# How do amateur radio experiences influence undergraduate student outcomes?

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# How do amateur radio experiences influence undergraduate student outcomes?


## Abstract

This scoping literature review addresses the research question: "How do amateur radio experiences influence undergraduate student outcomes?" Our review synthesizes articles regarding amateur radio integration in undergraduate engineering curricula, through both coursework and informal learning environments such as collegiate amateur radio clubs, and the resulting impacts on students across academic, career, personal, and social dimensions.

Following PRISMA guidelines for scoping reviews, we included work published in the 21st century that reports student outcomes or assessment. We searched four academic databases (Scopus, IEEE Xplore, ACM Digital Library, and Engineering Village) using Boolean search strings focused on undergraduate education, and supplemented academic sources with *QST*, a monthly publication of the American Radio Relay League, to ensure comprehensive coverage as a grey source.

Our initial search identified 234 abstracts from the academic literature, and 12 articles from grey sources. From these we screened for papers that reported outcomes in undergraduate student populations, and ended with 15 articles for analysis. Three pedagogical use cases emerged: (1) licensing as an accessible entry point for technical study, (2) amateur radio as a vehicle for engaging laboratory experiences and capstone design projects, and (3) radio clubs as communities of practice supporting informal learning.

Despite the success of these curricular interventions, we see an unmet opportunity to advance educational research in the use of amateur radio in undergraduate curriculum. Few studies have used validated research instruments or quantitative methods to assess their impacts systematically. Nevertheless, these results document a variety of use-cases that can guide educators interested in incorporating amateur radio into undergraduate curricula at their institutions.


## Introduction

Amateur radio is a pursuit that encompasses equal parts technology, communication, and public safety. The Radio Act of 1912 formalized the hobby in the United States by guaranteeing the use of the electromagnetic spectrum to the public for personal communications and experimentation, contingent on licensure. Amateur has introduced many participants to STEM concepts, fostering both professional careers and informal technical hobbies worldwide [1]. As of 2021, there are an estimated 2–3 million licensed amateur radio operators worldwide, including about 750,000 in the United States and 400,000 in Japan [19]. The practical nature of the hobby is recognized as a way to incorporate hands-on engineering and learning into college curricula through licensing, lab exercises, and design experiences [2]. With its strong tradition of mentorship ("Elmering" in radio parlance) and emphasis on experiential learning, amateur radio remains accessible across a wide range of educational backgrounds. Licensure provides access to public frequency bands in the electromagnetic spectrum, a valuable natural resource worth billions of dollars [18]. In the United States, licensing requires passing a multiple-choice test and has been formally integrated into some engineering programs [1].

Despite amateur radio's potential as a learning tool for electrical and computer engineering, relatively little work has systematically reviewed its impacts on undergraduate students. Some articles report summaries of amateur radio incorporation into several courses at individual universities [2], [3], while others survey work across multiple institutions [4], [5]. Many universities host amateur radio clubs, which are frequently among the longest-running student organizations on campus [6]. These clubs offer opportunities for learning technical skills in informal settings while providing channels for alumni engagement [7]. This community resource can extend outreach beyond engineering majors, developing technical literacy more broadly.

This review aims to identify common themes in how amateur radio experiences are integrated into undergraduate curricula. We focused our search on articles published in the 21st century concerning undergraduate education that report student outcomes. Outcomes were broadly categorized as academic (e.g., project completion, licensing exam success), personal (e.g., self-efficacy, motivation, attitudes), career-related (e.g., internships, job interviews), and social (e.g., community building, networking). We excluded purely descriptive studies that presented curricular interventions without reporting outcomes, but included assessments relying primarily on anecdotal evidence.

## Methods

To ensure comprehensiveness, the authors conducted literature searches through major academic databases and registers related to the topic, including Scopus, IEEE Xplore Digital Library, ACM Digital Library, Engineering Village, and *QST* archive. We used Zotero for literature management and SysRev for literature screening and data extraction. As shown in Appendix B, we developed database search queries related to amateur radio and undergraduate education to retrieve the most relevant and comprehensive literature search results.

We developed eligibility criteria, including inclusion and exclusion criteria, to be used for article screening. We included English-language sources published from 2001 to the present to focus on the use of amateur radio in the Information Age. Eligible sources must report some form of outcomes to address our research question about how amateur radio experiences influence undergraduate student development. We excluded sources that lacked evidence of impact, such as descriptive articles discussing amateur radio activities or classes without accompanying assessment data, student feedback, or anecdotes. We limited our scope to undergraduate student populations, excluding K-12 and graduate education studies, to maintain focus on undergraduate education contexts. Finally, we excluded studies that primarily emphasized interdisciplinary satellite communications projects, where amateur radio served merely as a peripheral technology rather than a central pedagogical approach, as these studies address distinct educational objectives outside the scope of our review.

