Research Article

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Making exploratory search engines using qualitative case studies: a mixed method implementation using interviews with Detroit Artisans

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Abstract: Search engine algorithms are increasingly subjects of critique, with evidence indicating their role in driving polarization, exclusion, and algorithmic social harms. Many proposed solutions take a top-down approach, with experts proposing bias-corrections. A more participatory approach may be possible, with those made vulnerable by algorithmic unfairness having a voice in how they want to be "found." By using a mixed methods approach, we sought to develop search engine criteria from the bottom-up. In this project we worked with a group of 16 African American artisanal entrepreneurs in Detroit Michigan, with a majority female and all from low-income communities. Through regular in-depth interviews with select participants, they highlighted their important services, identities and practices. We then used causal set relations with natural language processing to match queries with their qualitative narratives. We refer to this two-step process– deliberately focusing on social groups with unaddressed needs, and carefully translating narratives to computationally accessible forms–as a "content aware" approach. The resulting content aware search outcomes place themes that participants value, in particular greater relationality, much earlier in the list of results when compared with a standard Web search. More broadly, our use of participatory design with "content awareness" adds evidence to the importance of addressing algorithmic bias by considering who gets to address it; and, that participatory search engine criteria can be modeled as robust linkages between interviews and semantic similarity using causal set relations.

Keywords: search engines; participatory design; algorithmic bias; Detroit; mixed-methods

1 Introduction

Search results are grasped in a myriad of ways that mix multiple quantitative and qualitative approaches. For example, a phrase might be entered with multiple semantic interpretations; ask for results ranked in by price; or further introduce other categories on a search menu. The fact that the categories themselves are not neutral along with the opaqueness of the inner operations of the search result rankings can contribute to ongoing societal issues, such as which web pages are visible to a population and why, and especially when an assumption of neutrality masks various kinds of harms (Goren et al. 2021; Lucas and Introna 2000; Mager 2012). To address this issue various kinds of critiques and alternative search techniques have been explored (Benjamin 2019; Gillespie 2018a; Lewandowski 2019; Wijnhoven and van Haren 2021). In the 1980s researchers began to describe how the older model of fact retrieval – "what is the atomic weight of gold" – was giving way to exploratory searches, in which the user undertakes an iterative series of queries, often gathering information and even changing the query phrase as they proceed (e.g. Bates 1989). We discuss that in greater detail below, but the essential point is that in such cases, we tend to see the reduction of reality's rich description into a rigid set of keywords. This reduction allows "gaming the system" or appropriation that can mask underlying relationships. If, for example, one merely searches for a product using keywords such as "black-owned beauty products" they will likely see what appear to be "black owned" by cultural

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signifiers, and are sometimes even appear online in lists of "black owned", but are actually subsidiaries of large white-majority owned corporations. As (Morris 2020) notes these include geographic names such as "African Pride" or signifiers of kinship such as "Aunt Jackies".

As noted by Ziewitz (2019), the general phenomenon in which there is a gap between what users are actually seeking, and the ability of websites to deceptively elevate their positions in search results, has been characterized by a wide range of valuations, from vaguely positive ("aggressive marketing") to highly negative (misinformation, deception, misconduct, unethical behavior, gaming the system, etc.). For the purposes of this paper we focus on the distinction between what we term "superficial appearances" – the kinds of keywords most vulnerable to utilization in deception – and "deep content" that could be used to better identify more egalitarian and sustainable relationships between consumption and production. In doing so we hope to make search engines a better tool for achieving what has been referred to as a relational economy (Mhlambi 2020), ubuntu ethics (Birhane 2021) or generative justice (Eglash 2016). Because conscientious searchers care about deep content – the authentic product attributes that are often overlooked or whitewashed in standard marketing strategies – they instinctively want authentic descriptions. Artisans describing how they wish to be found along with their deep knowledge on what they have to offer are examples of these authentic descriptions.

This project will proceed in two phases. In the first phase, examined in this paper, we look at how machine learning can help facilitate the move from interviews with the artisans to data structures that can drive searches. In doing so, we want to get at elusive and qualitative aspects that have great value to some buyers: authenticity, grassroots legitimacy, sustainability via localization, and so on. We will then test a typical search for the same items against a search that can better tap into this body of knowledge. In the future phase of this work, we will look at the problem from the consumer end: how do we "translate" the words they might use into these kinds of searches?

Overall, we are designing for the set of consumers that are sincerely looking for more just and sustainable purchasing, and the set of makers involved in creating those items, systems, and asking how search algorithms might facilitate these connections from the bottom-up. There are top-down approaches – relying on certification programs, advertising campaigns, and so on – but they often reduce to the question of who can spend the most on marketing or other problems in which someone is "gaming" the system (Balsiger 2021).

As a research question, we consider an interested non-expert user that would like to conduct an exploratory search for two separate but culturally important topics: supply chains in Detroit and African art. Because of their pervasiveness, this user is interested in using search engines in a move towards the relational economy, specifically of generative practices (Eglash 2016), but largely does not know where to begin. This user can be viewed as exploratory searchers looking for expert knowledge that they know little about. As guidance towards potential pathways to knowledge one place to turn to are known experts, such as artisan entrepreneurs and their *generative* outcomes. There are ways that those made vulnerable by algorithmic unfairness would rather be "found," or represented, and connecting these voices to exploratory searchers is a type of search. Thus, in support of bottom-up exploratory search engines we ask the following initial research question:

Research Question 1 (RQ1): Can search results from a content agnostic search engine be reordered to reflect meaningful outcomes and practices present in semi-structured interview data using content-aware modeling?

To test this research question, we first identify conditions where *content awareness* can lead to successful exploratory search. This necessarily requires a viewpoint to be adopted. In our case, we worked with artisan entrepreneurs from Detroit. Through semi-structured and unstructured interviews we then developed a search engine criteria that models a body of rich description in computational addressable form. This integrative approach adopts a method from sociology for causal analysis (*qualitative comparative analysis* (Ragin et al. 2003)), and applied machine learning. Using these mixed methods, our initial test case uses the phrase "supply chain detroit" and "african art" because we expect superficial result appearances to occur and can examine differences between our proposal and standard searches. This initial exploration will be generalized more broadly in later work.

In comparison to a "content aware" version we highlight how participant themes, including greater relationality and practices, are listed in results far earlier. The results from the content agnostic approach, from a standard search engine, were primarily a list of job openings (16/30) whereas the content aware approach listed other opportunities possessing greater relational components while including far fewer job openings (7/30). Additionally, initial quantitative-qualitative evaluations of two searches suggest that our approach continues to bring potentially relevant results up front even as more and more web pages are considered, in contrast to standard approaches.

Generally, although our method is focused on reordering results, our approach contributes evidence towards the importance of addressing bias in algorithms by considering who gets to address it and how. For example, as briefly theorized in Section 5.1 Future work, our reordering approach could directly support reinforcement learning with human feedback (*RLHF* (Ziegler et al. 2020)) to create an exploratory chatbot, instead of a search engine. That a series of in-depth interviews can be used to significantly reorder and surface search results is striking given the relative directness of interview as a method. This suggests an

alternative way of accessing attributes or properties that may be unknown or poorly specified by top-down methods or that assume predetermined categories. Example qualities include broad descriptions of activities, retold experience, and evolving needs. For some, starting with qualitative modeling may better describe the kinds of statements from the kinds of people that the searchers are looking for.

