I was able to complete tasks without previously knowing how to do them which I thought was very helpful in a patent search engine."

PPS had much lower intuitiveness ratings. One participant ranked it as a 1. They commented on the databases that control whether a query will search grants or applications, the "USPAT check button didn't feel very intuitive. I would have thought if I unchecked it I wouldn't have any US patents." They mentioned that the default Boolean operator was not intuitive–they did not expect to have to choose between AND and OR when searching for multiple keywords. They thought that scrolling through the "Search Results" table and double-clicking to change the sorting order were not easy features to use. The other five participants ranked PPS as a 2. Features that were identified as unintuitive included the "small buttons", the layout of the screen in three parts, the "Document Viewer" in general and the special syntax needed for command language searching. Many participants said that if they had not taken the tutorial, they would not know how to use PPS. One participant related, "I wasn't able to figure it out on my own," while another noted that it is intimidating to first-time users. Another liked the fact that hovering over the "Document Viewer" buttons prompts the display of a tooltip that explains what the button does.

Efficiency
Figure 18 shows participants' ratings for efficiency (did the design help you to work quickly or did it take more time than you would have liked?).
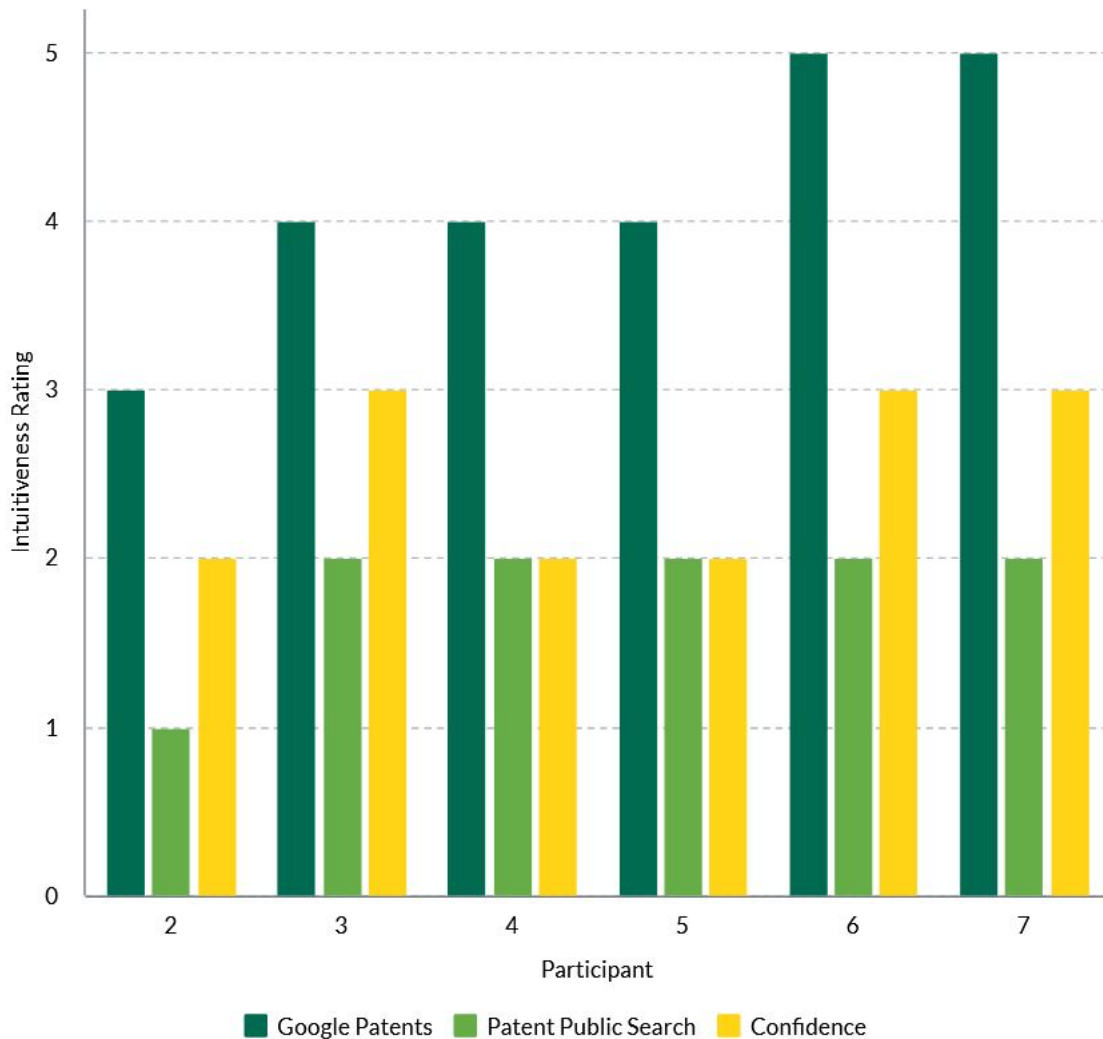
Figure 18. Participants' efficiency ratings, also including their initial confidence ratings.