The PRISMA flow diagram, as depicted in Appendix A, shows the entire literature searching and screening process [23]. The process includes literature searching, deduplication, title/abstract screening, and full-text screening. The initial literature searching returned 235 results from academic databases and 13 results from grey literature databases. 55 duplicate records were removed before screening, leaving 193 deduplicated records to be screened. 62 records were excluded based on the inclusion/exclusion criteria in the title/abstract screening stage. For example, a large number of papers that simply mentioned amateur radio in the context of a satellite engineering project course were removed. Out of 131 included records, 41 of them were not retrievable due to the unavailability of full-texts. During the full-text screening phase, 75 reports were excluded from the 90 reports based on the specific reason of eligibility criteria, as seen in Appendix A, leaving 15 studies to be included for final data extraction and analysis.

Full-text papers selected for inclusion were further coded across six categories as follows:

1. **Institution type**; *Where is amateur radio being used to teach undergraduates?*
   - 1.1. **Research focused**; R1 and/or PhD-granting institutions
   - 1.2. **Teaching focused**; does not confer PhD degrees
   - 1.3. **Community college**; two-year colleges not conferring bachelor's degrees
2. **Student level**; *What level of undergraduate student participates?*
   - 2.1. **First year**
   - 2.2. **Sophomore/Junior year**; class not specifically targeted to first-year or senior year students, like a technical elective course in an engineering program
   - 2.3. **Senior year**
3. **Instructional context**; *What is the learning environment?*
   - 3.1. **General education course**; class offered for any undergraduate major
   - 3.2. **Engineering course**; class offered primarily to engineering majors
   - 3.3. **Informal learning environment**; student organization/club or informal seminar
4. **Pedagogical intervention**; *How is amateur radio integrated in the curriculum?*
   - 4.1. **Licensing**; students are either required or can choose to obtain an amateur radio licensing exam as part of the course or learning activity
   - 4.2. **Hands-on**; students engage in experiential learning activities, such as operating radios, soldering, communicating, and using antennas, but not including design

4.3. **Project**; students engage in open-ended projects that use amateur radio, including senior design and capstone projects

4.4. **Research experience**; students use amateur radio principles or privileges to conduct technical research

4.5. **Writing**; students write about amateur radio as a means to develop critical thinking skills

5. **Assessment method**; *What evidence is used to identify student outcomes from engaging with amateur radio?*

5.1. **Quantitative survey**; study uses validated quantitative research instruments measuring psychometric constructs

5.2. **Qualitative survey**; study includes interviews or open-response surveys

5.3. **Course evaluation**; evidence cited includes end-of-class student evaluation survey

5.4. **Anecdotal**; informal reporting of positive outcomes, no empirical results

6. **Outcomes**; *How did students or the learning environment benefit from amateur radio?*

6.1. **Academic**; positive learning outcomes or achievement: successful project, earning a license, etc.

6.2. **Personal**; feelings and attitudes such as self-efficacy, motivation, value, sense of belonging, etc.

6.3. **Career**; job interviews, internships, career guidance

6.4. **Social**; building sense of community, social networking, alumni involvement or donations, press

## Results

After applying our full-text inclusion criteria, 15 articles remained. Of these articles, ten were from academic literature [1]–[5], [8]–[12], and five were from grey sources [6], [7], [13]–[15]. Articles were grouped into 5-year periods to visualize any publication trends over time (Figure 1), and no clear trend emerged. Papers reporting interventions were geographically clustered in the United States (>80%), with two articles from one university in Europe, and one mentioning activities in Asia.