2 Related work and background

2.1 Exploratory search

2.1.1 Definitions of exploratory search and relationships to our approach

To explore and situate our claims we first relate them to the broader field of exploratory search (e.g. Bates 1989; Belkin 1980; Marchionini 2006; White and Roth 2009) to illustrate the gap they fill. Exploratory search definitions in historical literature are largely based on activity and context. As an early case, the *berrypicking* model demonstrated that berry foraging strategies were closer to information seeking behaviors in practice than traditional information retrieval (IR) models by highlighting human variation in query intent, search processes and techniques used (Bates 1989). Later work in HCI and IR (White and Roth 2009; White et al. 2007) used an activity typology (Marchionini 2006) to encapsulate exploratory activities as learning and investigation. Exploratory search, especially of the collaborative kind, is often clear from user behavior but the variety of definitions do not point to a single commonly accepted definition (Palagi et al. 2017). That said, a popular definition of exploratory collaborative search, includes four core activities: sensemaking, division of labor, persistence, and awareness (Marchionini 2006).

Participatory design through ongoing interviews of search engine criteria varies the traditional divisions of labor between user, designer, and expert by commingling expertise and considerations that are often kept separate. One implication is that the conclusions and perspectives from those whose entrepreneurial practices contribute most to goals of diversity, equity, and sustainability are necessarily distinct from researchers aiming to do the same. This provides a new integrative viewpoint. Currently web searches typically deliver consumers to large corporations that can offer the lowest prices. Because of their size, they and other institutions are able to avoid labor laws, environmental restrictions, suppress democratic control of national and local policies (Mishel 2022; Mishel et al. 2020; Tian 2021). Searching using criteria from entrepreneurs allows searchers to choose different algorithmic biases.

2.2 Prior work

2.2.1 Empirical approaches: Dimitris Kardaras, Joeran Beel, and Lequn Wang

To differentiate we compare and contrast our claims to relevant literature on search personalization and algorithmic debiasing. These approaches fall into one of three kinds: qualitative comparative analysis, the use of personalized mental maps, and the use of multiple distinct fairness concepts. Like us, Kardaras et al. (2018) use qualitative comparative analysis to model the connection between rich descriptions and quantitative moves. Karadaras et al. (2018) draw on a large number of short text responses left on review platforms to develop models of user interest for, among other applications, web personalization in recommendation systems (Adomavicius and Tuzhilin 2005; Beel et al. 2016; Montaner et al. 2003).

What differentiates our approach is that we explicitly minimizing the relational moves from *thick to thin description*, following warnings from Pagliarin et al. (2022) by openly including artisan entrepreneur perspectives through repeated in-depth interviews. In doing so, the basis of personalization, even of the entire system, is broadened by multiple considerations. In computing related disciplines – such as CSCW – thick description (Clark and Chevrette 2017) is often used to (cf the work of Jonthan Grudin or Saul Greenburg) to better understand how users perceive, and work with computing systems, including how they would like them to be better designed (or eliminated). Following recent calls (Bennett 2021; Eglash et al. 2019; Green 2020) to incorporate other forms of understanding and action into the creation of equitable software, we propose an alternative term, "grounded description", because we would like to allow our interviewed participants' own words to indicate the ways they want to be found by search engines. The term comes from "ground truth" in GIS, where it refers to conditions of a locality prior to digital representation (Goodchild 2006).

In an earlier PhD thesis Joeran Beel uses personalized networks of linked associations, or *mind maps*, within interaction networks of other users to model a mind map belonging to a specific searcher using their research article recommender system, *Docear* (Beel 2017). In contrast to text responses, mind maps do structure rich content but both kinds of data overlook surrounding context inquiry and are not incorporated within measurement. Inquiry is often important because additional content and context is incorporated that may be overlooked yet still lead to useful recommendations.

Lequn Wang and Thorsten Joachims consider the problem of reordering (or, *ranking*) fairness across three related but distinct concepts ("*desiderata*"): user fairness,

item fairness, and diversity (Wang and Joachims 2021). By simultaneously addressing multiple concepts they attempt to mitigate other unintended conceptual harms caused by focusing on a single concept. However, qualitative moves provide an alternative way to express user intents. As a limitation, Wang notes that as the number of intents grows trade offs between their fairness concepts emerge. This gap suggests that participatory design approaches that attend and preserve grounded description may allow a greater range of users to express their intents where fairness convex optimization approaches may not.

2.3 Related broader critiques

2.3.1 Within the exploratory search literature

Sensemaking is another area where social and personal context can decide the applicability of results. Sciascio et al. explore reranking using implicit browser data but conclude that even richer sources could be considered: folk taxonomies, especially logsonomies, to suss out result relevance for sensemaking (di Sciascio et al. 2020). We consider a similarly rich source: interviews. Their contribution, an adaptive system, uRank, for exploratory search of documents, using implicit coordination is relatively rare in collaborative exploratory search. Sensemaking, social coordination, and social complexity interact together in significant ways that impact long term use but are often addressed only as single or paired concerns.

2.3.2 Within human computer interaction (HCI) and science and technology studies (STS)

The importance of participant involvement is echoed in many related critiques from human computer interaction (HCI) and Science and Technology Studies (STS). Most notably, Saifya Noble's imagining of public noncommercial search (Noble 2018, p. 179) is reflective of issues that arise when motivations such as classification, intersect in unexamined ways. After calling for Black Feminist Technology Studies as an intersectional theoretical perspective from which to investigate and resist ongoing technology, Noble proposes a "decoupling of advertising and commercial interests from the ability to access high-quality information." Noble proposes that anti-black and misogynistic content be filtered out (Noble 2018, p. 179) from search results. However, because filtering leaves in place the original search result ordering it is unknown how users can otherwise surface and include at an earlier point viewpoints those they wish to model in their exploratory searches. By reordering we complement filtering oriented approaches that leave original orderings intact because more desirable results can appear earlier.

A bottom-up participatory design approach to search engine design criteria can be taken as a response to a number of other broader critiques found in HCI and STS. Interviews and inquiries into how others want to be "found," their practices, and businesses provide alternatives to traditional design approaches that have received a number of critiques. Unchallenged quantitative modeling often follows from Donna Haraway's concept of the "view from nowhere" (Haraway 1988) where deductive objectivity appears universal both in form and application. Much of design in HCI is WEIRD and white (Botero et al. 2020; Himmelsbach et al. 2019; Ogbonnaya-Ogburu et al. 2020; Sturm et al. 2015). Because search engines themselves are platforms (Gillespie 2010, 2018b; Helmond 2015), that carry ideologies and issues (Plantin et al. 2018) it is useful to consider methods of design that provide proactive alternatives, such as the notion of content-aware as opposed to content-agnostic approaches found in Lachney et al. (2016). Participatory design is a known method for decentering traditional expertise while developing applications for long term use (Harrington and Dillahunt 2021; Kensing and Blomberg 2004; Wong-Villacres et al. 2020).

2.4 Background: why qualitative comparative analysis (QCA)?

The literature on representing qualitative statements in computational addressable forms is vast and spans several epistemological paradigms, including: quantitative modeling using neural networks (Cer et al. 2018; de Rosa and Papa 2021; Mikolov et al. 2013), graph based modeling (Mihalcea and Radev 2011; Osman and Barukub 2020), and, although differently than natural language processing, joint integration as a mixed method – where qualitative data is jointly integrated with, not reduced to, quantitative data (Guetterman et al. 2015; Maxwell 2016). Because grounded description highlights the nuanced ways multiple experiences and action can lead to similar outcomes, it is more than the sum of its parts. We chose to represent statements through integration rather than modeling alone so that the broader and overarching context of participant statements are computationally and visually addressable as well.