This question also showed a clear pattern of higher ratings for Google Patents. It had some overlap with the intuitiveness question: many participants noted that intuitiveness contributed to the efficiency of their experience. Because it was easy to figure out how to use, it was possible to work quickly. All participants gave Google Patents a rating of 4 or 5. One participant said that it was efficient because "all the parameters you can change are relatively in the same area", compared with PPS where they did not know where to find the search parameters. Another participant mentioned that finding the CPC classifications and citations were easy just by scrolling down and scanning the document. Another participant observed, "I like that this one is more simplistic than the other one [PPS]. It's easy to read… this looks just like Google with the title and the description underneath and some had the pictures on the sides so you could see before clicking on them." One participant who gave Google Patents a 5 for efficiency noted that

it is "not cluttered like PPS…the minimalist design helps you find what you're looking for. In PPS the buttons clutter the screen."

Three participants gave PPS a rating of 2 for efficiency. One participant said, "I'm not very confident in my abilities to find what I'm looking for. I feel like I'd have to look up how to do a search, then come back to the site and do it, and it's just not worth the time". Another participant specifically mentioned that the images available in Google Patents give it an efficiency that PPS is lacking. A third participant noted that the highlighted keywords help when scanning through, trying to determine if a patent is relevant to your search. The other three participants gave PPS a rating of 3. One participant said, "The only efficient part is that they have all the settings in one row. Scrolling through each patent isn't efficient; you can't see the patent title until you click on it." Another participant noted that it "feels a little crammed", referring to the layout of the site as a whole, but also specifically mentioning the search results that contain so much information.

Preference
The final question was, "Given a choice, which database would you prefer to use?" All participants answered Google Patents.

Discussion

RQ1: To what extent are students able to accomplish typical undergraduate patent searching tasks in Google Patents and Patent Public Search, given a typical amount of prior instruction?

The abundance of color in the rainbow sheet (Figure 7) quickly communicates that in this study a significant proportion of students experienced a significant number of usability issues in both websites. This was also clear from our observations and reinforced by students' comments.

The combined data showed that Google Patents was mostly effective, especially for sorting and reviewing search results, locating patent documents, and using CPC classifications. In these aspects, Google Patents was an effective tool for participants because - among other reasons - the sorting feature had a visible position, the results included thumbnail images, the documents were clearly labeled, and the CPC data was prominently positioned and easily loaded into a search. Google Patents presented difficulties for other tasks, such as filtering by status and date. These findings mostly

corroborated evaluations by Noruzi and Abdekhoda (2014), Meier (2015), and Jürgens and Clarke (2018).

Students rated PPS equally highly for effectiveness, but their comments indicated that these evaluations were in fact their evaluations of how effective PPS could be if they had more training or experience. Overall, more students experienced more difficulty on tasks in PPS than in Google Patents. The data for PPS showed a range of usability issues that impeded their performance of the assigned tasks, especially filtering by status and year, working with citation data, and working with CPC classifications. The difficulties of locating CPC classifications and running CPC searches (requiring command language syntax) in PPS are major usability issues, because classification searching is an essential strategy for effective patent searching. One participant voiced the wish that PPS would use Google-style natural language searching instead of command language queries.

For both websites, the difficulties experienced in performing basic patent searching tasks suggest several things. One, Google Patents has better support for undergraduate-level patent searching. Two, both websites contain design elements that obscure the meaning of certain features and do not help users to intuit what they are or how to use them. Three, the instructional content of the tutorial did not adequately equip the students with the conceptual and technical knowledge to search for patents effectively.

