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Technology Review
Review of Doenet: The Distributed Open Education Network

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1. INTRODUCTION

On the topic of Scalable/Online Education, this paper reviews The Distributed Open Education Network (Doenet), currently under development. Doenet is a data-driven education technology platform, and the goal of the platform is to "use data on how people interact with online content to drive innovation and improve educational experiences." [1] My main source for this review is an interview with one of the founders of Doenet, Duane Nykamp, on November 4th, 2021. I also consulted the Doenet website [2], as well as a previous article on Doenet [3], and the award abstract for the NSF grant[1] funding Doenet [4].

In this review, I will outline the goals of Doenet, some of the details of how it will work, and how it could contribute to the future of online and scalable education.

2. DOENET: THE DISTRIBUTED OPEN EDUCATION NETWORK

A project currently under development, Doenet will serve as a platform for students, instructors, and authors to create and use open educational resources. The vision for Doenet is to facilitate authors and instructors sharing their open content. Doenet will then track a student's activity as they interact with these resources, collecting data. Doenet will use this data to analyze and evaluate the effectiveness of the content. This feedback can then be passed back to the author, so that they can make improvements to the resource. The data can also be used by the instructors to evaluate their students work, and can also be used to suggest resources to students to facilitate their learning. Doenet aims to allow for a great variety of resources, including textbooks and videos, but also facilitating the creation of content with a high level of interactivity using a specialized markup language, DoenetML. Doenet aims to provide a platform for the sharing, development, and evaluation of open educational resources at no cost to students, as well as providing data analysis and feedback that can be used to improve the educational experiences of students.

2.1. **DoenetML.** To facilitate the creation of highly interactive resources, the Doenet team has been developing a specialized markup language, called DoenetML. This allows authors to create interactive visualizations and interactive webpages in a language that is highly semantic. The idea behind this semantic markup language evolved from PreTeXt [5], which is a popular XML vocabulary for writing textbooks. PreTeXt enables the author to write a single source file, from which a document can be generated in a variety of formats, including PDF, web, EPUB, and even Braille documents. DoenetML builds on this idea by creating a semantic language for describing interactive visualizations.

As an example for the types of interactive visualizations that would be possible, a student in a Calculus class would be able to view the graph of a function with its tangent line at a point, and drag the point around to see how the tangent line changed. Changing the point could also change content elsewhere on the page, for example changing the computation of the derivative at a point to match the point selected. The students interaction with this visualization would generate data, from which a student could be graded and the effectiveness of the resources could be evaluated.

One of the advantages of a semantic markup language is that content can be more accessible, as is demonstrated by the ability of PreTeXt documents to generate Braille texts. For example, an instructor might be creating a visualization where they wish to distinguish between two groups of data points. To generate this visualization with other tools, the instructor might do this by manually choosing colors for the data points. In contrast, in DoenetML, the instructor would simply label the data points with the class they belong to, and the distinction between the groups could be rendered in different ways depending on the needs of the student. For instance, while many students might see the groups rendered as two different colors, a color blind student could see the groups rendered with different shapes.

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[1]Note: I previously received funding through this grant for textbook writing, but did not contribute directly to Doenet.

2.2. **Connecting Resources.** The fundamental idea of Doenet is to create a platform where educational resources can be shared and connected. To facilitate this connection, the Doenet team is developing a Doenet API, through which different content and resources can connect and send data to Doenet. Communication can be done with LTI (Learning Tools Interoperability), a specification for learning systems to communicate with external systems. This is particularly important for integration with popular Learning Management Systems (LMS), such as Canvas and Moodle. Many instructors use an LMS to share content and grades with students, so this integration is essential for incorporating Doenet into the existing workflow for instructors. The vision is that an instructor will be able to choose resources for their students through Doenet, and as the students interact with these resources, the relevant data can automatically be transmitted back to the LMS, where the grades for the student are stored. Providing this "glue" between resources and an LMS is one of the great selling points of Doenet for instructors, since it can facilitate instructors using a wide variety of resources, while having their students work and data automatically communicated back to a centralized location in their LMS.