To achieve integration in our computational context, we adopt a widely used method in sociology and several other fields for causal description of small case data, *qualitative comparative analysis* (QCA). QCA is recommended for analytical situations where (a) multiple interactions among causal factors is possible, (b) the outcome phenomena under study can be constructed in a variety of ways, and (c) there are a small number of samples and the samples are qualitatively rich (Pagliarin et al. 2022; Ragin 2009).

Interview data from expert participants match these recommendations but our use of QCA differs from classical QCA

along two major areas. Firstly, as opposed to a singular hypothetico-deductive method, we locate QCA within a sequence of methods that together help formulate search engine criteria. Secondly, whereas classical QCA assumptions are designed to test hypotheses we use the method to answer research questions. For these reasons we refer to our use as *QCA inspired* to delineate its use apart from classical QCA assumptions.

3 Methods

3.1 Description of participants

We conducted multiple in-depth interviews with a group of 16 African American artisan entrepreneurs, a majority female and all from low-income communities to better understand their important services, identities, practices and how they wished to be "found," through grounded description (Table 1). We view these entrepreneurs as experts in their own experiences who are able to richly describe a foundation for bottom-up search criteria. This study was reviewed and approved by a large mid-western university Institutional Review Board. Interviews were conducted from August 2021 through June 2022 and involved 20 onboarding interviews and 32 semi-structured and unstructured interviews. We purposely included emerging artisans (cf case 5, Table 1) to contrast how their practices and opinions develop over time.

3.2 Semi-structured and unstructured interview

3.2.1 Qualitative sample size justification

Following sample size guidance using the concept of *information power* (Malterud et al. 2016), artisans possess rich and expert knowledge where: (a) they can share rich knowledge relevant to both small and wide study aims; (b) each expert has extensive unique knowledge and can recommend others, so the sample specificity is dense; and (c) the quality of dialog is typically strong and even absence of dialog is suggestive because of the length of interviews.

3.2.2 Procedure

After obtaining consent, participants initially were interviewed at home or their place of business using a semi structured protocol designed to facilitate open ended comments and discussion on business practices and relationships to technology. We purposely partially facilitated conversation with "how" type questioning and encouraged open ended responses. Confirmation bias was reduced through extensive snowball sampling through referrals to other artisans for potential interviews.

3.3 Thematic analysis

The interviews were transcribed using a popular transcription platform (Otter.ai) and revised for errors where present. Thematic coding was carried by a team of two graduate students related to the project. First open coding was performed and followed by axial coding.

3.4 Qualitative comparative analysis inspired approach

3.4.1 Requirements

Assigning cases to causal factors in a fuzzy set QCA can be done (Pagliarin et al. 2022) by assigning grounded description statements to thematic codes with a weighting, or fuzzy linguistic variable membership level (e.g. Table 2). Membership levels indicate the degree or extent that a statement in a case is encompassed. QCA requires that a selection of cases that (a) largely reflect the same general phenomena, often by having sufficient similarity, background, or other characteristics, (b) include a spectrum of the spectrum of positive and negative outcomes, (c) represent large degree of heterogeneity, and include a diversity of cases (Li et al. 2022; Ragin et al. 2003).

Table 1: We conducted in-depth case studies of 5 African American artisan entrepreneurs, selected from a larger group of 16.

Case	Participant name	Artisan practice(s)	Established artisanal practice	Primary location	Race	Gender identity
1	Artisan 2	Textile artist	Yes	Detroit	African American	Female
2	Artisan 3	Greenhouse produce, plants and farming	Yes	Detroit	African American	Female
3	Artisan 1	Fabric artist and clothing designer	Yes	Detroit	African American	Female
4	Artisan 4	Fabric artist and clothing designer	Yes	Detroit	African American	Female
5	Artisan 5	Fabric artist and calligraphy	No	Detroit	African American	Female

3.4.2 Case calibration

To express the relational economy aspects of artisan entrepreneur work we turn to an STS concept, *Generative Justice* (Eglash 2016). Generative Justice is defined as the right "to generate unalienated value and directly participate in its benefits; the rights of value generators to create their own conditions of production; and the rights of communities of value generation to nurture self-sustaining paths for its circulation" (Eglash 2016, p. 382). Using FsQCA case calibration, the value of wrestling with this qualitative to quantitative translation is tracing links from perspectives and practices of artisan experts to search results in ways and for potential users that may not have a chance to consider those linkages.

3.4.3 Causal configuration interpretation

Taking thematic codes as causal factors, we can read off the relative absence or presence of causal factors as the presence or absence of themes leading to one among several pathways towards our assessments of their generativity.

3.5 Proposed algorithm for connecting search engine criteria with grounded description

3.5.1 Overview

Although generic vector based semantic similarity methods are common, modeling research for retrieval relevance has yielded other advances in specific use cases. For example, in early work, purely quantitative models of user feedback provided efficient ways of manipulating the relevance of results, thereby changing the order of search results so that the most relevant appear first; Rocchio (1971) and Shen et al. (2005) used explicit and implicit feedback to control results returned by search. To address cases where feedback is unavailable, other approaches have modeled single users as aggregates of other users (Shen et al. 2005).

We approach retrieval relevance from a new direction: (a) we pass the responsibility of relevance modeling to the expert participant instead of the expert researcher using an interview first approach, and we (b) are able to contextualize similarity by referring to the interview itself, by assessing if the statement is positive or negative in relation to its theme; other contextualization approaches assume all similarity has the same valence or, if not, are initially decided by modeling decisions from expert researchers rather than expert participants. The novelty of our search system is working with expert participants to integrate known qualitative and quantitative approaches together to determine the relevance that they want retrieved.

3.5.2 Algorithmic description and architecture

Our search algorithm manipulates important concepts, definitions, and notations present in our data structure to deliver results. We facilitate qualitative and quantitative understanding by referencing interview statements in relation to web page sentences and inducing an ordering of web pages by similarity to a causal interpretation of outcomes found in participant interviews. To do this we describe two algorithms. Algorithm 1 'ASSOCIATED THICK DESCRIPTION' returns for each web page the thematic interview sentences strongly matching it to contextualizes how the web page might be "viewed" in terms of participant interview. Algorithm 2 'WEBPAGE LISTING' returns an ordering of web pages, from seemingly most relevant to least.

To introduce our algorithm we describe iteration over two knowledge sources – the interviews I and web pages W – using simple procedures ranging over index sets. We begin by assuming an open vocabulary of unique statements (e.g. sentences) $\{v \in V | I \cup W\}$. The statements are represented as sentence vectors (Cer et al. 2018). Then, let web pages W denote a set composed of m web pages containing statements $s_w \subset V$, for each $w \in W$. Finally, $\{i \in I\}$ indexes a family of sets related to the interview statements, let I denote a set composed of n interview statements from participant $p \in P$, coded with theme $t \in T$, and having a valance indicator $v \in \{-1, 1\}$ for each $i \in I$, such that $i_{p,t,v}$ refers to a statement belonging to participant p, theme t, with valence v. Importantly, the QCA solution configuration is translated into a $|T|$ length vector, $C = [x_t | x_t = 1$ *if QCAF(t) else* $-1, \forall t \in T]$, where QCAF returns 1 or –1 for themes that are present or absent respectively from the prior minimized solution. This translation allows us to computationally assess the strength of association among webpage w to participant themes T in Algorithm 2 'WEBPAGE LISTING' using the dot product. In our case study we worked with $|\{P\}| = 5$ participants, found $|T| = 10$ selected themes, with $|I| = n = 71$ interview statements. Each evaluation included $|W| = m = 100$ web pages.