RQ2: How do students perceive the usability of Google Patents and Patent Public Search?

Both sites contained non-intuitive elements, but students perceived Google Patents as the more intuitive site. All six participants commented on their familiarity with Google Search and how they expected Google Patents and PPS to function similarly. These comments came up regarding a variety of tasks. Comments included "I use Google a lot so it feels natural to me to use the interface" and "I'm searching snowboard bindings just like I would do in the Google search engine." Google Patents resembles Google search in many ways, for example in the layout of search results. It also positions key functions in high-visibility locations, such as the sort feature and "Classifications" information. This mitigates the cognitive load of using an unfamiliar website, minimizes the error rate, and conforms to Krug's first law of usability: "Don't make me think!"

Students perceived PPS as less intuitive. Some elements diverge from standard web design practices (e.g., OR as the default Boolean operator)   are in unexpected or low-visibility places (e.g., "Date Published" is one of many columns in a small table), or lack

labeling or explanation (e.g. no information to explain the Database options). In many cases, our study participants struggled to use PPS effectively because it did not conform to their expectations - often leading to confusion and task failure.

Additional aspects of usability worth considering are learnability and memorability (Nielsen, 2012, January 3). We expected that participants might not retain all the information in the tutorial, given the many demands on their attention. Even so, we were surprised by how much was forgotten. For example, one student had no memory at all of the command language queries in PPS. It suggests that the learnability and memorability of Google Patents and, probably even more so, PPS are low - which underlines the crucial role of intuitiveness in web design. If students are not going to recall their instruction in how to use a patent database website, they need to be able to figure it out in the moment.

RQ3: Do undergraduate students have a preference for Google Patents   or PPS for typical patent searching activities?

The students in this study expressed a clear and unanimous preference for Google Patents - echoing the results of Dudek et al.'s usability study of Google Search (2007). Overall, they thought it was the more usable site. They liked its layout and features, largely because these were more familiar due to their experience of using regular Google search, and more intuitive. They felt more comfortable, had to think less about how to accomplish the different tasks, spent less time on tasks, needed to ask fewer questions, and made fewer errors. One student commented that "As a new patent searcher, Google Patents was a lot easier to move through." Another highlighted the ease of adjusting a search's parameters with the "Search Fields" options. Google Patents has limited functionality compared with PPS, such as having fewer metadata fields for searching - but these students did not point to this as a major disadvantage. Given their lack of prior experience and instruction in using these websites, the lack of time for in-depth instruction and guidance, and the general-research (not comprehensive) searching that they needed to do, it makes sense that Google Patents was clearly preferred.

These students did recognize the potential usefulness of PPS, especially its capacity for constructing a very precise search if the user knew what they were looking for. Two participants described it as "powerful". This is an advantage for an advanced user. But undergraduate students mostly do not know what they might find in the patent literature or what exactly to look for, so the need for highly specific searches tends to be limited. Also, participants noted that even though they thought PPS was effective and useful, its learning curve was steep and would require a significant investment of time to learn how

to use it correctly. One stated that "PPS could be a go-to place, once you learn to use the software". These opinions support Zwicky's suggestion (2019) that USPTO websites are usable for expert users and not for beginners - or "a normal person who doesn't know about patents".

Given these students' preference for Google Patents, and the usability considerations underpinning it, it is an appropriate pedagogical choice to present it to undergraduates as a primary tool for patent research. This also applies to other users doing general patent research and when getting started quickly is a priority.

Could some usability issues in Google Patents and PPS be remediated? Some concerns identified in this study seem to suggest straightforward fixes, such as mouse-over tooltips for detailed explanations of labels and features; setting the default Boolean operator to AND; or adding attention-grabbing icons to indicate whether a patent is a grant or an application.

Implications for patent literacy instruction

Patent literacy instruction for undergraduate students has some constraints. One is a shortage of time and curricular space, limiting opportunities for practice and reinforcement (Sherriff & Rand, 2022). Another is the low learnability of patent websites that we observed in this study. How can patent literacy instruction be improved in order to make the most impact?

