Preservation concerns around dissemination of information face professionals, consumers, and hobbyists performing tasks that are heavily reliant on unsupported legacy equipment. This paper seeks to acquire information that may be used to develop a broadly applicable ontological framework and intentional support community for a structured knowledge base of equipment issues, parts, and details. This will be accomplished by conducting structured interviews that seek to better understand the information-seeking behavior of technicians and consumers in a variety of disciplines reliant on skills, practices, and information surrounding "old gear."

Headings:

Conceptual structures

Information-seeking behavior

Preservation Equipment

Audiovisual Equipment

MAKING IT WORK: GERMINATING AN INFORMATION FRAMEWORK FOR
KNOWLEDGE DISSEMINATION SURROUNDING LEGACY EQUIPMENT USAGE
AND REPAIR

by
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A Master's paper submitted to the faculty
of the School of Information and Library Science
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Science in
Information Science.

Chapel Hill, North Carolina

August 2022

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INTRODUCTION

Over the course of several decades, a number of interrelated factors have rendered a wide variety of equipment obsolete. Increasingly streamlined manufacturing technology — as well as the proliferation of inexpensive computing power, networking, storage, and memory — have placed very powerful low-cost computational logic at the heart of many pieces of equipment ranging from handheld consumer electronics to highly specialized medical devices. Newer, and often more efficient, processes and designs have been introduced to accomplish similar tasks, with additional functionality and streamlined user interfaces. Many would likely consider this a leap forward. In many cases, products are more easily scalable, more readily replaceable, increasingly compatible with one another, and in general, measurably more powerful and convenient in accomplishing their purpose.

As technological advancements create newer products, this "innovation" can be troubling for those who rely on, maintain, or simply enjoy using equipment that has been superseded through this obsolescence. Many of these machines accomplish similar tasks using entirely different technologies than their successors do. As such, the machine itself may not have readily available parts or diagnostic support from the original manufacturer. Knowledge required to understand the equipment's operation and repairing potential issues can degrade with irrelevance as technically savvy individuals age or

move on to less niche work, taking with them experience and information; parts become scarce on the secondary market. The resultant preservation problems are multifaceted. In addition to a dwindling pool of equipment that is no longer manufactured or supported, the information that may otherwise keep this equipment operational – or the information necessary to build a functional equivalent – is threatened as well.

Communities invested in maintaining legacy equipment and the information that supports it have, in many cases, coalesced around the preservation of the equipment in organic ways. Internet forums, conferences, swap meets, and interest groups provide like-minded individuals with the ability to exchange information among one another. Individuals approaching these communities may have varying levels of investment and existing knowledge surrounding this information. Some may have a passing interest; some may still make daily use of the equipment; some may be heavily involved in repair; others may be part of a hobbyist community.

Web forums themselves can fall victim to obsolescence, complicate or introduce vastly incorrect information, or go offline entirely. Conferences are often localized and may not focus on documentation. Interest groups can lapse or decrease in membership. Instructional initiatives may lapse. Accessibility, vocabulary, and gatekeeping may all be factors in limiting transfer of this knowledge across user groups.

Through a series of interviews, this research gathered snapshots of the contextual information-seeking behavior of several individuals whose interests or livelihoods hinge on the sustained maintenance of legacy equipment. The goal of this research is to provide useful information that may assist in forming a working group to create a resource that

provides an agnostic enough structure to sustain repair and maintenance information across multiple communities.

LITERATURE REVIEW

Technical knowledge dissemination in audiovisual preservation

The impetus for this research is my participation in the field of audiovisual preservation. The work of the audiovisual preservation field involves the digitization and reformatting of audiovisual materials created throughout the 20th and 21st centuries, stored on a variety of media carriers. Because a wide variety of media carriers have been used over time, the field has also grown increasingly reliant on late-model equipment that is no longer manufactured or supported. In his 2015 article "Why Media Preservation Can't Wait: The Gathering Storm," Mike Casey highlights legacy equipment obsolescence as one of the central issues in A/V preservation work.

Vast arrays of audiovisual cultural heritage material – important documentation of major historical events, as well as stories from the margins – are stored on magnetic media. These media exist within libraries, archives, private collections, and homes. Extracting this information from its carrier at a reasonable level of quality depends on functioning technology to do so and an abundance of suppliers, as audiovisual information carrier formats have been improved upon and/or superseded. This is further complicated by the increasing risk of complete carrier degradation. As Casey asserts, "all analog and physical digital formats are on the same obsolescence slope," and notes the varying factors that make this so with regard to equipment:

- End of manufacturing
- End of availability in the commercial marketplace
- End of bench technician expertise
- End of bench technician tools
- End of calibration and alignment tapes
- End of parts and supplies
- End of availability in the used marketplace
- End of playback expertise

A variety of institutions and initiatives have attempted to slow this obsolescence curve within the field. Two primary approaches have been used, highlighted by UCLA Master's student Brianna Toth: "hands-on mentorship, where technical skills are taught by older engineers or technicians to younger apprentices", and "partnerships connecting archives and collecting institutions with larger proprietary companies." (Toth, 2019). However, as Toth observes, the efforts are largely a product of best-case circumstances or lack sustainability and/or funding. Crucially, "efforts are rooted in the physicality of tape, and for the most part have neglected the playback equipment." (Toth, 2019)

Knowledge surrounding playback equipment has another benefit – documentation and understanding of irreparable, sub-standard, or fragile equipment can be used to create new methods of playback through collaborative projects. A thorough understanding of the drawbacks surrounding mechanical playback of fragile grooved transcription discs has brought about several new technologies to play back the media using optical, non-contact technologies (Shimoda, 2020). Several examples of this type of innovation exist, such as advanced cylinder playback devices (*Endpoint Cylinder Transfer Machine — Endpoint Audio Labs*, n.d.), but they would not be feasible without knowledge of the flaws in the original technologies and materials used to create the media.