3.5.3 Socio-technical diagram

Figure 1 illustrates the workflow of our proposed algorithm for determining the relevance of search results according to the preferences of expert participants. The process begins with ongoing interviews of *artisan participants* conducted with *researchers*. The interviews are transcribed, and the

Algorithm 1. ASSOCIATED THICK DESCRIPTION

Require: Web pages W, Interview statements I
Ensure: $D_{w,t}$ contains maximal similar web page and interview statements per theme so folks can quickly inspect
1: **for** $w \in W$ **do**
2: **for** $t \in T$ **do**
3: $D_{w,t} = \{(s,i) \mid \arg\max_{s \in s_w, i \in i_t}(sim(s,i))\}$ ▶ most similar interview and web page statement per theme
4: **end for**
5: **end for**

Algorithm 2. WEBPAGE LISTING

Require: Web pages W, QCA vector C, Themes T, Interview statements I
Ensure: Ordering of W by similarity to C vector, to display web pages by potential relevance
1: $O = [o_{w,t} = 0]_{|W| \times |T|}$ ▶ webpage to thematic matrix
2: **for** $w \in W$ **do**
3: **for** $t \in T$ **do**
4: $o_{w,t} = -i_{ptv} \cdot \arg\max_{s \in s_w, i \in i_t}(sim(s,i))$ ▶ most similar statement pair with valence of maximum participant i_{ptv}
5: **end for**
6: **end for**
7: return SORT($C \cdot O^T$) ▶ sort by strength of association to C

statements are coded in an open coding process. These coded interview statements are then *axial coded* by researchers to identify themes using an inductive and deductive approach. The axial coded interview statements are then extrapolated as *cases*, within a *QCA inspired calibrated approach* that produces *vectors*. These vectors, along with their corresponding tagged interview statements are used by the proposed algorithm (see Algorithm 1 and Algorithm 2) to re-rank search results according to the preferences expressed by the interviewees. There is an option to make the workflow continuous if ongoing interviews are conducted that update the search-engine criteria. This process is broadly categorized by three stages:

(1) "In-person" Participatory Group: Conducting ongoing interviews with artisan participants.
(2) "Offline" Creating structured data: Transcribing, tagging, and axial coding the interview statements to generate the search engine criteria for our algorithm.
(3) "Online" Utilizing structured data: Using the structured data (QCA calibrated vector and causal thematic vector) in the proposed algorithm to search for and rank relevant results that align with interviewees' preferences.

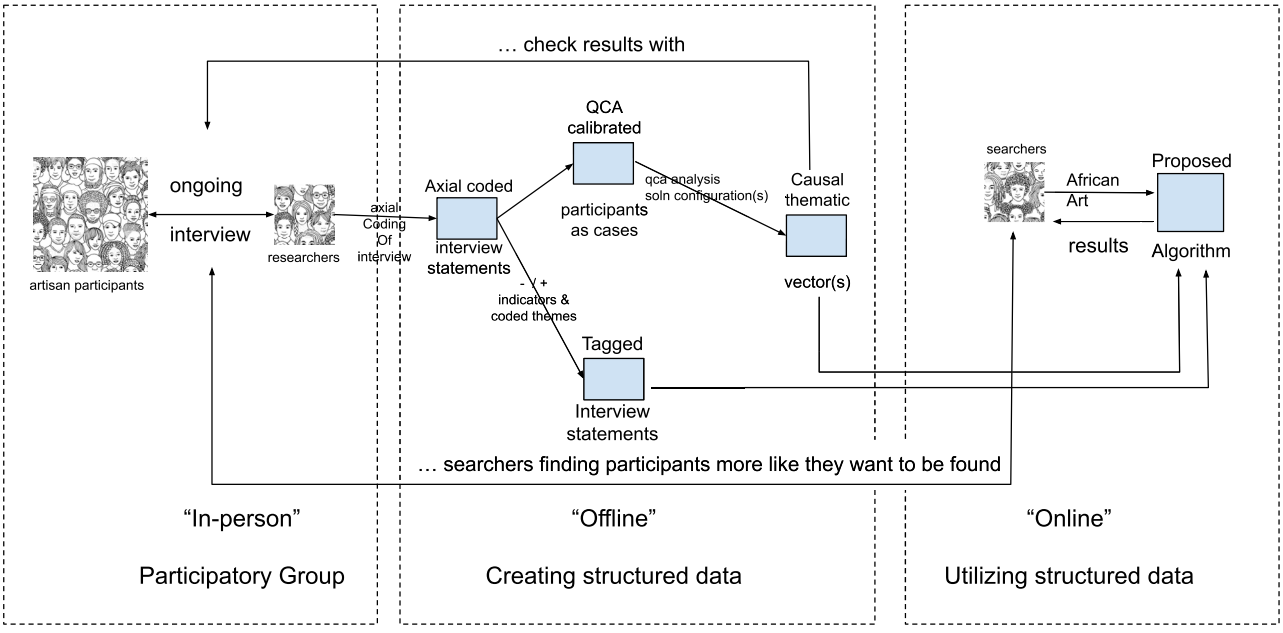


Figure 1: Qualitative case studies feed into axial coded and QCA inspired solution vectors, that are used within the proposed algorithm to help determine the relevance that interviewees want retrieved.

Table 2: Fictitious cases Jessie and Adah.

Case	Participant name	Artisan practice(s)	Established artisanal practice	Primary location	Race	Gender identity
1	Jessie	Textile artist	Yes	Detroit	African American	Female
2	Adah	Fabric artist	Yes	Detroit	African American	Non-binary

3.6 A brief example

Through a brief fictitious example involving *dye making* and artists we illustrate our method of constructing search engine criteria. For simplicity we use two participants, three thematic codes and assess generativity as our outcome causal factor.

3.6.1 Description of participants

In this fictitious example, we have two participants, Jessie and Adah. Both use dye in their businesses but source them through different methods and supply chains. Jessie uses a mix of synthetic and natural indigo as blue dye. Adah mostly uses natural indigo dye and has recently begun exploring fungi based alternatives with lab cultured Rhodosporidium toruloides (see Table 2).

3.6.2 Semi-structured and unstructured interview

After IRB approval, Jessie and Adah are interviewed over a period of several months. They are regularly asked how their practices, source of dye, and business networks have changed or remained the same. Multiple hours of interviews across many days are collected and transcribed. We are particularly interested in how they use dye in their practice with connections to cultural heritages and how they would like their work to be "found."

3.6.3 Thematic analysis

Following thematic analysis, we identify three themes: (1) Diversity of Dye Sources, (2) Importance of Cultural Heritage in Art, and (3) Proportion of Art involving Dye.

Table 3: Case calibration of themes to causal factors weighted by set membership.

Case/ condition	Diversity of dye sources	Importance of cultural heritage in art	Proportion of art involving dye	Generativity (outcome)
Jessie	0.33	1.0	0.33	0.67
Adah	0.67	0.33	0.33	0.33

Levels are completely out (0), more out than in (⅓), more in than out (⅔), and completely in (1). Completely in and out are taken as approximate.

3.6.4 Qualitative comparative analysis inspired approach: case calibration

The case calibration is shown in Table 3.