In Google Patents, there was a small number of significant issues. The difficulties that participants experienced were varied but each task was difficult for only one or two people. Students did well at conducting searches, reviewing results, accessing the USPTO document, finding citation data, working with CPC data and searching by CPC. The tasks that needed more guidance were locating the "Search Fields" menu and operating some of those fields. Patent instruction – whether in an online tutorial, a classroom presentation, or a research consultation – should therefore emphasize the role of combined-field searching and draw attention to the stylus icon. Another option is to direct students to the URL for Google Patents's "Advanced Search" (https://patents.google.com/advanced), which is essentially the regular search with the "Search Fields" menu pinned open by default.

Within the search fields, students need clear explanation of the difference between grants and applications, how to distinguish between them, and how to adjust a search for either as needed. They also need clear explanation of the date field and the difference between priority dates and dates of publication. Lastly, they need thorough

instruction in how to operate the office field in order to narrow results to a specific jurisdiction; this entails a technical explanation of how to use this field ("US" is at the top), and also conceptual explanation of what constitutes a patent office or jurisdiction. For example, some jurisdictions are national, such as the USPTO, while others are supra-national, such as the European Patent Office (EPO).

Patent instruction for undergraduate students should acknowledge the comparative disadvantages of Google Patents, such as the time lag in ingesting new grants and the absence of lower-importance (for students) search fields. It should also introduce them to PPS as the US's official patent repository and as an option for comprehensive searching, or searching where the highest level of precision is needed. PPS does not have the same usability as Google Patents, but it has the advantages listed in Figure 3: recent publications, advanced field searching, and more-reliable searching for patents published since 1970. However, students need to understand that PPS is a complex and less-than-intuitive tool, and they will likely need expert assistance to use it effectively.

Limitations

The study aimed to identify the usability issues in Google Patents and PPS that undergraduate engineering students are mostly likely to experience. It did not aim to identify every usability issue that a user might encounter. According to Nielsen (2000), "you need to test with at least 15 users to discover all the usability problems in the design". An exhaustive study with 15 or more users would be possible with more time and funding, though recruitment at a mid-sized institution like ours, or smaller, could be challenging.

This study focused on most issues likely to be experienced by most users and did not evaluate the two websites' accessibility for all users with all levels of ability to read and interact with web content. Google does not currently provide information on Google Patents' conformance with accessibility standards for web content (Google Accessibility, n.d.). Information on PPS's accessibility conformance is available at https://ppubs.uspto.gov/pubwebapp/static/pages/faq.html.

Future directions

As described in the literature review, there is much scope for investigation of patent researchers' interactions with patent websites. There are many user groups of patent database websites, with different research needs, and usability testing with any of these groups would have interesting results for patent educators. Usability testing of user

groups with advanced needs would be worthwhile, for example academic researchers, practicing engineers, inventors and entrepreneurs, or patent agents or attorneys. Usability testing might also be applied to other patent database websites, including other jurisdiction websites (e.g., Espacenet (EPO) and PatentScope (WIPO)), open websites (e.g., Lens.org), or commercial databases.

Within this study, some observations and student comments raised questions about how students interact with patent information, especially how students review and evaluate patents for relevance to their technological area. Future studies might investigate how students read patent information, how they relate it to their research, and how they extract useful information from patents and apply it to their own design work.

Conclusion

Patent searching is an important competency for students in many programs, including biomedical, electrical, and mechanical engineering. It is important for their academic and experiential learning, and for their careers as practicing engineers. But often students dive into patent searching with negligible familiarity with IP concepts or patent database websites. Students need some understanding of both these things: they need some knowledge of specialized concepts - like patent status, offices and jurisdictions, citation data, and classifications - before they can find that information using patent database websites.

To a limited extent, instruction has the potential to address these knowledge gaps - but not completely, because programs tend to lack the curricular space for detailed instruction or reinforcement; and because the learnability and memorability of patent database websites are relatively low. Any tutorial-based instruction on the basics of patent searching, like the tutorial used in this study, should come in a format that is easy to return to as a reference guide, as students probably will not absorb all the concepts initially.