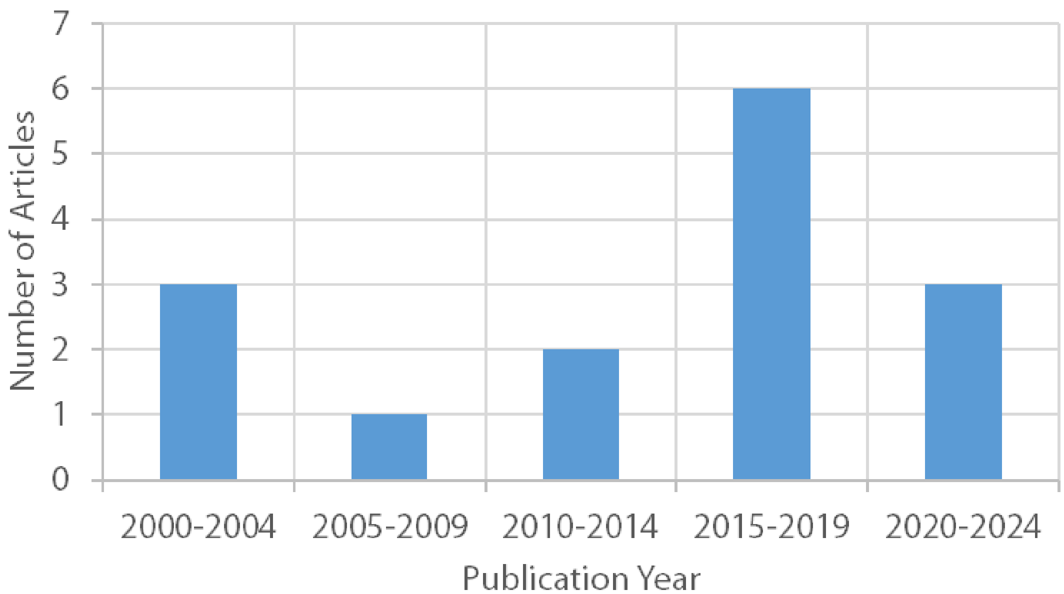


**Figure 1:** Article publication dates grouped into 5-year periods

Since our article inclusion criteria targeted undergraduate education, most articles described undergraduate classes or collegiate amateur radio club activities. To better understand any institutional bias in our search, we labeled articles by institution type. No courses from community colleges were reported, and a nearly even split of articles mentioned research-focused institutions versus teaching-focused institutions (Figure 2). Some articles mentioned at least one undergraduate institution of each type.

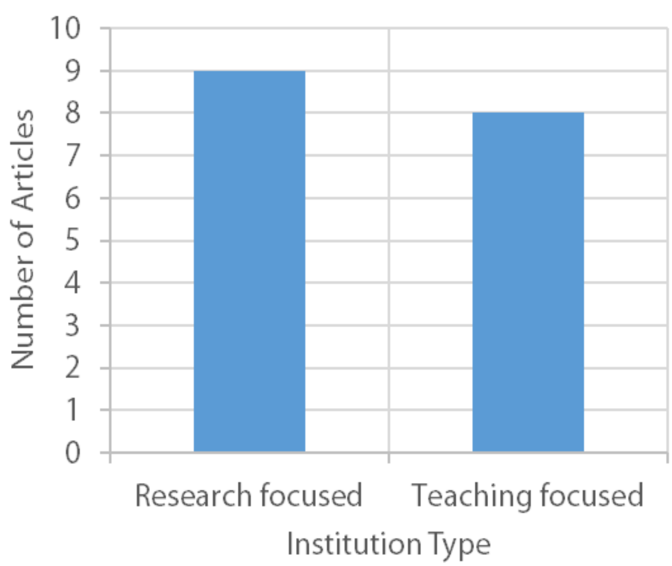


**Figure 2:** Article breakdown by institution type

When specific engineering courses were mentioned, the authors classified them by academic level, as either specifically targeting first-year students, such as orientation seminars, or seniors, such as capstone. Other technical courses, like Antenna Theory or Electronics, were classified as sophomore/junior level. Amateur radio licensing was most commonly a course objective used in first-year seminars [1], [4], perhaps because the licensing process does not require deep technical knowledge, but rather more familiarity with operating regulations. Senior capstone or project-based courses were described most frequently [9], [11], [13], [15]. The two general education courses that surfaced in our study did not appear to target specific student levels and were designed to develop critical thinking and writing skills [8] or radio licensing [3] among a broad target audience. Informal learning was the primary educational environment mentioned in four articles [6], [7], [14], [15], and all of these were from the grey source *QST*, a public interest magazine for amateur radio operators.