For simplicity, we calibrate themes in cases to one of four levels of condition membership (Oana et al. 2021): completely out (0), more out than in (⅓), more in than out (⅔), completely in (1). We also broadly assess the generativity of the artisan's practice as an outcome. These moves from thick to thin description contains back references to interview statements and the weighting itself includes imprecision (or, "fuzziness").

3.6.5 Qualitative comparative analysis inspired approach: causal configuration interpretation

In this example there is one solution configuration and it largely reflects Jessie's practices and concerns. Reading off the presence and negation of causal factors, the conditions of the solution configuration indicate a solution thematic vector of <–1, 1>, with the relative absence and presence of each theme, respectively (Table 4). This can be read as the greater generativity brought about from placing an importance on (a) cultural heritage within art in the face of (b) a reduced diversity of sources of dye and these causal factors are independent of the overall amount of dye that the artisan incorporates in their work. Intuitively, artisans using artificial dyes are able to purchase them from a wide variety of venues whereas artisans using sustainable sourced dyes have often fewer sources. This suggests a relationship

Table 4: Fiss style chart of minimized solution.

	Solution configurations
	Solution 1
Diversity of dye sources	○
Importance of cultural heritage in art	●
Proportion of art involving dye	–
Consistency	1.0
Raw coverage	0.5
Unique coverage	0.5
Overall solution 1 consistency: 1.0	
Overall solution 1 coverage (covS): 0.50	

● Core contributory condition present. ○ Core contributory condition absent ('negated').

Table 5: Example search results comparing standard and content-aware ordering.

Result#	Standard ordering	Content-aware ordering	Example web page sentences divided into high and low similarity
1–5	Detroit dye place – widelytwisted Widelytwisted tie dye & detroit dye placy Widelytwisted | clothing manufacturers in Detroit Color spoke Top 10 best fabric dye in Detroit, MI – Yelp	Color spoke Detroit dye place – widelytwisted About | Marinerose textiles Natural dyeing workship with @rock.-textile.studios Detroit Institute – Botanical Palette	High "We connecting dyeing practices to cultural heritages" "Color Spoke is an organization that connects community and environment by exploring…" "Fully functioning production center… Movetown neighborhood" "We are growing Japanese indigo, Woad, Dyer's Chamomile, Cosome, …" Low * Powerful FEEDBACK Help fund our A B Clark Prep Academy

between cultural heritage in work and the cultural importance inherent to the limited dye sources (within the context of our participants). Interestingly, the amount of work involving dye is not important; an artist may do a lot or a little dye work independently of their interest in promoting cultural heritage.

3.6.6 Connecting search engine criteria with thick and thin description linkages

Table 5 contrasts the standard and content-aware approach by presenting top five web page titles and example sentences present in the content-aware approach. For this example we use the search phrase "dye making detroit". The standard ordering duplicates 3 out of 5 webpages and includes the most generative web page, a dye collective named Color Spoke, as its fourth result and concludes with a list of storefronts selling mass produced dyes. The content-aware ordering is able to avoid duplication because artisan interview content is not well matched other Detroit Dye Place pages; includes the most generative web page, the Color Spoke dye collective, as its first result; and continues with independent textile artists. Interestingly, "Botanical Palette" is based in Tacoma, Washington, but is included because of a page referring to a collaboration with a Detroit based apparel brand. The content-aware ordering of web pages situates artisans' perspectives earlier in a listing by presenting collectives, connections between dyeing practices and cultural heritages, local production centers, and identifying several types of dye.

Standard and content-aware orderings of web pages results are differentiated by the fact that collectives, connections between dyeing practices and cultural heritages, local production centers, and identifying several types of dye are listed earlier.

4 Results

Our results stem from in-depth interviews with 16 African American, majority female, and all low-income artisan entrepreneurs, conducted from August 2021 through June 2022, as described in the Methods section. The multi-month nature of our investigation and our sample size enabled us to examine the rich range of experiences within this select artisan group, though not necessarily representative of all artisan communities. The interviews provided rich, detailed data that informed our content-aware method. We argue in Section 4.3 that it performs significantly better than standard search engines. However, we caution against extrapolating these context-aware vectors to all artist communities without further participation and consideration. Importantly, while the specific content-aware vectors may not be universally applicable, we expect our methodological processes to be readily adaptable to groups with similar characteristics: closely knit, artistic communities working together on a semi-weekly or monthly basis. This description encompasses many entrepreneurial networks and small businesses, suggesting broader potential applicability of our approach.

4.1 Thematic analysis

Thematic coding of participant semi-structured and unstructured interviews uncovered ten broad themes related to how these Detroit artisans entrepreneurs practices, related to their business and social networks (which were often one and the same), and wanted to be "found." These themes span technology, relationships, physical and virtual sites, geography, and finance aspects of business. Strong relational themes crossing business and social domains were uncovered, for example, [Artisan 1] "It's not easy for us, unless we're collective. And we

go like, well, what the heck did he say? How do you do that? Oh, I forgot. You know what I'm saying? Because we're at that point where we need each other to manage things." Education and teaching, passing on knowledge, was important for all of the established artisans entrepreneurs, like many of our participants, [Artisan 3] reflects on their orientation to the community as giving and teaching: "We are givers, definitely not takers. Well, this will be good for us as well, whatever we learn, we will be bringing it back out to the community. … I want to do more teaching." Tensions between being known and the complexity of advertising technology were paramount. "I guess, one of my challenges has always been social media or marketing. Yeah, that's not my wheelhouse. So, and on top of all of that, I don't I don't have time." [Artisan 2] was a statement reflected in other artisan conversations, along with concerns of platform mediated theft, "Amazon, I don't know anybody who uses Amazon, they're too afraid because if you do well on Amazon they take it from me." [Artisan 4]. Most advertising was through physical media, in places of gathering; following that, two participants described the need for a collaborative website highlighting the work of their peers and themselves that remained under their control. Historical context of their work integrated past experiences and skills into their current entrepreneurial work. The themes and abbreviations identified were *business technology* (biz tech), *context of business relationships* (biz context relationships), *physical and virtual places for business* (biz making place), *geographical context of business* (context biz), *teaching/class* (class), *knowledge of customers* (biz customer), *supply chain related* (context supply), *personal and business history of the owner* (context background), *advertising, focus on advertising* (biz adv), and *internal business relationships* (biz money).

4.2 Qualitative comparative analysis inspired approach

We use the results of qualitative comparative analysis to associate thematic codes with generative outcomes through solution configurations. Starting with case weighting we then use R (cite) SetMethods (cite) to perform FsQCA analysis. We manually interpret our results in relation to qualitative interviews and general experience as evidence for consistency and robustness. From the interpretation we construct a solution thematic vector.

4.2.1 Case calibration

For case calibration of qualitative themes to causal conditions weighted by set membership, see Table 6.

4.2.2 Causal configuration interpretation

Using the R 'setMethods' (Oana et al. 2021) following a practitioner guide that draws on years of expert workshop experience, the calibrated cases are logically minimized into two casual configurations. Table 7, in the form of a Fiss chart, contains the configuration. The overall coverage is medium (0.67), suggesting that this configuration explains much but not all of the causation of generativity we observed. Medium coverage can be suitable for approaches attempting to explain substantive causality diversity at the expense of false positives (Baumgartner 2022).