Our study indicates that students prefer Google Patents. Several factors point to the conclusion that they perform best on typical undergraduate-level patent searches when they are familiar, or feel some familiarity, with the website they are using. For example, students found Google Patents particularly effective for sorting and reviewing search results because the layout and functionality aligned with their expectations from prior experience using Google Search. They found Google Patents effective in other respects because features were intuitively positioned, such as locating patent documents, and using CPC classifications. Aspects that were not self-evident were mostly self-

explanatory. Our students saw the value of PPS for expert users, but struggled with their own searching and expressed confusion regarding the non-intuitiveness of key features like filtering by status and year, working with citation data, and running classification searches.

Students rely heavily on cues provided by these websites to search for patents and determine which ones are relevant to their research interests, so the usability of the site is crucial. Our students expressed a clear preference for Google Patents over PPS because it did not require them to think as much about how to interact with its design elements. In theory, this mitigates the cognitive load and allows the user to focus on the patents.

Google Patents and PPS are key resources for patent researchers, with different content, characteristics, and design elements. One of the implications of this study is that Google Patents is an appropriate choice as the primary tool for undergraduate engineering students or other users conducting general-purpose research with limited time for learning how to use a more-complex resource like PPS.

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Sherriff conceived the study and designed the patent searching tutorial. Sherriff and Rogers designed the study methods; obtained funding; recruited subjects; conducted the usability testing; coded and analyzed data; and drafted and edited each section of the paper.

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Appendix: Testing instrument

Preliminary

C01. What is your level of confidence in your ability to search for patents in a patents database website?:
> 1-not at all confident; 2-slightly confident; 3-moderately confident; 4-very confident; 5-extremely confident

Tasks (performed with both Google Patents and PPS)

1. Using simple keywords, run a query for patents relating to snowboard bindings.

2. Narrow your results to patents with the following characteristics: awarded grants (not applications).

3. Narrow your results to patents with the following characteristics: patents published in 2022.

4. Clear the date filter - then make sure you are looking at only US patents.

5. Make sure that the sorting order for results is from newest to oldest.

6. Review the patents returned by your search and identify one patent that might be relevant to the development of snowboard bindings.

7. Save information about this patent offline, in any way that would enable you to return to its online information.

8. For this patent, locate and view the patent document (not the HTML version).

9. For the same patent, where would you look for numbers of its citations?

10. For the same patent, where would you look for its "cited by" citations?

11. For the same patent, locate its CPC classifications.

12. For the first CPC classification listed, is a definition available?

13. Run a search for this CPC classification.

Interview questions - Google Patents

G01. Which tasks did you find easy to accomplish? Please explain.

G02. Which tasks did you find difficult or problematic? Please explain.

G03. Evaluate the website's effectiveness - did it successfully do what you needed it to?
- 1 - not effective, 2 - slightly effective, 3 - moderately effective, 4 - very effective, 5 - extremely effective
- Please explain your rating.

G04. Evaluate the website's intuitiveness - was it readily apparent how to use it?
- 1 - not intuitive, 2 - slightly intuitive, 3 - moderately intuitive, 4 - very intuitive, 5 - extremely intuitive
- Please explain your rating.

G05. Evaluate the website's efficiency - did its design help you to work quickly or did it take more time than you would have liked?
- 1 - not efficient, 2 - slightly efficient, 3 - moderately efficient, 4 - very efficient, 5 - extremely efficient

Interview questions - Patent Public Search

P01. Which tasks did you find easy to accomplish?

P02. Which tasks did you find difficult or problematic? Please explain.

P03. Evaluate the website's effectiveness - did it successfully do what you needed it to?
- 1 - not effective, 2 - slightly effective, 3 - moderately effective, 4 - very effective, 5 - extremely effective
- Please explain your rating.

P04. Evaluate the website's intuitiveness - was it readily apparent how to use it?
- 1 - not intuitive, 2 - slightly intuitive, 3 - moderately intuitive, 4 - very intuitive, 5 - extremely intuitive
- Please explain your rating.

P05. Evaluate the website's efficiency - did its design help you to work quickly or did it take more time than you would have liked?

- 1 - not efficient, 2 - slightly efficient, 3 - moderately efficient, 4 - very efficient, 5 - extremely efficient

Interview questions - final

F01. Given a choice, which database would you prefer to use? Explain your preference.