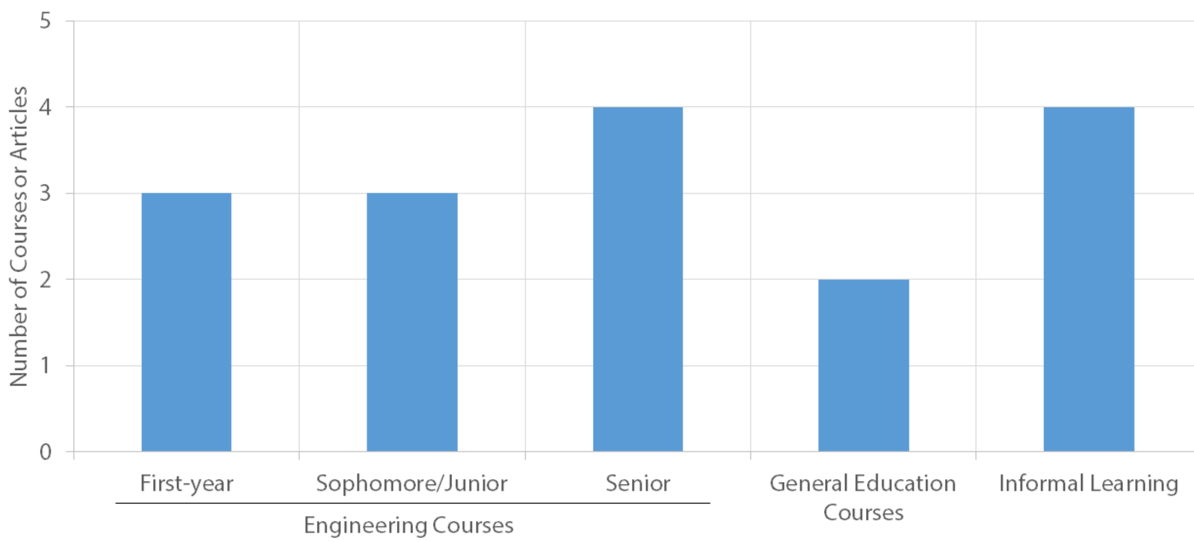


**Figure 3:** Course levels and disciplines mentioned within the articles. Informal learning refers to articles that primarily discuss radio club-related educational activities.

The papers included are summarized in Table 1, which codes pedagogical interventions, assessment methods, and outcome types. Hands-on experiences (67%), projects (60%), and licensing (40%) were the most commonly reported pedagogical interventions. Projects included both capstone courses and student organization activities. One interdisciplinary business and engineering collaboration had students design and market a shortwave radio product, with reported benefits for students across disciplines and their instructors [9]. Several articles described undergraduate research projects, including THz-wave research experiences [11] and ionospheric measurement studies conducted within a foundations of engineering seminar [4]. In "Radio Sloyd," a general education writing course [8], amateur radio provided the context for analysis of communications technology and society, with writing as the primary learning activity.

**Table 1:** Data extraction results summarized. Heading abbreviations: Lic. = Licensing, H.O. = Hands-on, Proj. = Project, Res. = Research, Wri. = Writing, Qual. = Qualitative survey, CE = Course evaluation, Anec. = Anecdotal, Acad. = Academic, Pers. = Personal, Soc. = Social

| Article Title | Pedagogical Intervention | | | | | Assessment Methods | | | Outcomes | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lic. | H.O. | Proj. | Res. | Wri. | Qual. | CE | Anec. | Acad. | Pers. | Career | Soc. | |
| *First-year amateur radio licensing for electrical engineering students* [1] | X | X | | | | X | X | | X | X | X | | Class: First-year Orientation |
| *Ham radio and engineering education* [2] | | X | X | X | | | | X | X | | | | Class: Electronics II<br>Class: Antenna Theory<br>Project: Formula Solar Car |
| *Comprehensive Amateur Radio Education including Public Outreach* [3] | X | X | X | | | | | X | X | | X | X | Class: Amateur Radio seminar<br>Project: High-altitude balloon telemetry<br>Other: Radio direction finding competition |
| *Fostering Collaborations with the Amateur Radio Community* [4] | X | X | | X | X | | | X | X | | | X | Class: Foundations of Physics and Engineering<br>Other: HamSci citizen ionospheric science initiative |
| *Amateur radio in STEM education* [5] | | X | X | X | | | | X | X | | | X | Project: VHF repeater system in Nepal<br>Project: Satellite launches<br>Project: Doppler radar/THz research |
| *Radio Sloyd: An Amateur Radio Approach to a University-Level Critical Thinking and Writing Class* [8] | X | X | | | X | | X | | X | | | | Class: Radio Sloyd, general education writing course |
| *Development and marketing of a short wave transmitter as an interdisciplinary student project* [9] | | | X | | | X | | | X | X | | | Project: Marketing a short-wave transceiver product, team of one business student & two engineering students |
| *A fun hidden transmitter hunt offers an inexpensive hands-on antenna experiment rich with insight for the students* [10] | | X | X | | | | X | | X | X | | | Class: Applied Field Theory |
| *Reintroducing amateur radio in ECE capstone design projects* [11] | | | X | | | | | X | X | | X | | Class: Capstone |
| *Geek Civilization: Amateur Radio And First Year Projects To Improve Recruitment And Retention In An ECET Program* [12] | | X | | | | | | X | X | X | | | Class: Electronic Fabrication<br>Class: DC Electrical Circuits |
| *Strategies for reviving a college radio club* [6] | X | | | | | | | X | | | | X | Other: Student-led license exam study |
| *Up front: College hams collaborate at Orlando HamCation* [7] | X | X | | | | | | X | | | X | X | Other: Alumni involvement |
| *Happenings: ARDC grants help fund elementary and college projects* [13] | | | X | | | | | X | X | | | | Class: Capstone |
| *Club station: Student club members upgrade their university station* [14] | | X | X | | | | | X | | X | | X | Project: Antennas for club station |
| *Up front: Field Day 2013 at the University of California Santa Cruz* [15] | | | X | | | | | X | X | | | X | Class: Capstone |

A persistent limitation across the literature was the lack of validated assessment instruments to measure student outcomes. Most studies relied primarily on anecdotal evidence or instructor narratives to describe impact. No article met our criteria for a quantitative research study, and only two provided qualitative results beyond what is typically collected from end-of-term course evaluation surveys [1], [9].