Reading off the presence and negation of causal conditions the first and second solutions can be summarized manually and translated directly to thematic vector. Manually, the first solution can be summarized as high levels of generativity arising from (a) placing an importance of business and social relationships, aligned with supply chains, with attention to supply chain background, coupled teaching others and (b) continuing this importance in the face of the opportunity cost of reduced levels of technology, spaces for creating, traditional advertising, and focusing on increasing profit (e.g. money). The second solution can be summarized as the high levels of generativity arising from (a) placing an importance on supply chains, with attention to supply chain background, coupled with teaching others and (b) continuing this importance in the face of the opportunity cost of reduced levels of technology, business relationships, space for creating, focusing on diversifying customers, traditional advertising, and focusing on increasing profit. Given that artisans represent an unique kind of industry and often have generative connections to their communities these results are no surprise.

Table 6: Case calibration of qualitative themes to causal conditions weighted by set membership.

Case/ condition	Biz tech	Biz context relationship	Biz making place	Context biz	Class	Biz customer	Context supply	Context background	Biz advertising	Biz money	Generativity (outcome)
Artisan 2	0.33	1	0	1	0.67	0.67	0.67	1	0.33	0.33	0.67
Artisan 3	0	0.33	0.33	0.33	0.67	0.33	1	1	0	0.33	0.67
Artisan 1	0.33	1	0.33	1	0.33	1	1	1	0	1	0.33
Artisan 4	0.67	1	0.67	0.33	0.33	0.67	0.67	0	0.33	0.33	0.33
Artisan 5	0	0	0	0.33	0	0	0.33	0	0	0	0

Levels are completely out (0), more out than in (⅓), more in than out (⅔), and completely in (1). Completely in and out are taken as approximate.

Table 7: Fiss style chart of minimized solution.

	Solution configurations	
	Solution 1	**Solution 2**
Biz Tech	○	○
Biz context relationships	●	○
Biz making place	○	○
Context Biz	●	○
Class	●	●
Biz customer	●	○
Context supply	●	●
Context background	●	●
Biz Adv	○	○
Biz money	○	○
Consistency	1.0	1.0
Raw coverage	0.5	0.34
Unique coverage	0.34	0.17
Overall solution 1 + solution 2 consistency: 1.0		
Overall solution 1 + solution 2 coverage (covS): 0.67		

● Core contributory condition present. ○ Core contributory condition absent ('negated').

4.3 Connecting search engine criteria with grounded description

To answer our research question RQ1 (*can content-aware modeling reorder search results to reflect meaningful outcomes and practices*) we examine the order and quality of search results resulting from our proposed algorithm and contrast with results from a standard search algorithm (e.g. Google). For our theoretical test case we use the search terms "supply chain detroit" and "african art" to obtain results. For Table 8, our "supply chain detroit" qualitative results show that where the standard search results were primarily employment listings we see substantively different results in the "content-aware" case. Standard search results are primarily a list of industry and job openings (16/30) whereas the content aware approach listed non-job opening results with greater relational components earlier and also included far fewer job openings (7/30). Opportunities for learning, emerging business opportunities, and connecting with others at regional events: Detroit auto shows involving the US president, the fact of emerging opportunities among creative businesses seeking to resolve supply chains woes, and crowdsourced warehousing firms all characterize the content-aware results. Quantitatively, the mean Average precision at N (mAP@N), shown in Figure 2, contrasts the performance of the content-aware method to the standard search. Here the content-aware approach provides relevant results in starting ranges ($1 \leq N \leq 8$) that standard search provides none, while maintaining a consistently higher score afterwards. With content-awareness relevance decreases as the user scrolls through the results (or as n grows). In contrast, standard search starts *without* relevant results and gradually introduces more relevant information as the user continues to review results, potentially burying the most valuable information deeper in the results. These results hint at fundamental differences in long-tail performance, initial relevance, decay of relevancy, and sustained relevance over search results.

In Table 9, precision at k (P@k) and mean average precision (mAP) metrics provide evidence of the stability of reranking, of promoting potentially relevant web pages earlier, as the number of webpages n grows. This stability suggests that while the reranking itself is important that our proposal brings relevant results up earlier and continues to do so even as we enter the long tail of results, in contrast to standard searches. For evaluation simplicity, we defined a potentially relevant result as those with a dot product greater than 2. Table 9 explores result distribution changes among standard searches and our proposed method using an initial quantitative-qualitative joint display (Guetterman et al. 2021) containing excerpts and information retrieval metrics (Ceri et al. 2013).

5 Discussion

Working with purposively selected participants to develop structured qualitative-quantitative data structures reflecting their preferences suggests an additional method for developing exploratory search criteria because prior methods discussed in *Related Work* utilize probabilistic

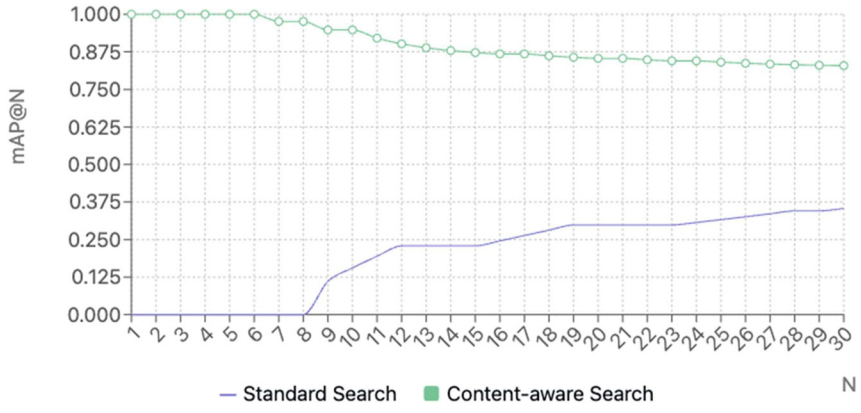


Figure 2: Comparison of mAP@N for content-aware versus Standard search results for "supply chain detroit" query.

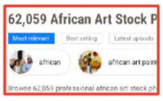
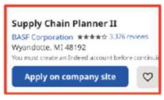
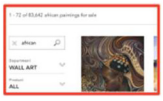
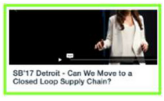
Table 8: The first 10 search results for "supply chains detroit" from a standard search engine and our content-aware method.

Result#	Standard ordering	Content-aware ordering	Example web page sentences divided into high and low similarity
1–5	'Supply Chain Jobs, Employment in Detroit, MI | Indeed.com'; **'160 Entry Level Supply Chain jobs in Detroit, Michigan, United …';**	'FXpress Detroit: Revolutionizing Supply Chain Management'; 'Meet The Team | MGM Grand Detroit, MI syncreon – syncreon';	High "We truly believe disruptive insights are delivered when one collaborates.", "We are a company with a purpose, a purpose of creating meaningful human experiences for our 158+K associates.", "We live the philosophy of connected world and connected experiences."
	'Supply Chain Management in Detroit, Michigan, United States'; 'Top 13 Supply Chain and Logistics Companies in Detroit, MI';	'Supplier Eaton uses Detroit auto show to unfurl EV ambitions'; 'James Group';	Low "VIEW ALL IMAGES
	'Supply chain Jobs in Detroit, MI, September 2022 – Glassdoor'	**'160 Entry Level Supply Chain jobs in Detroit, Michigan, United …'**	"; ""; "25 COUNTRIES SERVED"; "$100,000+ (8)"
6–10	Supply chain Analyst jobs near Detroit, MI – SimplyHired 20 Best supply chain manager jobs in Detroit, MI (Hiring now!)	Supply chain Manager job in Detroit | CareersInFood.com Logistics – Detroit Regional Partnership	High Explore opportunities
	Supply chain Management jobs in Detroit, MI | Monster.com	Supply chain Management in Detroit, Michigan, United States	Your curiosity, technical prowess, and appreciation for the assembly process will be crucial for your success in the business and engineering field.
	Logistics – Detroit Regional Partnership	2022 supply chain Management Internships in Detroit, MI	Grocery Internships in Detroit, MI
	Automotive Logistics & supply chain Global Conference	Supply chain jobs in Detroit, MI, September 2022 – Glassdoor	Low " ", Recreation Internships in Detroit, MI,

