Retrieving and Recommending for the Classroom

Stakeholders, Objectives, Resources, and Users

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ABSTRACT

In this paper, we consider the promise and challenges of deploying recommendation and information retrieval technology to help teachers locate resources for use in classroom instruction. The classroom setting is a complex environment presenting a number of challenges for recommendation, due to its inherent multi-stakeholder nature, the multiple objectives that quality educational resources and experiences must simultaneously satisfy, and potential disconnect between the direct user of the system and the end users of the resources it provides. In this paper, we outline these challenges, highlight opportunities for new research, and describe our work in progress in this area including insights from interviews with working teachers.

KEYWORDS

multiple stakeholders, multi-objective recommendation

1 INTRODUCTION

Students in the U.S. primary and secondary educational systems frequently engage with educational content through textbooks and commercially-available reading collections. Supplementing or replacing these readings with *authentic* (that is, created for purposes other than pedagogy, such as news or information), *current* texts that are *accessible* to students at their reading skill and domain knowledge and resonate with students' various interests has the potential to help students better engage with the material.

While suitable resources likely exist, it is difficult to find current news articles that are appropriate (both in content and readability)

for upper-elementary, middle, and high school classrooms. As a result, teachers often either reuse outdated materials or opt not to engage students in this type of authentic reading. One Boise-area teacher we recently interviewed said "I want to make sure they are reading and writing in my class more, but I just, sometimes, either can't find or don't have the time to find the resources I need to get them to do that at the level where I know they can do that."

This is particularly true for teachers working with struggling readers and language learners, as the additional scaffolding such students require in order to understand the content of typical news sources seems (and often is) time- and cost-prohibitive. We see significant potential for information retrieval and recommendation technology to aid in this process, enabling teachers to quickly locate a diverse collection of texts from the Web to help their students connect their learning to life and the world around them.

Elsewhere [11] we have discussed some of the challenges, particularly around data availability, in building and evaluating applications in this setting. In this paper, we focus on the intrinsic complexity of the recommendation problem itself: locating relevant, current texts in a classroom setting. We identify four primary dimensions that complicate this problem — multiple stakeholders, multiple objectives, multiple desired resources, and a disconnect between the system user and the end user of the retrieved content — that together make it a significantly more complex recommendation scenario than is typically considered in the research literature.

Effectively meeting teacher and classroom information needs in this setting will require significant new advances across multiple disciplines and specialties. Our argument here draws from our study of the problem space, interviews with teachers about their current and desired information practices[1], and our experience developing a prototype tool for locating news articles for classroom use.

2 MULTIPLE STAKEHOLDERS

Many — if not most — recommendation problems involve multiple stakeholders [3]. Systems have direct users, but content creators, system operators, and society at large can be helped or harmed by the recommender system's operation. The extent to which these

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[1]Interviews were conducted under a study design approved by the Boise State University Institutional Review Board, protocol #113-SB17-238.

different stakeholders' perspectives should be considered or represented in the design or evaluation of recommender systems is just now starting to see exploration [3, 5].

Burke and Abdollahpouri [2] identify a number of stakeholders involved in certain educational recommendation contexts: in recommending educational opportunities to students in the Chicago City of Learning program, both individual students' needs and interests as well as the interests of the various institutions providing recommended opportunities are relevant to assessing the system's effectiveness at matching students with opportunities.

The classroom setting we endeavor to enhance creates even more complex problems in terms of the set of stakeholders:

- Individual students have an interest in their education, and also have particular interests, ambitions, and capabilities.
- The teacher has an interest in fostering student learning engaging students with content.
- The school and its supporting institutions (e.g. the state, in public education) have particular learning outcomes and established standards regarding student learning and classroom instruction.
- The community has an interest in well-educated youth who are able to apply content knowledge to their world and meaningfully interpret current events.

Accounting for the impact of new educational capabilities on these stakeholders in both the design and evaluation of these technologies is a challenge. We are taking a teacher-centered approach, trusting teachers to know their educational contexts as well as anyone, and beginning our work by seeking to understand how they locate and curate resources for their classrooms.

3 MULTIPLE OBJECTIVES

Most recommendation systems are optimized with a single objective in mind, i.e., optimize sales or click-rate. Multi-objective recommendation techniques [13] move beyond this to jointly optimize multiple criteria such as offline accuracy and diversity. Classroom material recommendations need to consider trade-offs between several objectives that sometimes compete between each other in order to find adequate resources; further, some of these objectives are imposed by external constraints.

The teachers we spoke with highlighted the difficulty of using existing systems to locate new texts. One teacher said "I try to look online, on Google and stuff like that but there's… a vast array of stuff and you have to really search for it…". Existing technologies, while effective at optimizing for general query relevance, do not take into account the specific objectives of teachers in a classroom setting. Tools that do so have the potential to make it far easier for teachers to locate useful material.