Toth uses the example of the conservation of a Nam June Paik video piece at the Museum of Modern Art to illustrate interdisciplinary collaboration as a key element to success. "[The piece] required the help of a trained conservator, the audiovisual engineer and an electrical technician who helped Paik build the original piece. Looking to these success stories in neighboring disciplines allows us to adopt similar practices, workflows, and partnerships."

"Broken World Thinking," Maintainers, and a feminist ethics of care

This paper extends beyond the realm of the audiovisual preservation field to examine information-seeking behavior across similar disciplines that require support, collaboration, and information maintenance. Additionally, I seek to be critical and cautious of the constant heaving forward of calls for "innovation," focusing instead on examining the basic infrastructure of what might make successful knowledge-sharing in the domain of "old gear.'

A useful framing to consult is "broken world thinking," a term coined by Steven J. Jackson in the 2014 essay "Rethinking Repair," and described by others as "focusing on the constant processes of entropy and un-doing…and the work we do to slow or halt them." (Russel & Vinsel, 2016)

Jackson criticizes the "dominant coding of innovation," noted as being at the "start of the technology chain," and asks:

> "can repair sites and repair actors claim special insight or knowledge, by virtue of their positioning vis-à-vis the worlds of technology they engage? Can breakdown, maintenance, and repair confer special epistemic advantage in our thinking about technology? Can the fixer know and see different things—indeed, different worlds—than the better-known figures of 'designer' or 'user'?" (Jackson, 2014)

Adopting knowledge infrastructure from the practices of maintainers can be advantageous, as it engages the "fixer" as a valid part of the knowledge generation process. In particular, this framing is useful when considering modifications and adaptations of legacy equipment to meet the needs of those who repair it or create better solutions. The Maintainers group, founded by the aforementioned Russell and Vinsel, offers a useful *Maintenance Community Framework* for – which seeks to convene organized groups to increase support for the people involved in maintenance. An existing information maintainers group has written its own document, "Information Maintenance as a Practice of Care: an Invitation to Reflect and Share."

In this paper, I hope to consider a feminist ethics of care, as expressed by Jackson and the Information Maintenance group. Both refer to feminist philosophers as being crucial to their approach to maintenance work. Referencing care as a core concept within the individual, the community, and knowledge organization systems, the Maintainers group seek to "sustain generative, speculative, and interdependent systems and environments." (Acker et al., 2019) For Jackson, "care" has a duality of meaning applied to technology and repair:

> For the purposes of understanding media and technology—how it's produced, what it does, what powers and freedoms it opens up and forecloses—the language of care does double work. As elaborated here, it speaks to the ongoing work of maintaining media artifacts, systems, and technologies; it is itself a form of tailoring, appropriation, and resistance (to use language more commonly appearing in media and technology scholarship). But it also opens up an important moral and political terrain. To care for something (an animal, a child, a sick relative, or a technological system) is to bear and affirm a moral relation to it. For material artifacts, this goes beyond the instrumental or functional relations that usually characterize the attachments between people and things. Care brings the worlds of action and meaning back together, and reconnects the necessary work of maintenance with the forms of attachment that so often (but invisibly, at least to analysts) sustain it. We care because we care. (Jackson, 2014)

Both groups, and this research, seek to see the concepts of care, repair, and information structures surrounding this care as inextricably linked.

Right-to-repair

Right-to-repair legislation is also relevant to this discussion, though it is difficult to know how exactly legacy equipment communities and right-to-repair activists overlay, other than that it would be sensible to conclude that there are shared goals. Legislative action has been brought about by communities that cannot perform their own maintenance or have no legal standing under copyright law to perform repair on products. This renders all information surrounding the equipment that falls under this category as proprietary. (Hopkins, 2018). While the full extent of right-to-repair activism is a relevant and important topic, communities that self-identify as "right-to-repair activists" and communities that hinge on maintaining legacy equipment may in be facing more legal hurdles in theory than in practice.

Electronic preservation through collaboration

Much has been written about attempts to capture information collaboratively using novel software, particularly within corporations. 'Groupware' infrastructure is of interest to this project, brought about by information administrators in the mid 1990s who sought to shift software away from a single-user focus within working environments. (Grudin, 1994) In some cases, these would be designed to capture internal decision-making processes, company information, and promote collaborative practices that would ultimately lead to a more communicative information infrastructure. Ultimately, much of this was a failure: "When confronted with a new technology individuals try to understand

it in terms of their existing technological frames, often augmenting these frames to accommodate special aspects of the technology. If the technology is sufficiently different, however, these existing frames may be inappropriate, and individuals will need to significantly modify their technological frames in order to understand or interact effectively with the new technology." (Orlikowski, 1992). While technological interactions have shifted since the 1990s, many of the cautions listed by Grudin in his writing on groupware are relevant to creating collaborative information systems today, most particularly who works on the system, and who benefits. Reaching a critical mass, motivation to use the system, and the system being counterintuitive for users may lead to minimal system usefulness and adoption. (Grudin, 1994)

More modern utilities dedicated to knowledge preservation, particularly in knowledge-holding institutions like libraries, are "essential to large-scale preservation projects employing technology." (Besser, 2007). Contrary to corporate infrastructure, libraries "found it necessary to not only build collaborative teams from various departments within a given library, but to also collaborate with a host of other insitutions." (Besser, 2007). These included "interoperable retrieval of digital content," and "preservation plans." (Besser, 2007) This research hopes to better understand how existing information is disseminated to those seeking it in order to encourage this type of collaboration.