The full 30 results are included in the Appendix.

not integrative sampling, even if done with purposive intent (Kardaras et al. 2018). For search engine criteria who and how participants are involved have enormous implications. From our results it is clear that a searcher who was not specifically thinking about or had not thought of themes expressed by artisan entrepreneurs could use our content-aware approach to arrive at those kinds of results. For example, the 20th result is an article describing oscillatory supply chain mismatches in producer inventory and consumer demand, or the "bullwhip" effect (Lee et al. 1997), caused by pandemic disruptions. But in reordered results this result appears earlier and continues to do so on average as more and more results are considered (see P@k, mAP results). In our "african art" results a Zimbabwean and a Kenyan native, both following fair trade like principles with years of community presence, surfaced earlier than many stock art webpages. Searchers may not have otherwise considered these results in exploratory searches because of additional keywords and other user interface requirements. Results that superficially may appear as authentically black owned can be effectively down ranked by translating qualitative

Table 9: High, average, and low recommendation performance at $K = 3$, $K = 5$, and $K = 10$ from separate "african art," and "supply chain detroit" search results.

Algorithm	Precision metrics		Pairs of potentially relevant examples (ranking)			
	Metric	Low, avg, high	Expected		Unexpected	
Proposed Algorithm	P@3 P@5 P@10 mAP@N	1.0, 1.0, 1.0 1.0, 1.0, 1.0 1.0, 1.0, 1.0 0.47, 0.59, 0.70		Over 20 highly descriptive gallery pages & links to other Zimbabwean artists by a 4th generation white Zimbabwean artist…		On Pablo Piscasso's stylistic development: he denied the influence of African museums and art upon his cubist period of work, no community…
				is listed before…		is listed before…
				A royalty free stock image commercial website without references to artists or community		Indepth interviews with three individuals from the African diaspora on President Macro's partial restitution of African art from French Museums
Standard Search	P@3 P@5 P@10 mAP@N	0.66, 0.66, 0.66 0.60, 0.70, 0.80 0.40, 0.50, 0.60 0.25, 0.35, 0.44		A fair trade, black women owned painting and print online warehouse working with African artists since 2004, mentions long time point of contacts		An Indeed.com page advertising an open role for a Supply Chain Planner II within a large corporation…
				is listed before…		is listed before…
				Online warehouse featuring mass produced art mostly reflecting a small number of themes: people, elephants, and lions		A popular press article on and moving towards closed loop supply chains as discussed at a 2017 Sustainable Brands conference

Both expected and unexpected ranking examples are present but precision metrics favor the proposed algorithm over standard search results. This is because it is able to maintain relevant results earlier, even as more and more results are considered, per mAP@N. Using Google on 9/17/22 and 1/7/23. $N = 100$. Assumed relevance indicated by dot product $(W, C) > 2$.

expectations and stories of our participants. Relational economies, such as generative justice, are not often modeled purely quantitatively and our results suggest that bottom-up mixed-method approaches involving key participants is an alternative.

5.1 Future work and the importance of the user query

The question of how our participants want to be authentically found and discovered suggests that users of our method also would prefer ways that better authentically reflect their search intents. The next phase of this project is to investigate how user queries can be translated using our proposed methods. Generating more accurate outputs for contexts that serve low-income communities suggests a pathway towards better AI because it provides better social justice through surfacing authentic results predicated on generative themes. As a topical example, participants using our reordering method could automatically provide initial supervision (e.g. *contrastive self-supervision*) for training a chat bot: an RLHF framework (Ziegler et al. 2020) operating over search queries and their exploratory search engine ordered results provides a form of preference between textual results and their queries. Large language model projects such as Open Assistant (Laion.ai 2023) provide open source alternatives to OpenAI's ChatGPT and small scale chatbot models could be fine tuned with relatively modest compute. Bais and harms are increasingly prevalent concerns in generative artificial intelligence (Bender et al. 2021) and for chatbots this method of user querying can help decide who and how participants they want to be found.

5.2 Limitations and ethical considerations

The strength of our method is only as strong as the weakest link(s) among qualitative thematic coding, qualitative comparative analysis, and neural sentence embeddings. The sensitivities of each separate method can interact: poor agreement among selected codes or calibrated cases could result in noisy results at higher levels of agreement than in each method alone. To combat this instead of necessarily

improving the algorithm in the next phase of work we plan to improve the user interface – enabling users to boost themes and honing in on storefronts. Knowing how agreement, or *integration*, in mixed method approaches like ours interact with user querying would help suggest where and when our method is recommended or not recommended.

From a "scale thinking" (Hanna and Park 2020) perspective the difficulty of speeding up participant interviewing and human powered thematic coding can be viewed as a limitation. Alternatively, this ambiguity can be an exploratory site to consider and launch other modes of scale (e.g. (Morel et al. 2019)). For example, Seaver's analytic of *decorrelation* suggests that scale and care can be considered separate and as an assemblage (Seaver 2021, p. 521), and Hanna et al. (2020) describe how intentional communities, with the Bed-stuy New York neighborhood as an exemplar, prioritize relational concerns in technological development. Indeed, many of these concerns motivated the development of exploratory search engines with qualitative case studies. Less so a limitation, the resistance to scale provides other opportunities for socio-technical development.

That said, the use and placement of participant interviews in our algorithm is a methodological strength that requires careful ethical consideration because participant thinking is juxtaposed, or integrated, alongside future results that they are unaware of. Participant anonymity, use for what kinds of searches all invoke GDPR like considerations (Bowyer et al. 2022) that should be carefully explored as a design problem in our next phase of work. At a broader level, although content-aware search helps resolve semantic ambiguity, it is not able to address higher order characteristics, such as ownership. For example, searches for black-owned beauty products could still produce white-owned companies. To anticipate this critique, in future work, it would be worth exploring linkages between content-aware results because it is much harder to "game" reciprocality, or horizontal linkages between web pages.

Finally, while our sample size is small, it is crucial to note that variability in how groups wish to be found is a key aspect of our study. A one-size-fits-all approach to artist discoverability preferences is insufficient. Many groups have distinctly different preferences that do not overlap; for example, consider textile artists and hobbyist programmers, both selling products. Nevertheless, we recognize the value of a larger sample for broader insights. In future work, we plan to incorporate the concept of *qualitative saturation* (Saunders et al. 2018) to determine when to stop interviewing, as a way to simultaneously expand our sample and test the limits of generalizability. This will ensure qualitative generalizability while respecting the diverse and evolving nature of artist preferences. Artists adapt and there are changes in their stories and work. To adapt, an ongoing interview procedure could be carried out, whether self-guided or with researchers, where artists respond to a set of standardized prompts at their convenience. These regular updates would feed into new search engine criteria that define content-aware vectors, with assistants performing the axial coding. The technical infrastructure of our system would remain unchanged, but the continuous sampling would maintain the integrity of our method while addressing the dynamic nature of artistic practice and business evolution.