2.3. **Data and Analysis.** One of the goals of Doenet is to leverage the data collected as student interact with resources, and use this data to evaluate the effectiveness of resources and inform recommendations. Of course, this data can also be used by instructors to grade their students. Doenet hopes to use data mining and machine learning to evaluate the effectiveness of activities. This can be done by looking at how a student interacts with a single page, for example if they come back to it a lot, but can also be determined in relation to other resources. For instance, if a student visits Resource A before visiting Resource C, are they more or less successful at completing Resource C than if they had instead visited Resource B before visiting Resource C? The evaluation of these resources is highly context dependent, since a resource could be valuable for one course, but irrelevant for another. As a result, this poses a difficult machine learning and data mining problem.
If Doenet is able to successfully leverage the data collected into this type of evaluation of resources, this will be incredibly useful. Doenet would be able to recommend effective resources to instructors and to students. For instance, if a student is struggling to complete an assignment, Doenet could recommend another resource that the student could complete first, that has proven to be effective preparation for their assignment.
Analysis of the data collected by Doenet is both a great challenge and a great opportunity, and this work is still in its very early stages.

2.4. **Privacy Concerns and Open Data.** With the data being collected on students, privacy is an important concern. Doenet plans to address this by allowing students to control their data, giving their instructor permission to use their data. When data is shared, it will only be with the permission of the user, only shared in anonymized form, and only shared in aggregate form when necessary for privacy. However, one of the goals of Doenet is to offer open data, by publishing data in the in an open data warehouse. Doenet is still working on figuring out this balance between offering open data and protecting user privacy, and this is one of the bigger challenges they face. In addition to the ethical obligation for privacy, Doenet will also need to advocate regulations and school policies as they determine how to handle data.

2.5. **Distributed Storage.** Although in early development, Doenet intends to scale by using distributed storage of resources and data. They are currently laying the groundwork for a distributed system with content addressing. This uses a hash to identifies files, so that a resource can be retrieved from anywhere, and it can be checked for corruption using the hash. The database will also be distributed, and user's computers will be able to make their own computer a node. This will enable students to be on Doenet, even if they're not on the internet. This also helps Doenet with their goal of accessibility, accommodating users with intermittent internet connectivity.

2.6. **Open Source.** Doenet is committed to the open source and open content movement, and arose from a shared interest in open educational resources among its contributors. In particular, Duane Nykamp has developed Math Insight [6], a webpage with interactive visualizations to help students understand concepts from calculus. Jim Fowler is one of the creators of Ximera [7], a platform for interactive online textbooks. Doenet strives to take open source materials to the next level, connecting open resources, facilitating the creation of open resources, offering open data, and improving open educational resources by offering sophisticated analytics.

2.7. Funding for Doenet. The development Doenet is currently funded through the NSF Improving Undergraduate STEM Education Program: Education and Human Resources. [4] Doenet is also indirectly funded through the University of Minnesota, through faculty salaries and hardware. The Doenet team is also brainstorming longer-term sources of funding.

2.8. Work on Doenet. Duane Nykamp (University of Minnesota) in the Principal Investigator for the NSF grant funding Doenet. Jonathan Rogness (University of Minnesota) and Michael Weimerskirch (University of Minnesota) are Co-Principal Investigators. Jim Fowler (The Ohio State University) and Matt Thomas (Ithaca College) are also very involved in the grant. Other contributors include Kevin Charles, Liz Anderson, Stan Pride, and a team of student developers.

3. Conclusion

Doenet is an exciting new project that aims to promote access and quality of open educational resources, and leverage the data collected for increasing the utility of these resources. Although most of the features are still in development, the ideas behind Doenet have the potential to revolutionize access to open educational resources.

References

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