Limitations of information structure

Ontological development is complex and involves an extremely granular level of detail beyond the scope of this paper. Additionally, this research seeks to gather

information for group ontology-building with a community team that has not been formed yet. However, it is useful to understand the limitations and constraints of attempting to build an axiomatic network when approaching the process of gathering information.

The idea that information systems always contain power structures is central to this research. Though this is summarized in great detail in general information science and social science literature, ontologies, along with all information systems, are "reflections of the people and organizations with the privilege to build them." (Acker et al., 2019)

Additionally, ontology-engineering practices struggle in what digital researcher Martin Hepp writes are five distinct categories: ability to build them fast enough to reflect changing domains; resources they consume; communication structures set up between "creators" and "users"; incentivizing use and avoiding conflict; and managing the individual intellectual property of existing ontological structures. (Hepp, 2007). Much of this can be mapped to the previous groupware cautions.

While there are many tools for building ontological structure, few tools seem to exist that provide recommendation of specific system adoption based on a goal of repair information dissemination and human readability. For these reasons, this research does not seek to make recommendations for adoption of existing information ontologies.

METHODOLOGY

Through a series of seven semi-structured informational interviews in August 2022, I gathered context and detail regarding the information-seeking behavior of several individuals who engage in the task of maintaining a range of unsupported legacy equipment. To assist in scoping of what "legacy equipment" means, I defined this equipment as "anything someone cannot feasibly send to the original manufacturer or a certified technician to repair, that someone would also have interest in maintaining."

Sample / Research Participants

Participants were recruited via purposive sampling through a combination of professional and personal networks. I posted on Facebook and Twitter to recruit or receive referrals to potential participants (Appendix A). Confirmation via a follow-up email allowed participants to schedule time slots for interviewing. (Appendix A). Using a combination of the confirmation email's language and the information disclosed to me regarding the participant prior to the interview, mutual judgement for fit between myself and the participant based on the definition outlined above determined qualification for participation. While I asked participants questions about their skill level, I did not recruit based on skill.

Data Collection Methods

Semi-structured interviews were conducted via Zoom video chat and phone call, whichever the participant preferred. Zoom calls were recorded to the University of North Carolina's own Panopto server, whereas phone calls were recorded locally on my computer using a Digital Audio Workstation and moved to the same upon completion. Interviews were targeted for 60 minutes each, but ranged from 60 to 90 minutes in length. Participants were assigned participant identifier members in order to maintain a level of confidentiality. Interviews were transcribed using the transcription software Descript. Although demographic information was obtained, these communities of interest can be small even if they are globally distributed. To maintain confidentiality, only participant identifier numbers and information-seeking interest will be disclosed in this report.

Interview questions were primarily to guide the conversation. (Appendix B) In determining guidelines, I opted to divide the thoughts into:

- the type of information sought around the interest in general, or the motivating factors for gathering information that were not necessarily repair-oriented;
- the resources that contained this information, and
- the diagnostic and information-seeking processes that would lead to information that could assist with repair and maintenance tasks.

The questions sought to provide details to address the research questions of how users seek information about unsupported legacy equipment, what information is captured within existing resources, and where these resources may lack features or

properties to deliver adequate long-term support. I followed up with additional questions where necessary to obtain more detail. I closed with questions that directly asked the participant where they found information resources to be lacking.

Data Analysis Methods

Interview transcripts were coded in the software application NVivo, using a combination of and code identification. I used an iterative process that combined inductive and deductive methods to develop a codebook that identified key themes in responses. In some cases, specific interests could potentially lead to identification, so I have generalized to maintain participant confidentiality. Because some repair communities can be small enough to identify participants based on specialization, some specific details regarding part numbers, locations, and model numbers may be redacted to ensure confidentiality.

Positionality / Researcher Role

As mentioned previously, I participate in the field of audiovisual preservation and have many relationships with "old gear" in personal and professional settings. I have personally convened information maintenance projects within the audiovisual preservation community, and perform maintenance tasks myself. One of the research participants is also a member of this field. Whereas I specialize in audio, this participant specializes in video. In each interview, I began by detailing the central purpose from this perspective so that the core research was contextualized and the interview could be more conversational in nature. However, I attempted to keep the questions broad and general in order to allow for full expression of detail with regard to the participant's interest.

While the research output of this study seeks to assist in the formation of a community resource, it does not seek generalizability to *all communities of repair.* Additionally, I plan to use this research as a starting point for a more formal community focused on carrying forward equipment repair and maintenance documentation.

Since this research will hopefully contribute to the formation of a community, I hope to debrief with peers regarding the results after the conclusion of the project, and stakeholders who may be able to facilitate community involvement, including the aforementioned Maintainers group.

Limitations

The small sample size of seven and single methodological approach were the primary limiting factors during this process.