One immediate objective in the classroom setting is *readability*. In order to learn from a text with assistance, a child should be able to decode 90% of it; to learn independently, that requirement rises to 98% [1]. Multiple teachers mentioned this specific difficulty; one commented on the difficulty of finding "things they [her students] can read and understand." An effective retrieval or recommendation system for educational reading material should help the teacher ensure the documents are readable by each student in the class.

Retrieved materials should be *curricularly relevant*: they should connect to the curricular needs of the students and classroom so that core topics taught in class are reinforced by the readings. To date, there is not one set of curriculum standards, therefore the needs are going to vary by state and district. Furthermore, there are additional standards to meet the needs of diverse students — for instance, those instructing English Language Learners need to address both content and language development standards [15].

In addition to relevance to core curriculum topics such as math or science, the teacher may wish to target resources that promote *side skills* such as critical thinking, reasoning, or understanding and respect towards other cultures. For instance, students are better able to understand those who are different from them when they have an opportunity to read about and vicariously experience other perspectives [6, 14].

Student interest is important to motivate students and facilitate learning. Prioritizing resources likely to match student interests will make it easier for the teacher use the system to enhance their teaching. In order to prioritize interesting resources, the system should be able to consider the time of the year, location, and recency (a document might become of interest right after an specific event) of candidate resources, as well as individual backgrounds and personal interests of the students. Several teachers mentioned this challenge as well; one biology teacher specifically wished she could find readings to make the content more relevant, as very few of her students had interest in pursuing STEM fields.

Finally, the content of recommended resources should be *appropriate* for an educational environment, avoiding content that can risk the psychological integrity of the students. Defining such safe or suitable content, however, poses a challenge on itself, as it is influenced by multiple factors including age, culture, religion, geopolitical context, or even past experiences of the student. As the experts on their particular teaching context and group of students, teachers know these factors as well as anyone. A system that works with and empowers the teacher, instead of replacing or automating their work, can enable learning experiences that leverage that expertise to avoid local faux pas.

The complex multi-objective needs of recommendations in the classroom environment highlight a need of researchers from multiple disciplines to cooperate in order to adequately address the problem.

4 MULTIPLE RESOURCES

Much existing recommendation literature has focused on recommending individual items or lists of items from which the user will select one to purchase or experience. Some work has looked at *set* or *package* recommendations, where multiple items are to be consumed together, or where the set is selected as a whole with the goal of improving the user's overall experience with the decision-making process and its outcome.

In selecting resources for classroom instruction, the teacher will typically be looking for a collection of readings that will map to different students' interests, experiences, and abilities. One teacher we interviewed described her efforts to find "mild", "medium", and "spicy" (referring to the reading levels) texts on a similar topic to
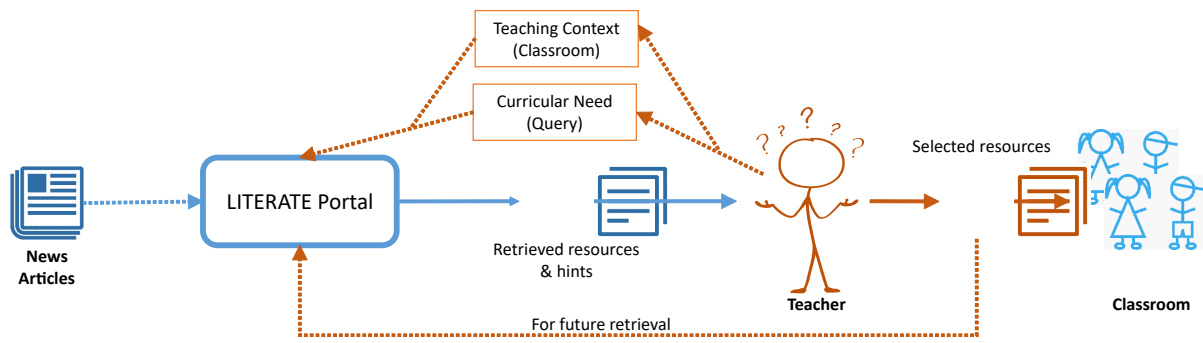
Figure 1: LITERATE Architecture

reach the diverse needs of her students. One-size-fits-all recommendation and retrieval is unlikely to produce a compelling learning experience.

We have the opportunity, though, to decompose the problem somewhat: rather than attempting to do single-shot recommendation of an entire collection of readings, we can consider algorithms and interfaces that support incremental curation of the final selection: suggesting articles that will meet student needs that are not already covered by the articles selected so far.

This setting will also provide opportunity to study additional modes of recommendation in the curation process, such as identifying items in the collection that have become redundant, or items that could replace existing items and improve the collection's overall usefulness for the classroom.
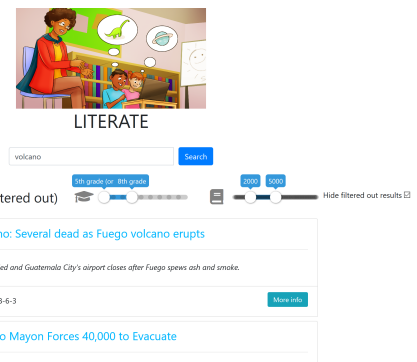

Figure 2: The current LITERATE Interface

5 EXPERT IN THE LOOP

Finally, supporting classroom instruction involves a system user (the teacher) who is distinct from the end users of the content (the students). This is quite useful for addressing some difficulties in supporting classroom instruction, such as final assessments of resource suitability and accounting for local context in selecting resources. However, it takes the problem outside of the realm of most existing research on human-recommender interaction.