Outcomes described were primarily academic (80%) and social/community building (47%). Personal outcomes (33%) most commonly took the form of student-expressed self-efficacy or confidence in undertaking radio-related projects [14], though these were not assessed using validated self-efficacy instruments. Career outcomes (27%) ranged from successful job interviews [7] to positive feedback from industry advisory boards and employer-sponsored capstone projects [1], [11].

**Discussion**

Amateur radio integration into undergraduate curricula has been pioneered by faculty members with deep expertise and enthusiasm for the hobby, who recognize its potential for authentic engineering experiences [1], [10]. The literature documents rich opportunities for experiential learning across diverse contexts, from antenna labs to capstone projects to community partnerships. However, most reported outcomes rely on anecdotal evidence and descriptive results rather than empirical assessment, a literature gap that presents a significant opportunity for the engineering education research community. While some instructors have speculated that ham radio experiences are valuable for student engagement and skill development, there is a lack of systematic evidence of how and why these experiences benefit students. Rigorous studies examining constructs such as motivation, self-efficacy, and engineering identity development could provide the empirical foundation needed to move amateur radio integration from individual passion projects to evidence-based pedagogical practice [16]. Such research would not only validate existing initiatives, but also provide guidance for broader adoption by faculty uncertain about amateur radio's educational impact [1].

To provide actionable guidance for ECE practitioners while identifying opportunities for future empirical research, we organize the reviewed literature into three pedagogical use cases, each illustrated with examples from Table 1:

1. Broadening participation in engineering and technology through radio licensing
2. Creating engaging student labs and capstone projects using the amateur radio spectrum
3. Building communities of practice for informal and personally meaningful learning experiences.

We follow these summarized cases with a discussion of the limitations of our literature survey, and how they may be addressed with follow-up work.

***Broadening participation through radio licensing.*** Technical literacy is an increasingly important outcome in a world shaped by technology, which is increasingly abstract and complex. Graduates entering the workforce may see their role with technology as passive consumers rather than users with agency [20]. Amateur radio provides an entrance ramp for a more proactive relationship with technology, and becoming licensed is the first step.

Licensure at the entry level license class (Technician) in the United States requires passing a 35-question multiple choice test covering rules, regulations, and technical fundamentals. The question pool is published online, allowing students to study questions and answers without necessarily requiring deep prior knowledge. This accessibility makes licensing an achievable goal for students from diverse backgrounds with varying levels of technical preparation.

A common pedagogical pattern integrates licensing as an entry point into broader technical study. Derickson *et al.* incorporated amateur radio licensing into the summer reading assignment for incoming first-year ECE students at California Polytechnic State University, with the licensing exam occurring during the first week of class [1]. Frissell *et al.* report another strategic first-year integration at the University of Scranton. Students in a physics and engineering foundations course earned their licenses and then applied their knowledge to analyze ionospheric propagation measurements as part of the HamSci citizen science initiative [4]. At Case Western Reserve University, instructors created a general education writing course called "Radio Sloyd" that taught critical thinking through the lens of amateur radio and communications history, inspired by the 19th-century Finnish handcraft education system [8]. Students earned their licenses as part of this writing class, enabling hands-on engagement with the technology they were studying critically.

In each case, licensing serves as a gateway for further exploration rather than a destination; a starting point for lifelong technical learning and identity development as someone who can understand and shape technology rather than merely consume it. This level of participation is accessible to students outside of traditional STEM majors due to the relative ease of licensing.

***Creating engaging labs and capstone projects using the amateur spectrum.*** A persistent theme across the literature was the role that amateur radio and wireless experimentation play in enabling meaningful laboratory coursework and capstone design projects. Silage reintroduced amateur radio into ECE capstone offerings at Temple University after observing student interest in radio communication topics, with resulting projects spanning antenna design, transceiver development, and digital communications [11]. Gasper *et al.* similarly report using amateur radio as a framework for design projects throughout the ECE curriculum at South Dakota School of Mines and Technology, from antenna theory courses to senior capstone projects [2]. The hobby's emphasis on tinkering and experimentation aligns well with the iterative design process central to engineering practice.

Radio-frequency engineering has traditionally relied on use of expensive vector network analyzers or anechoic antenna measurement chambers. Such dependence on costly equipment and facilities creates bottlenecks that limit student access to hands-on learning. When an antenna measurement facility closed for renovations at the U.S. Air Force Academy, a faculty member replaced planned laboratory exercises with an amateur radio direction-finding project that required only portable, low-cost radios and handmade directional antennas [10]. More recently, the development of inexpensive handheld vector network analyzers (<$100 USD) has expanded access to RF measurements, enabling more students to perform network analysis independently, supporting remote or asynchronous laboratory models [21].