For example, though only one of the participants was a self-identified beginner, it would have been helpful in understanding the perspective of more beginners in gathering this information. However, there were a broad range of experience levels within those who self-identified as intermediate or expert.

Additionally, the format of the interview allowed for in-depth conversations given the limited time-frame of the research process, but it may have been advantageous to be present for diagnostic processes or information-seeking as it happened rather than prompting for critical incident examination in a questionnaire. Future research in this topic should consider this approach. An advantage of Zoom and phone interviews was the ability to conveniently recruit participants that were more geographically diverse.

Relying on personal networks and purposive sampling for connections was also limiting. Many of the participants I spoke with interface with the specialized interest they were selected for as a primary or supplementary business, making them easier to identify and contact. A possible explanation for this is that outward-facing specialists may have a tendency to monetize their specialty.

Original proposals for this research discussed sentiment analysis of online forums or field observation at swap meet events as alternative or supplemental methodologies for gathering data. Due to time constraints and personal challenges, I was unable to conduct these additional methodologies. I hope to conduct further research as I continue working in this domain, especially with the assistance of other information specialists and scholars focused on maintenance and repair.

FINDINGS

These seven participants' responses regarding their information-seeking interests and behaviors provided useful perspective on how those in hobbyist and professional positions of maintenance navigate the information available to them. Several themes emerged from the responses that may be helpful in informing information resources' construction and possible shortcomings. For reference, a table of research participant information is available in Figure A, below:

Participant Number	Interest	Beginner/Intermediate/Expert (Self-Identified)	Full-time professional?
001	Obsolete / "retro" video game consoles	Expert	Yes
002	Tube audio amplification (instrument, home audio)	Expert	Yes
003	Japanese motorcycles (60s-70s)	Beginner-Intermediate	No
004	Video playback equipment	Expert	Yes
005	Pinball machines	Intermediate	No
006	Vacuum cleaners	Expert	Yes
007	Italian motorcycles (60s-70s)	Expert	No

Fig. A. Research participant information.

Motivations for repair

The feelings, thoughts, and skills that prompted these participants to enter their respective disciplines were a useful part of more thoroughly understanding the context surrounding information seeking during our conversations.

Participants expressed that repair work was often present during childhood:

"So, my dad was, um, into motorcycles for his whole life, because he made a living working on motorcycles. So, we had, like, just, this house that he built out in the country and he would work on motorcycles out there." -Participant 003

"I'm the first born of three children and my dad is an engineer. So as a kid, my dad was in the garage doing different projects…We had a boat. So, I was helping him work on the boat or I was, you know, tinkering with him." -Participant 006

"First, you need to know, I have a bit of a mechanical background. My dad…loved working on things. And so he would tear a motor down like a, you know, a tractor or a car or something in our driveway." – Participant 007

Additionally, several noted that repair work, particularly on legacy equipment, involved a particular kind of technical thinking or mechanical inclination that offered satisfaction in addition to activities that did not involve modes of repair.

"So, I, I kind of enjoy taking things apart and knowing how they work and stuff. So, this has been a really fun place for me to be because not only have I learned about the integral parts of small business and sort of been to the school of life as far as small business is concerned and learned a lot there, but I've also been able to support my curiosity of how things work." – Participant 006

"…The mode of being able to take everything apart and kind of have like a working diagram in your head and just being able to put things back together, um, you know, some people's brains are just kind of mechanically inclined and I, I think pinball was kind of the thing that allowed me to realize that that was something I excelled at." – Participant 005

"The older, like repairing older video game consoles kind of goes more into that kind of technical aspect of it, or mechanical aspect, even though it is, uh, a computer, it is more, uh, mechanical than the modern stuff, in my opinion." – Participant 001

As a specialized skill set and service, maintenance of legacy equipment also offers financial and material incentives. This was not exclusive to those who perform the work professionally, and it was also a point of interest or entry for those who did.

"And, uh, [technicians] would charge me $150 [to fix it] at the time -- this would've been the early nineties - or 200 bucks, whatever. Right. And, uh, then it would break again. So, I taught myself how to fix it through trial and error… once people that I was playing in bands with other bands figured out that I could, uh, fix my own gear, they started asking me to fix their stuff." – Participant 002

"It's, uh, you know, supplemental income right now, as far as like the operation side goes, but I do also do like service calls on people's homes, and things like that. So, if someone has a, a game that's busted that they, you know, it's been sitting in their basement for 10 years and they've never, you know, they've turned it on twice and they're like, I don't know, it doesn't work, come fix it… the restoration side is like more or less kind of a, a hobby so to speak, but then the operation and repair side out in the world is definitely a money-making endeavor." – Participant 005

"Typically, I could buy them for, you know, in trashed, basket case barn find condition for about 1500 bucks and sell 'em for 10 or 11 grand when I was done. But of course, it costs thousands of dollars, many thousands, and countless hours to restore one. And so, it's a question whether this was actually a profitable enterprise for me at all." – Participant 007

Sentiments like that of Participant 007 were also reflected in other responses – occasionally the interest in repair superseded the profitability of it. Participant 002 stated that "out of stubbornness, and I've done this many times over, or just wanting to learn, I have, you know, done something where I've charged somebody a thousand dollars for it, but I should have done $4,000 worth of work in that time."

Training and contextual knowledge

Much of participants' familiarity around the subjects of the information they seek relied on a broad array of contextual knowledge that was not necessarily obtained from specific reference material, but through processes learned in direct repair practice.