6 Conclusions

Evidence from our initial case study demonstrates that themes that our participants value are placed earlier in the list of results as compared to standard search approaches. Generally, the use of participatory design with "content awareness" adds evidence to the importance of addressing algorithmic bias by considering who gets to address it and how. That participatory search engine criteria can be modeled as a robust linkages between grounded experience and semantic similarity using a QCA inspired approach suggests that mixed-method approaches can also contribute to search engine system designs. For qualitative phenomena that are more easily understood using qualitative methods, our method offers a multi-step procedure for translating interviews into a partial understanding that can be used for content aware reordering of search results. Although future work will answer broader questions of reliability and suitability, we offer an initial look at what bottom up participatory search engine making from Detroit Artisan grounded experience can look like.

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Informed consent: Obtained.
Author contributions: KPR drafted and revised the manuscript with RE and MG with input from all other authors. KPR designed the algorithm, conceived and drafted the experiments. MG carried out interviews. KPR and RE analyzed interviews, and all authors contributed to interpretation of the results.
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Appendix

Table A: The first 30 search results for "supply chains detroit" from a standard search engine and our method of reordering using context aware qualitative to quantitative methods.

Result#	Standard ordering	Content-aware ordering	Example web page sentences divided into high and low similarity
1–5	'Supply Chain Jobs, Employment in Detroit, MI | Indeed.com'; '160 Entry Level Supply Chain jobs in Detroit, Michigan, United …'; 'Supply Chain Management in Detroit, Michigan, United States'; 'Top 13 Supply Chain and Logistics Companies in Detroit, MI'; 'Supply chain Jobs in Detroit, MI, September 2022 – Glassdoor'	**'FXpress Detroit: Revolutionizing Supply Chain Management';** **'Meet The Team | MGM Grand Detroit, MI syncreon – syncreon';** **'Supplier Eaton uses Detroit auto show to unfurl EV ambitions';** **'James Group';** '160 Entry Level Supply Chain jobs in Detroit, Michigan, United …'	High "We truly believe disruptive insights are delivered when one collaborates.", "We are a company with a purpose, a purpose of creating meaningful human experiences for our 158+K associates.", "We live the philosophy of connected world and connected experiences." Low "VIEW ALL IMAGES"; ""; "25 COUNTRIES SERVED"; "$100,000+ (8)"
6–10	Supply Chain Analyst jobs near Detroit, MI – SimplyHired 20 Best supply chain manager jobs in Detroit, MI (Hiring Now!) Supply Chain Management Jobs in Detroit, MI | Monster.com **Logistics – Detroit Regional Partnership** **Automotive Logistics & Supply Chain Global Conference**	Supply Chain Manager Job in Detroit | CareersInFood.com **Logistics – Detroit Regional Partnership** Supply Chain Management in Detroit, Michigan, United States **2022 Supply Chain Management Internships in Detroit, MI** Supply chain Jobs in Detroit, MI, September 2022 – Glassdoor	High Explore Opportunities * Instagram Your curiosity, technical prowess, and appreciation for the assembly process will be crucial for your success in the business and engineering field. Grocery Internships in Detroit, MI Low " ", Recreation Internships in Detroit, MI
11–15	**global supply chain program – Mike Ilitch School of Business** **Council of Supply Chain Management Professionals Eastern**… Top Logistics Companies in Detroit – 2022 Reviews | Clutch.co $49k-$131k Healthcare Supply Chain Jobs in Detroit, MI Supply Chain Jobs in Detroit, MI – Apply Now | CareerBuilder	**Automotive Logistics & Supply Chain Global | Event** **Biden to Tout EVs at Detroit Auto Show | Manufacturing.net** **Warehousing Companies in Detroit 2022 – GoodFirms** **global supply chain program – Mike Ilitch School of Business** **Wither Detroit? | Supply and Demand Chain Executive**	High + Coronavirus and Germany Creative Industries Sponsored * Supply Chain * Instagram The suppliers are really just an extension of manufacturing capability, and the OEMs have got to realize that, and they have to become more relationship-focused and more principled,\" Michels says Robotics, Automation to Future-Proof Reshoring, Nearshoring Efforts Low o Financial Services " " Under the newest law, electric vehicles must be built in North America to be eligible for a new federal tax credit of up to $7,500 Bertie Greer

Table A: (continued)

Result#	Standard ordering	Content-aware ordering	Example web page sentences divided into high and low similarity
16–20	**Top Supply Chain Management Executive Salary in Detroit, MI** **ACG Detroit Program: Supply Chain Management** **Supply Chain Global Live 2021 – Automotive Logistics** **2022 Supply Chain Management Internships in Detroit, MI** Supply Chain Management | Henry Ford Health – Detroit, MI	**INTEGRATED SUPPLY CHAIN SOLUTIONS, LLC, Detroit**… Supply Chain Jobs in Detroit, MI – Apply Now | CareerBuilder **Detroit – Supply Chain Brief** **Automotive Logistics & Supply Chain Global Conference** **'Bullwhip' hits supply chains as missing links reverberate for**…	High Get new state, local and federal government contract opportunities that match your business daily * Black American Get new state, local and federal government contract opportunities that match your business daily Most supply chain suppliers have solutions that are very similar to each other The cheese is just another casualty to the ongoing supply chain shock of the COVID-19 pandemic * Instagram For the uninspired purchasers, these issues are leading to less variety to limit all the overhead cost to bring the product in,\" Hartwig said For those that are creative, you're going to see unique products and solutions on a consistent basis and, potentially, newer producers are going to be able to come on board faster. That's a good thing Low Join 120,000+ Contact Us
21–25	Manager OR Supply Chain Management Detroit Supply Chain Jobs Hiring in Detroit, MI Supply Chain Management jobs **Stories About Supply Chain – CBS Detroit** **Vendor Services Detroit Medical Center | DMC**	Top 13 Supply Chain and Logistics Companies in Detroit, MI **Supply Chain Management and Logistics – CASS Tech** **Supply Chain Management Intern at AJM Packaging**… Supply Chain Management Jobs in Detroit, MI | Monster.com **Detroit | 3PL, Warehouse & Global Logistics Company**	High MARKETING & ADVERTISING o IT for Education Low Troy, MI, US CASS Tech
26–30	**Blog – ASCM Michigan East** **Detroit, Michigan Supply Chain Degree Programs & Colleges** **Supply Chain Management Consultants – Detroit – MapQuest** Supply Chain Manager Job in Detroit | CareersInFood.com **Automotive Logistics & Supply Chain Global Conference**	**Car guy Biden touting electric vehicles at Detroit auto show** **Car Guy Biden Touts Electric Vehicles at … – USNews.com** **Top Supply Chain Management Executive Salary in Detroit, MI** **Supply Chain Management Graduate Programs in Detroit** **Gripes over electric car tax credit as Biden visits Detroit Auto**…	High Stay informed daily on the latest news and advice on COVID-19 from the editors at U.S. News & World Report * Just-in-time manufacturing We at EducationDynamics believe you should make decisions about your education with confidence These classes could introduce students to a variety of research methods, statistical linear models, probability and supply chain-marketing interface + Fine Arts & Design * Instagram Low Under the new law, electric vehicles must be built in North America to be eligible for a federal tax credit of up to $7,500 * PDF US adds 528,000 jobs in July amid mounting concerns over inflation Search for

Results unrelated to job openings are in bold and reflect generative themes. Underlined results describe current job openings. There is a substantive difference between standard results and our content-aware ordering that reflect many of the themes present in interviews.

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