Amateur radio projects also demonstrate potential for interdisciplinary collaboration. Batz *et al.* describe a project pairing a business student with two electrical engineering students to design and market a shortwave transmitter, providing authentic experiences in both technical development and commercialization [9]. At the University of California Santa Cruz, students designed and built a complete amateur radio station for the ARRL Field Day operating event, integrating antenna engineering, RF electronics, and operating procedures in one project [15]. These examples illustrate how amateur radio's combination of technical challenge, regulatory framework, and active practitioner community creates authentic design constraints that mirror professional engineering practice.

***Building communities of practice for informal learning.*** Amateur radio's has a unique strength in its ability to create communities of practice that extend beyond the formal curriculum, similar to how makerspaces are playing an increasingly important role providing informal learning opportunities on engineering campuses. While engineering courses account for most documented uses of amateur radio in higher education, the hobby's accessibility to non-technical participants presents opportunities for broader impact. Public outreach initiatives, such as those conducted by *Ostbayerische Technische Hochschule Regensburg* [3] and the HamSci ionospheric citizen science project [4], demonstrate how amateur radio can build technical literacy across diverse populations while connecting universities with their communities.

The real-world relevance of amateur radio strengthens these community connections. A compelling example from the literature describes Nepali university students establishing their country's first VHF backup communications network following the devastating 2015 earthquake [5], a direct translation of amateur radio skills to emergency response and public service. Such visible demonstrations of impact can help universities articulate their educational mission and value proposition at a time when higher education faces increasing scrutiny.

Student clubs represent another critical venue for community building through amateur radio. Social and community-related outcomes appeared frequently in our review, often linked to active student organizations [6]. These clubs offer face-to-face technical collaboration and mentorship at a time when many students report feeling isolated despite constant digital connectivity. Several articles from our survey focused on community building across universities, and students anecdotally reported an increase in technical self-efficacy by helping with a large antenna construction project [6], [7], [14]. Activities like radio direction finding competitions ("fox hunts" or "signal safaris") can generate widespread curiosity and draw participants from across campus [3], [10]. Given that sense of belonging and community are essential for student resilience and retention [16], amateur radio clubs may serve dual purposes: developing technical skills while fostering the social connections that support student success and well-being [6].

The informal learning environment of radio clubs also supports personally meaningful projects that might not fit within formal course structures: antenna experimentation, contest operating, satellite communications, and emergency preparedness drills. These self-directed activities allow students to pursue intrinsic interests while developing troubleshooting skills, technical judgment, and the confidence that comes from solving authentic problems within a supportive community. Amateur radio community demographics skew toward older participants, with 60-70% of operators over the age of 55 [22]. This intergenerational knowledge transfer, pairing college students with experienced practitioners who have decades of hands-on expertise, offers access to experience and professional networks that traditional classroom settings cannot provide.

***Limitations of this review.*** Our review is limited by its reliance on English-language publications and predominantly North American sources. *QST*, our primary grey literature source, is published by the American Radio Relay League, and our search strategy prioritized English-language academic outlets. These geographic and linguistic constraints may have excluded significant work from other regions, particularly countries with substantial amateur radio populations such as Japan, Germany, and Brazil.

Many course integrations are not formally captured by the literature, as faculty do not always report their outcomes in traditional academic venues. The authors are aware of several amateur radio courses that have not been described in peer-reviewed publications, and a more comprehensive survey might include systematic searches of public course syllabi, institutional repositories, and departmental websites. Similarly, the full extent of informal learning through radio clubs is difficult to ascertain through literature review alone. The Collegiate Amateur Radio Program maintains a directory of over 200 active university-affiliated clubs worldwide [17], suggesting a scope of activity far exceeding what appears in published scholarship.

Another conspicuous exclusion from our survey are student satellite projects. Small, low-earth orbiting satellites frequently use licensed amateur radio spectrum for communications, and dozens of articles about CubeSats and similar projects were screened from this review. While these projects leverage amateur radio infrastructure, they did not focus primarily on amateur radio as a pedagogical intervention. However, the substantial volume of satellite-related work, and their frequent reliance on using the amateur spectrum, represents an adjacent body of literature that may warrant separate examination. Of particular interest is how amateur radio licensing may support learning broadly across large, interdisciplinary team projects.

***Future directions.*** The limitations identified above point toward concrete opportunities for advancing our understanding of amateur radio in engineering education. Instruments measuring motivation, self-efficacy, engineering identity, and sense of belonging are well-established in engineering education research [16], [20] and could be readily applied to assess the developmental outcomes that have so far been observed anecdotally. Longitudinal studies tracking students from initial licensing through graduation could illuminate how amateur radio experiences influence persistence, career choices, and development of engineering identity over time, though this would require significant resources.