The vast majority of research has focused on supporting direct users who are consuming content for themselves. Outside of human-centered recommender systems research, existing models and theories of information-seeking behavior [4, 12] similarly tend to focus on users seeking to meet their own information needs. There is little existing research to guide adaptations to algorithms, explanations, and other aspects of the system to such settings.

In addition to retrieval and recommendation algorithms for locating and ranking candidate resources, meeting educators' information needs will require substantial user interface work to enable the teacher to express their needs and provide them with aids and explanations to evaluate the retrieved resources. This may be eased somewhat by the fact that the system user has substantial domain expertise, but both the information need and resource relevance criteria have a great deal of information that needs to be elicited and displayed.

6 THE LITERATE PROJECT

These issues arise in the context of our work to develop LITERATE (Locating Informational Texts to Engage Readers And Teach Equitably) [11], a tool for helping teachers locate informational texts from the web to enhance their work with students.

Reading about and understanding the experiences of others can promote empathy and civility amongst students [8]. In its current iteration, which will serve as foundation for future research projects in this area, LITERATE aims to promote equity and empathy in education by helping teachers more efficiently find *news articles* to engage their students in dialog about current events. Incorporating such material into the classroom will help teachers engage learners in the democratic process; providing computational support to help the teacher tailor material to the needs and interests of the various students in the classroom will enhance their ability to provide these benefits to *all* students.

Using news to discuss current events in education gives students an opportunity to consider diverse perspectives and learn to engage as active and responsible citizens [7]. This sort of civic education can increase political engagement for underrepresented minority and marginalized populations [10]. We eventually want to help teachers locate resources from across the web, but the high pedagogical usefulness of news makes it a promising domain for the first version of LITERATE, shown in Figure 2.

As illustrated in Figure 1, LITERATE will support teachers in tailoring content to match individual student needs. We use NewsAPI to locate news articles for a teacher-specified topic, and filter and annotate the results based on *reading levels*, in addition to other contextual features, such as resource *length*, *type*, targeted *grade* ranges, and top-3 representative *keywords*. The key technical contribution of LITERATE's current iteration is the incorporation of readability into the search process.

To inform our development and research work, we have been interviewing teachers in the Boise, Idaho area about their current practices and desired capabilities for locating supplemental texts and incorporating them into their teaching.

LITERATE is an ongoing project, and its further development will require us to address each of the dimensions of complexity we have described, in addition to modeling nontrivial information in a complex information space. We will need to further develop news representations with rich metadata we can leverage to match K-12 curriculum, design and test interfaces to capture complex information needs via the expert in the loop, and adapting the content of "relevance" to capture classroom suitability, students' abilities and backgrounds and teachers' curricular needs.

Using LITERATE as a platform, we will be able to evaluate and refine solutions as we receive direct feedback from teachers, advancing the state of the art in supporting complex information retrieval and recommendation tasks. As an immediate next step, we expect to incorporate much richer notions of text cohesion and content suitability into our ranking strategy while slowly transitioning from retrieval to recommendations. We also aim to enable LITERATE to tune its results to the curricular and stakeholder requirements of an specific classroom and to suggest sets of news articles that match curricular needs as the academic year progresses while accounting for readability levels and other needs of the students in the corresponding classroom.

We see the Web as the greatest open textbook available to educators, and LITERATE will — we hope — give them the power to find the right page in their quest for suitable class resources.

7 CONCLUSION

Supporting teachers in the work of preparing for classroom instruction is a complex, multi-dimensional information need. Substantial new work in both the user experience and underlying algorithmic foundations of information retrieval and recommender systems will be needed in order to deliver applications that are efficient and responsive to pedagogical needs.

At the same time, there is great promise in the ability for new technologies to support the work of teachers in providing compelling, engaging, and current material to their students. The teachers we interviewed repeatedly highlighted the difficulties in locating, curating, and using new texts with existing technologies in the limited time they have available, and we don't think it needs to be so difficult.

Empowering teachers to improve the diversity, relevance, and representativeness of the texts in their classrooms will also have valuable social effects. The texts themselves are likely to promote civic and political engagements [8]. There is also a significant gap

in the availability of enriching texts for students of different socioeconomic status [9]; aiding teachers in making use of freely available texts from the Web has the potential to help close this gap by providing richer sets of readings to students who previously did not have them available.

We expect our future work on this project to result in significant advancements in recommender systems and information retrieval technology, particularly in eliciting and meeting complex, multidimensional information needs, and have a positive impact on the work of teachers and their students' learning experiences.

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