"Learning by doing" was a common theme amongst the participants. Though training was a factor in some of the participants' practice, only one participant reported to have attended any formal training surrounding their discipline. Additionally, one of the participants mentioned future plans related to formal training.

> "I do want to apprentice with a couple people that I know that have like small shops, even if it's just like, can I just come and watch you do the repairs? Or like, I can help you out and like, not get paid or anything like that. So that's, yeah, that's something that I'm curious about. I mean, there are also just like general automotive courses, mechanical courses that are at community colleges and stuff…" – Participant 003

Informal apprenticeships, relevant employment, and iterative practices comprised the bulk of sources used to obtain contextual knowledge. Participant 001 said that "A lot of the stuff with retro video game repair is, uh, applied knowledge, right? You fixed one thing one way, and then you're working on something else. And you realize that the way it's built is very similar to the previous one."

> "What are the principles of how a vacuum cleaner performs and what are the essential things in it? So, we had to learn anybody who came to work here. One of the first things you do is, you know, you get a handful of machines set in front of you and you're asked to put them together. So, by the assembly process, you begin… and then over time, being able to have that basic foundation of information, then as new things come along, you're just sort of adding more layers to what you've been able to understand and learn over time. Um, I call it the vacuum technology parfait, because you just keep adding layers to this information that you're learning by manufacturers coming up with these new ideas." – Participant 006

Most described similar feelings about consistent learning through iterative process, and a development of a baseline knowledge of terminology, principles, and best practices as being part of this process.

Support communities & forums

Participants often referred to being part of a community as an important

component of their information-seeking. Participant 003 expressed that community and

social interaction is a motivating factor for participation and interaction with repair work:

> "A real-life community here…where we all kind of like, help each other work on
> our bikes and everything, we ride together and all of that. But, you know, I think
> there is a lot I love like, in person, like, getting information from another person, I
> think that's the coolest thing in the world…A lot of my friends that I ride with and
> everything, are kind of in the same place as me where we're all just like, figuring
> out what we're doing together."

Participants also mentioned that like-minded community members can differ just

enough to provide useful perspective on an issue or process:

> "Well, one of the things with, uh, talking to other technicians that you know is a
> lot of times you end up like in life, you know, friends are people that you usually
> can relate to, right, have a similar mindset and things like that. And a lot of the
> technicians that I've gotten to know, personally that I keep in touch with have a
> very similar brain, like process as mine, but still different. And, uh, like, a lot of
> things, when you're having a hard time with them, sometimes a fresh pair of eyes
> is all you need, you know, somebody to look at something and they think just a
> little bit different than you and they'll catch something that you didn't." –
> Participant 001

> "So if you're having trouble approaching a problem, you can post there and likely
> someone will come at it with maybe the right answer or at least like a totally
> different perspective on it. Um, You know, those, those forums are all like pretty
> readily active. Um, and I… I'll go there and kind of, uh, you know, if I'm ever
> stumped on something, I'll ask a question there all the time." – Participant 005

All participants mentioned at least one electronic forum or online community that

they consulted on a regular basis that had information-seeking value. These were mixed

resources and consisted of social media, dedicated user forums, and collaborative web

resources, the latter often being within the framework of legacy or "web 1.0" sites. These

all varied in scope and specificity. Both motorcycle technicians, participants 003 and 007,

referred to forums that were hosted for specific model ranges or makes in their range of

interest. Participant 006 spoke of forums that are hosted by brands particularly for trade professionals, such as dealerships and licensed technicians.

Generally, participants expressed that forums were key sources of information for corroboration of experience, advice from more advanced or knowledgeable peers, or specialty information. In particular, solutions to issues often appeared in forums without the need for additional diagnostic activity for the participant:

> "I'll take a look at their solutions. I'll take a look at what my game looks like. And then I'll go back to the, you know, then I'll go back to the issue and say, well, is that the same thing I'm experiencing? And oftentimes it is. And then I don't need to ask anything." – Participant 005

Participant 005 also spoke of consulting a defunct forum, Rec.Games.Pinball (RGP) in which professionals from the original manufacturers were networking and heavily involved. For Participant 005, this forum was not just useful for obsolete information but was also useful documentation of networking, job lineage, and potential contacts that may not have carried over into newer resources.

Participants did tend to speak of forums and community channels as helpful but potentially overcrowded sources of information:

> "There's plenty of times too, where, um, even going on the Facebook groups, they don't have answers because unfortunately with the Facebook groups, um, as, even though there's plenty of guys that know what they're doing, there's even more that have no idea what they're doing. They're gonna recommend you things that you already know won't work just because *they* think it worked." – Participant 001

> "So you gotta kinda discern and that's, you know, based on experience and, and, and that sort of thing where you, you start realizing like, oh, I've seen this, this thing repeated over and over and over, and it's just become a fact, you know, but it's not really a fact. It's just, you know, somebody's opinion from 20 years ago, iterated enough different times." – Participant 002

> "I think people like, you know, one of the things about we all have internet now, which is great. Um, but part of that also means that like a lot of useful information is a lot more diluted than it used to be." – Participant 005

"I think that people are trying to be helpful. I think just, a fair amount of people who don't know what they're talking about and are wrong, but they're sharing like experiential stuff fairly openly." – Participant 004

Those who were full-time professionals spoke of spending less time commitment as an active participant within these communities compared to those who were not, as community participants, but particularly in relation to information sourcing:

"I have only a few times, ever posted on forums - because I have a short attention span for that. So once I found what I needed, uh, I'm not likely to go visit again until the next time I need something." – Participant 002

"We're not gonna probably encourage or try to spend even more time going to a forum. For other dealers to tell us the same thing that it's just not available and it's not worth doing, okay - at that point in time, we would talk to a customer about upgrading and just getting something new." – Participant 006

Participant 001 stated that "over time, less and less people use the [legacy] forums, which means less and less people to give you answers." This participant also stated that the majority of support had moved to Facebook groups where travel of information was more immediate.