The gap between documented practice and actual implementation calls for alternative research methodologies. A systematic survey of engineering programs beyond a literature search would better quantify the prevalence of amateur radio integration. Mixed-methods approaches combining surveys of faculty club advisors with case studies of successful programs would provide a broader understanding of impacts. The hundreds of university-affiliated clubs identified by the Collegiate Amateur Radio Program [17] represent a rich, largely untapped source of data on informal learning outcomes and factors contributing to student engagement. These research directions would transform amateur radio integration from a collection of isolated initiatives into an evidence-based pedagogical approach, providing the foundation needed for broader adoption.

## Conclusion

Amateur radio was the introduction to a lifelong pursuit of technical literacy for a generation of engineers and tinkerers alike [12]. Far from being a dated pursuit, the hobby has continually evolved with technological advances and offers students the opportunity to experiment with the electromagnetic spectrum. This resource has been protected for public use for over a century, despite its immense monetary value exceeding billions of dollars [18]. The beauty and opportunities presented by these remarkable commons may yet inspire future generations of engineers and innovators, motivating them through authentic hands-on experiences.

Potential outcomes extend beyond traditional academic measures. Hands-on amateur radio experiences can foster stronger self-efficacy, build communities of practice outside the classroom, and create opportunities for career networking that all contribute positively to student well-being and resilience in a world where modern technology can have the opposite effect. There is an enormous opportunity ahead for empirical studies that observe how these amateur radio experiences influence modern students who crave connection and real-world impact.

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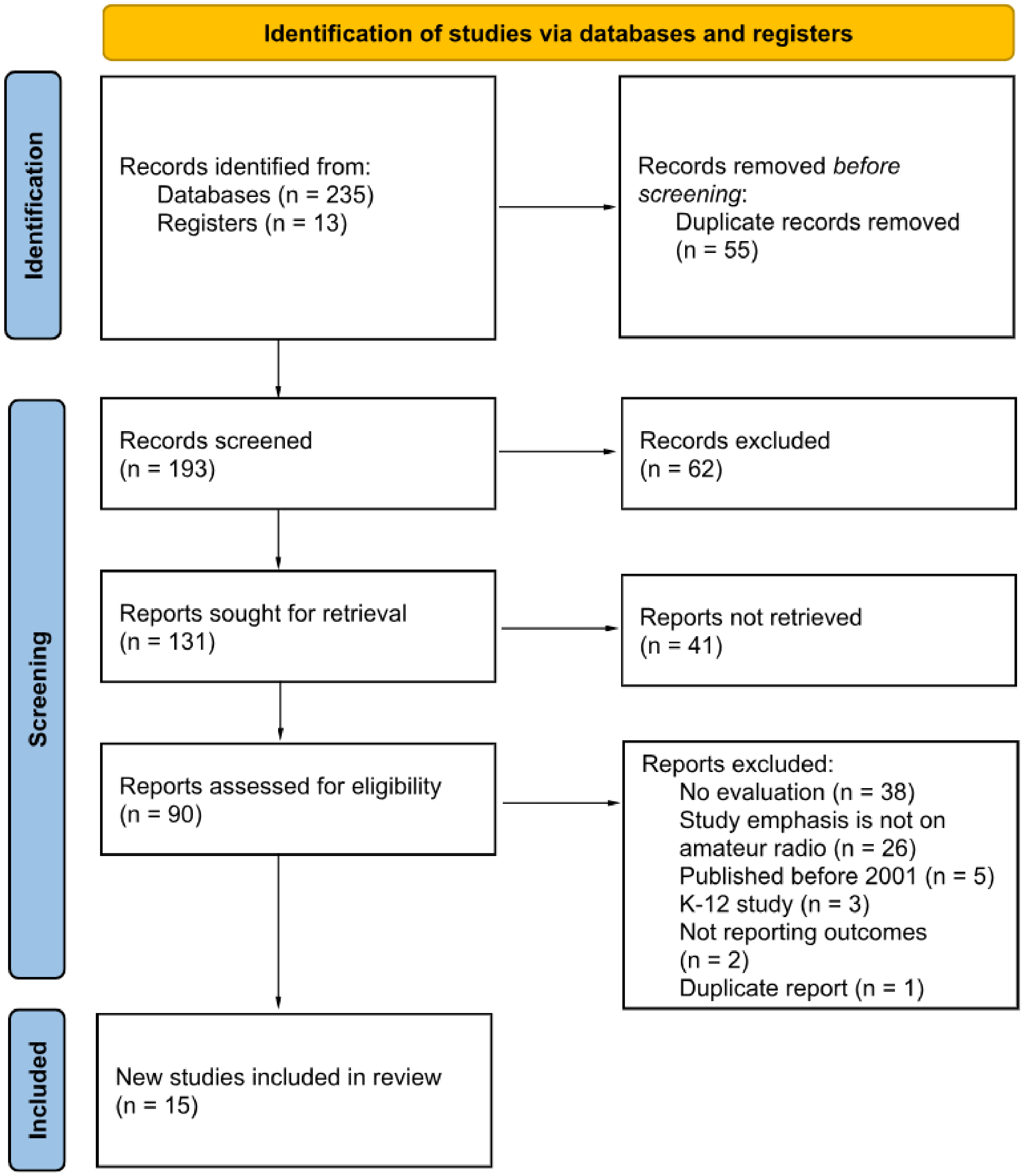
**Appendix A: PRISMA Flow Diagram**