Known issues, modifications, improvements, and diagnostics by "feel"

One consistency across respondents was the identification of commonly known problems - and solutions for them - as a useful tool for expediting repairs. Several respondents noted that their disciplines of interest had already-known issues that were common, but not part of regular diagnostic procedures for more general equipment. Often, solutions would be documented in information resources:

"Over years, that [Atari 2600] grease caused issues with the, um, potentiometer in there because the grease itself was non-conductive. But as you're using the paddle and dirt and dust and grim is collecting in there and the paddle itself is slowly deteriorating and the brass is scraping off little bits of like microscopic parts of, uh, the carbon. Now that grease is all mixed together. And now that grease is

conductive and it cause an issue with the paddle. So going, you know, fast forward and almost 50 years, we know it doesn't need the grease. So we just open up that potentiometer, completely remove the grease and close it back up." – Participant 001

"This screw right here, this a, a [part number]. It like, it breaks it's - oh, it's infuriating. It's like, it's broken on every single game I've ever gotten and I've broken a bunch of 'em and I've, I've learned my lesson that you like, you don't mess around with that screw from the front…The one guy with the information on how to make it went ahead and found a way to make it for all of us who had been, you know, banging our heads against the wall every time that we come in, that screw's broken." – Participant 005

Modifications and improvements to unsupported equipment can also provide preventative maintenance and solve common problems. For example, participant 003 outlined a low-cost solution for improving motorcycle ignition by replacing the existing system with a modern electronic version. Participant 007 also mentioned a low-cost solution for replacing a bearing that caused particular problems on a particularly specialized and rare Italian motorcycle, saying that "I have done that with every engine that I've put together and it will never again cause a problem. Like that's just a, it's a clear and obvious improvement over the original…that I would never have known about without talking to someone who's a true expert."

Multiple participants also noted that diagnosing and solving an issue was often based on "feel," a tangible way of fitting components together that could not be documented but only achieved by direct interaction with the repair object:

"It's a combination of finding information and then actually doing it and coming up with my own little kind of tactile routine for how, how these parts feel when they go together the right way and how they're going to behave." – Participant 007

"In my job, I've always figured out that, that my ears and feel, you know, both in repairing and just sort of, if I'm playing through, you know, the amp, which is part of the instrument, that type of feel as well, but the feel I was talking about first is

sort of just the knack of getting things working. Which comes from sort of a different place than, you know, than a textbook." – Participant 002

Parts, specifications, documentation, and revisions

For some fields, supplementary documentation - such as schematics, service manuals, and parts information – was not difficult to find and was widely available on the, internet either for free or minimal cost. Several respondents kept a library of this documentation or acquired it alongside equipment and referred to it often for reference:

> "An important, uh, resource, which is a website that the guy gave up on, but somebody else had, you know, people archived it…schematicheaven.com or.net. I forget what it is by now, but, uh, that one's broken down by manufacturer and then click on the manufacturer and it's got, you know, schematics, people supplied to this guy." – Participant 002

> "The first resource that I'm gonna turn to is a service manual…I'm lucky that I have a library of them." – Participant 004

However, challenges in this domain were frequently discussed. For parts, two distinct trends appeared. One trend was an intentional manufacturer obsolescence in contrast with actual parts scarcity on the aftermarket. Participant 006 services new vacuum products in addition to older equipment, and expressed that often more challenges are faced with intentional lack of manufacturer availability in products currently in production, often making these products more difficult to service than the unsupported legacy equipment.

> "In the forties and fifties and sixties when Electrolux salesmen were going door to door - when I started working here in the nineties, people still had those 30-year-old machines, which we could still service. But they were very simply designed. So, I mean, it was, you know, a switch, a motor, and a chamber for the bag. And you had your hose and things were pretty simple. It was easy to maintain those machines for a long period of time. And then by the time we had the early two thousands and then we're approaching 2010, things became more plastic, motors were not made to run as long. So, the life cycle of these things were shortened, um, considerably, and, and now in 2020, I would say it's been severely shortened

as far as what the lifetime is, because a lot of manufacturers now do not make very many, if any parts available for their product after that unit leaves, you know, the store where a person buys it."

This is in contrast with scarcity or accessibility of useful legacy parts production information available in some disciplines, where participants' experience stated that direct manufacturer replacements cannot be obtained, but suppliers may exist in the aftermarket, or sources of original manufacturer parts may exist in inaccessible places. Participant 007, when speaking of visiting a repair shop which was purported to have rare parts: "They have the stuff. I think the old, the old guy might have been, like, a mechanical expert back in the day, but now he kind of can't be bothered." Respondent 001, when speaking of original equipment manufacturers for name-brand gaming consoles, discussed that factories held onto overstock and willfully sold it but that the quantity was finite: "So a lot of times it's not that the company, um, can't make this part anymore. It's that they, uh, don't see the need to."

Aftermarket suppliers can serve as useful sources of part information, but respondents had a wide variety of experience in terms of production metrics, production quality, and richness of supplier information with regard to specification or fit.

> "So it's like parts, databases do exist…it's just a, it's just a matter of, um, you know, like how, how willing am I to go and like find all of them, and how useful and…useful and dissectable or digestible is all this info, you know?" – Participant 005

Used parts frequently required specific context to obtain or understand in these terms:

> "So these two carbs…uh, are connected using this linkage device, which is like just a bent piece of metal that you can put on here and you cannot buy them anywhere on the internet. You literally either have to like, make your own or buy an old pair of carbs that still has the linkage device on it. So that essentially was like scrolling through eBay until I found one that had pictures of carb device, I

bought it. And then I just took that tiny piece of metal off, used it and then put the full carbs in my shed, you know?" -Participant 003

"People are gonna go nuts over that [part], you know, because. because, um, you know, a lot of the time, those parts, you can't find them a lot of the times, uh, when people try to reproduce those parts, there's no way to actually recreate them sometimes. Um, you know, uh, it's, you know, it's illegal to paint with these types of chemicals now or something like that, you know, there's, there's all sorts of, you know, there's all, there's - sometimes there are, are value to games that have X, Y, and Z that come along with them." – Participant 005

A primary reason indicated for lack of access to source materials that may assist in maintenance was intellectual property ownership, often because of an acquisition or merger. Multiple respondents indicated that companies who stewarded information were either no longer effective owners in terms of support or litigated against owners of intellectual property for maintenance purposes. I will omit direct quotes for this example to protect participants.

Finding and validating "correct" information

Another key finding is that information, particularly repair information, present in materials is not often easy to validate, and that as such there is limited ability for users of information resources who may not have adequate context to find the "correct" solution to an issue if that is the intended goal. However, when questioned respondents overwhelmingly stated that a "correct" solution in repair work on legacy equipment is rarely present, due to a number of factors.

One reason respondents indicated may be that the most readily available solution that was "correct" according to the community in the past may no longer apply in current circumstances, due to information "dilution," known failures over time, a scarcity of resources, or better available solutions, all previously mentioned.

Additionally, participants indicated that behavior within information communities may not clearly point to one available solution, because of a lack of issue replication, agreement, or confirmation of success:

> "No one agrees on any of it. Like people think that their bikes run better on this size jet than this size jet or this size gap on this bar plug and this one. And so it's like, it would be helpful, um, if we agree, but we just don't agree on it, you know? …I think it would be cool if there was some kind of method in which you could sort things like by solution, I guess like the thing about all of these forums is there's all of this helpful advice on there, but then there's not really a whole lot of follow up of someone following up and saying like, Hey, this worked, or this didn't work." – Participant 003

Instances of communication issues or skill gaps were also noted as hinderances to obtaining a correct solution:

> "And compared to a lot of the books that I'd read earlier, where people are trying to teach guitar amp stuff. For some reason, the [engineer] that's not a professional amp dude is way better at explaining many of those things." – Participant 002

> "A lot of the time these people have been working on [motorcycles] for their entire life and they answer your question, but in order to understand what the answer is, you have to do another, like two hours research of every term that they used." -Participant 003

> "I think that having like, venues for community for discussion is really important because like, I don't think I'm a particularly good writer…Where I would fit in personally with like wanting to share my information would be like in a room full of people who are gonna do a good job of translate what I tell them into some sort of written documentation, having like a conversation with people." – Participant 004

> "I'm not a programmer. I've never looked at like, you know, I don't know - the difference between building something in like assembly versus building something in like a more modern framework that they use now. It's way over my head. I love hearing about it, but I, it's not, it's just not something I can re like relate to." – Participant 005

> "He doesn't, he doesn't wanna sit there and talk with you all day. It's like, right. You give him a brief sentence of what you want. He probably will come back with a bit of a smart ass answer and probably tell you to go read the manual or something, but then he'll feed you some nugget of gold that's exactly the thing you needed to know." – Participant 007

Participants also indicated a sense of stubbornness and purposeful gatekeeping from experts as an issue. Respondent 004 commented that "I feel like when you get to like the older school, like actual experts and technicians in video, you get like a fair amount of like hoarding of information." Participant 006 noted, "There are a handful of folks out there who tend to hold things pretty close and feel like everything's a competition."

Generally, participants did not seem to indicate that "correct" information was what their information-seeking behavior was after:

> "It would be nice to kind of divorce it from like the capitalistic mode a little bit. And that would be like just a, like a venue for people to talk and not worry about like wasting time or wasting resources than just like discuss. And I think the communities in the discussions have to be less geared towards: what is the right way to do this and more geared towards like, what is a way that we can do this?"
> – Participant 004

CONCLUSION

It is difficult to determine based solely on this information how a discipline-agnostic resource surrounding repair tasks may be germinated. In conducting this research, it was apparent that many of the issues faced in prior attempts to collect information were still present. The continuous morphing of information as technology advances is incredibly difficult to capture as the amount of information grows, redirects, and shapes to fit its users, and experts pass on knowledge in ways that are not entirely translatable to modern, digital information structures.

Several issues in the findings indicated possible efforts that might be investigated in further research:

- Literature, recommending repair-based ontologies that apply generally across repair disciplines.

- Methods to assert multiple user-submittable solutions to repair problems within structured information.

- Aggregation of parts databases into a centralized resource and modernization of diagnostic flowcharts from service manuals.