## Appendix B: Search Strategy

| Database | Search Statement | Fields/ Limiters | Number of Results |
|---|---|---|---|
| Scopus | TITLE-ABS(("amateur radio*" OR "ham radio*" OR "radio amateur*" OR "amateur radio club*" OR "radio club*") AND ("undergraduate*" OR "college student*" OR "university student*" OR "higher education*" OR "postsecondary education*" OR "universit*" OR "college*") AND ("academic*" OR "career*" OR "learning*" OR "education*" OR "skill*" OR "development*" OR "experience*")) OR AUTHKEY(("amateur radio*" OR "ham radio*" OR "radio amateur*" OR "amateur radio club*" OR "radio club*") AND ("undergraduate*" OR "college student*" OR "university student*" OR "higher education*" OR "postsecondary education*" OR "universit*" OR "college*") AND ("academic*" OR "career*" OR "learning*" OR "education*" OR "skill*" OR "development*" OR "experience*")) | Default | 123 |
| IEEE Xplore Digital Library | ("Document Title":"amateur radio" OR "Document Title":"ham radio" OR "Document Title":"radio amateur" OR "Document Title":"amateur radio club" OR "Document Title":"radio club") AND ("Document Title":"undergraduate" OR "Document Title":"college student" OR "Document Title":"university student" OR "Document Title":"higher education" OR "Document Title":"postsecondary education" OR "Document Title":"university" OR "Document Title":"college") AND ("Document Title":"academic" OR "Document Title":"career" OR "Document Title":"learning" OR "Document Title":"education" OR "Document Title":"skill" OR "Document Title":"development" OR "Document Title":"experience") OR ("Abstract":"amateur radio" OR "Abstract":"ham radio" OR "Abstract":"radio amateur" OR "Abstract":"amateur radio club" OR "Abstract":"radio club") AND ("Abstract":"undergraduate" OR "Abstract":"college student" OR "Abstract":"university student" OR "Abstract":"higher education" OR "Abstract":"postsecondary education" OR "Abstract":"university" OR | Default | 12 |

| | | | |
|---|---|---|---|
| | "Abstract":"college") AND ("Abstract":"academic" OR "Abstract":"career" OR "Abstract":"learning" OR "Abstract":"education" OR "Abstract":"skill" OR "Abstract":"development" OR "Abstract":"experience") | | |
| ACM Digital Library | Title:("amateur radio*" OR "ham radio*" OR "radio amateur*" OR "amateur radio club*" OR "radio club*") AND Title:("undergraduate*" OR "college student*" OR "university student*" OR "higher education*" OR "postsecondary education*" OR "university*" OR "college*") AND Title:("academic*" OR "career*" OR "learning*" OR "education*" OR "skill*" OR "development*" OR "experience*") OR Abstract:("amateur radio*" OR "ham radio*" OR "radio amateur*" OR "amateur radio club*" OR "radio club*") AND Abstract:("undergraduate*" OR "college student*" OR "university student*" OR "higher education*" OR "postsecondary education*" OR "university*" OR "college*") AND Abstract:("academic*" OR "career*" OR "learning*" OR "education*" OR "skill*" OR "development*" OR "experience*") | Default | 2 |
| Engineering Village | (((amateur radio WN TI) OR (ham radio WN TI) OR (amateur WN TI)) AND ((undergraduate WN TI) OR (college student WN TI) OR (university student WN TI) OR (higher education WN TI) OR (postsecondary education WN TI) OR (university WN TI) OR (college WN TI) OR (engineering education WN TI) OR (electrical engineering WN TI) OR (engineering WN TI) OR (student WN TI) OR (capstone WN TI) OR (design WN TI))) OR (((amateur radio WN AB) OR (ham radio WN AB) OR (amateur WN AB)) AND ((undergraduate WN AB) OR (college student WN AB) OR (university student WN AB) OR (higher education WN AB) OR (postsecondary education WN AB) OR (university WN AB) OR (college WN AB) OR (engineering education WN AB) OR (electrical engineering WN AB) OR (engineering WN AB) OR (student WN AB) OR (capstone WN AB) OR (design WN AB))) AND ({ACOPDW} WN CN) | Default | 98 |