- Reconciliation of structured repair information as repair needs change over time.

- Methodologies for increasing diversity and accessibility within repair conversations, using a centralized resource.

It was heartening to learn that many of the participants were enthused about the idea of creating a new resource and faced similar issues within their respective disciplines. As communication structures diversify and modernize, I hope to contribute to better resource-building for knowledge maintenance through community organization.

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APPENDIX A : EXAMPLE RECRUITMENT MATERIAL AND

FOLLOW UP

Example recruitment social media post

Hi! Does anyone I know personally (or have connections to people who) maintain and repair unsupported equipment? I've got audio and video covered, but this can be anything else, basically. For example, old farm equipment, vacuum cleaners, pinball machines, coffee makers - anything that you can't feasibly send to the original manufacturer to repair that someone would have interest in maintaining. I know this is a weird ask, but it's for my Master's research - please feel free to message me. Thanks!

Example recruitment follow-up email

Hi [Participant],

I'm writing to see if you might be interested in speaking in detail about [subject of interest] with me. This is part of the research process for my Masters' paper. I'm looking to discuss this with you as part of a larger project, which hopes to better understand how people seek and use information surrounding unofficially supported legacy equipment. Since you've indicated that you regularly repair or maintain legacy equipment, it'd be great to have you participate in this research.

If this interests you, I'd like to schedule a one-hour informational interview via phone or Zoom, preferably the latter. If it is a Zoom interview, it's up to you whether you would like to have your camera on. There will be a portion of the interview where I request that you share your screen - If this is not possible, I can also share mine. The meeting will be recorded for note-keeping purposes only. Please use <this Calendly link> to select a time that works best for you. You can contact me with any questions at dwh@email.unc.edu.

A high-level, generalized agenda for the meeting:
- Introductions and background
- Discussion of information
- Discussion of resources that contain information

      • Screen-share/walk through (if you are able to share your screen)
      • Other thoughts/closing

Thanks, and looking forward to this. Please take care!

[email signature]

IRB (Institutional Review Board) Study Number: 22-0876
You can contact the IRB at 919-966-3113 or by email to IRB_subjects@unc.edu.

APPENDIX B : INTERVIEW AGENDA AND QUESTIONS

- Introductions and background

  - I'm going to record this, just want to double check once again that that is OK. Also going to enable transcription - this is for note-taking purposes only.

  - Please introduce yourself, and I'd love a little background on how you became interested in [subject of interest]. Additionally, if you could describe your experience level and self-identify as a beginner, intermediate, or expert in terms of this world.

  - To speak a little bit on where I'm approaching this from, I work in audiovisual preservation so I spend my days transferring old A/V formats to digital surrogates using late-model equipment. One of the key challenges of audiovisual preservation is what we call "degralescence." This describes the degradation of the information on the media we are trying to preserve, which is actively decaying, and the increased obsolescence of technology. This obsolescence is not just impacted by the fact that the machines aren't the current standard and aren't supported by their manufacturers - it's also that you can't get parts for them anymore, the knowledge base around them is growing older, etc.

  - With this challenge in mind, the goal of these interviews is to see how other folks who deal with similar unsupported equipment seek out information, in the hopes of gathering enough data to see how maybe we can be more mindful of how we structure, store and pass the information on.

  - So in this interview, we'll cover a few modes of investigation. I'm interested in what you know, but what I'm after is not necessarily expertise, it's more about how you use what you know, to contextualize and find information when you don't know it. I want to talk about the information you're after when you do maintenance and repair work, how you find it, and then if it's okay with you I'd like to actually walk through the process as best we can based on this information. I may ask for more detail on a topic, and please be as detailed as you can be!

- Discussion of Information

- So let's talk about what kind of information you typically look for in terms of [subject of interest] in general.

  - Do you spend a lot of your free time researching or thinking about [subject of interest]

  - What kind of information intrigues you?

  - Are there parts of this information that don't intrigue you, or generally feel less interesting or useful?

  - Does this extend into a community?

    - If so, what kind of information presents itself in that community?

- Discussion of resources that contain information

- Ok, now I'd like to talk about some of the resources you might turn to for this information.

  - For this, and the following section, it might be helpful to think about a time you had to troubleshoot something recently, or an issue you encounter often.

- I'm focused mainly on electronic resources here, but I'd like to know - are there non-electronic resources you frequently turn to in your current work?

  - If so, what value or useful information do they provide?

- Ok, let's talk about electronic resources if you use them. These can be forums, listings, anything.

  - What kind of resources do you turn to?

  - What value or useful information do these resources provide?

  - Are you aware of a user base for these resources (think beginner, intermediate, expert)

  - Is the resource forthcoming with correct information?

- Screen-share/walk through (if you are able to share your screen) - feel free to open up a separate browser window, do whatever you've gotta do.

- OK, let's think back to a time recently where you had to troubleshoot something using an electronic resource.

- What do you search?

- Where do you start?

- Walk-thru resource

  - Things to keep in mind: what details feel like they are "crucial?" What keywords do you use to determine whether a piece of information is trustworthy? How do you navigate the resource?

  - I may stop you.

- Other thoughts/closing

  - In your opinion, how might [subject of interest] be better supported by information resources?

  - Do you have future plans to build your skill set or train in some way? How might resources better inform this? What information might be helpful?

  - Thanks so much for your time. If you happen to have additional thoughts after the meeting, please feel free to be in touch.