OLI Torus: a next-generation, open platform for adaptive courseware development, delivery, and research

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ABSTRACT: Torus is the next-generation of the Open Learning Initiative (OLI) platform, providing an open, community-based system for designing, delivering, improving, and researching adaptive courseware. The project has attracted a diverse array of active partners, users, and contributors, notably ASU's Center for Education Through Exploration (ETX). Current capabilities support and interweave OLI and ETX approaches, with expanded features in development. This report discusses the Torus platform and community.

Keywords: Adaptive Courseware, Learning Analytics, Learning Engineering, OER, OSS

1   INTRODUCTION

For two decades, Carnegie Mellon University's OLI has been a leader in science-informed adaptive courseware, developing learning environments designed to improve outcomes while providing a testbed for learning research. Multiple, rigorous studies demonstrate the potential of OLI courseware to improve student outcomes while enacting research (e.g. Kaufman et al., 2013; Bie et al., 2019; What Works Clearinghouse, 2020). The OLI platform has been a key element in this success. This tool for creating and delivering online instruction embeds core learning science principles into the system's design. The platform ensures an instrumented experience, capturing rich learner interaction data in conjunction with semantic context to support feedback for learners, educators, authors, and researchers (Moore et al., 2020a). The richness of this data stream is foundational for OLI's pioneering work in learning analytics, best seen in the Learning Dashboard (Lovett, 2012; Bier et al., 2014).[1] This instructional intelligence system provides educators with per-learning-objective measurements of learning as well as more detailed information, including sub-skill summaries, individual student learning estimates, and guidance on student struggles.

The platform has seen expansive use, with enrollments from more than 5 million independent learners and over 750,000 enrollments from hundreds of academic institutions. 6,180 educators have instructor accounts; authoring and improvement tools host 900 users, who include faculty, learning engineers, authors, and instructional designers, developing more than 300 courses. The platform also supports a large research community via seamless integration with DataShop (Koedinger et al., 2013) and LearnSphere (Liu et al., 2017); 700 researchers access OLI datasets for primary and secondary analysis. With this use has come many lessons learned about the system's limitations, particularly architectural assumptions; alternate R&D models; community; outreach, and licensing. As the legacy

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[1] Lead by Marsha Lovett, the Learning Dashboard was funded by the Spencer Foundation and developed at CMU by Judy Brooks, Bill Jerome, John Rinderle, Ross Strader, and Candace Thille. See oli.cmu.edu/educators/the-learning-dashboard/

technology has grown more dated and new technologies have emerged, the legacy platform's limitations have become even more glaring.

To meet these challenges, OLI has launched Torus as its next-generation platform, built on OLI's successes and integrated with CMU's larger learning engineering ecosystem. Launched in 2020, and developed under an open, business-friendly MIT license, the effort aspires to attract a broad coalition of post-secondary and industry participation, maintaining essential elements of OLI's success while expanding options for delivering and researching learning. Key Torus goals include:

- Addressing lessons learned from the legacy platform, across multiple dimensions, including cost, effectiveness, ease-of-development, and community engagement.
- Delivering on OLI's commitment to grow as a "community-based research activity," broadening participation in learning engineering (Thille & Smith, 2011).
- Promoting active exploration of new approaches to pedagogy, learning, and analytics.
- Supporting the next two decades of OLI success.

This report to LAK reflects on Torus progress, previews plans and describes ways to engage.

2   OLI TORUS

Torus is the latest iteration of the OLI platform, updating and expanding capabilities for developing, delivering, and improving adaptive courseware while providing a workbench for learning science research. Launched in 2020, the effort is informed by a number of goals. Foundational to the project is OLI's need to replace its legacy system; while the platform has effectively served OLI since its first use in 2006, it has become increasingly restrictive. Torus development was launched as an open effort, reflecting OLI's open philosophy and also as an attempt to build trust among users who had suffered from prior vendor lock-in and to invite broader participation. Torus has also been architected to be pedagogically agnostic. OLI's scientific agenda demands humility and an acknowledgment of how much is still unknown about human learning, creating clear requirements for Torus to support alternate approaches, particularly as they can be implemented for fresh investigations. Finally, the new platform is informed by a number of technical requirements, balancing lessons learned with the need to build a robust, cloud-native codebase that can be effectively developed and maintained by a relatively small development team. The Torus technical stack was carefully selected with these requirements in mind. These initial requirements have already drawn exceptional interest from industry and academy collaborators; Torus has quickly grown into an open-source, community-based project with the promise of an even larger community.

Early, enthusiastic participation from Arizona State University's Education Through Exploration Center (ETX)[2] has accelerated progress towards a broader, open-source community with a shared commitment to science-based courseware. ETX is a leading developer of highly immersive, adaptive courseware, with millions of dollars invested to develop materials on the Smart Sparrow platform, and commitments for additional development from a variety of grants (e.g., Horodyskyj et al., 2018; Mead et al., 2019). Pearson's 2020 acquisition of Smart Sparrow left ETX's prior work and future commitments at risk. The Inspark Teaching Network,[3] closely aligned with ETX, faced the same challenges. To address this risk, ETX became a key partner in the Torus community, recapitulating

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[2] https://etx.asu.edu
[3] https://inspark.education

Smart Sparrow capabilities and migrating existing content to the new platform. At the close of 2022, ETX is central to the now-shared Torus effort, with all its content (and Inspark's) being delivered on an open Torus platform that provides feature parity with the now-defunct Smart Sparrow platform. Additional users and contributors include the State University of New York (SUNY) system, KTH Royal Technical Institute of Stockholm, Unicon, and WyeWorks. This growing community boasts an array of post-secondary and industry participants that have jointly invested $8.3 million in the platform.

In its current form, the Torus project demonstrates the viability of both the platform and the larger community-based approach. Over the past year, Torus has received open code contributions from more than 8 universities and companies; during that time, the platform has served 35,000 enrollments via 380 educators on 90 campuses. The platform has also seen expansive use in supporting independent enrollments and experiments. New and migrated content is being used by OLI for thousands of students, in courseware representing many domains. ETX is now developing new courseware on the platform. In the coming year, this use is projected to grow dramatically, with an estimated 110,000 enrollments as development and migration continue. The platform instantiates a three-tier client server architecture, combining a Postgres backend, an Elixir/Phoenix application layer, and an HTML/React/LiveView presentation tier. This technology stack was chosen to accelerate development, scale, leverage cloud-native capabilities, aggressively address accessibility, and drive engagement with a broader open-source community. Torus is built for scale in multiple dimensions and architected to support two-orders-of-magnitude growth from our legacy system. Our priorities in developing Torus have emphasized elements that will expand our user base by targeting historically limiting factors in adoption and contribution. Torus is under active development, with a focus on finalizing migration from the legacy system and a longer-term roadmap with a host of new features and affordances. Torus supports a growing array of analytics, supporting course designers, authors, and students. The authoring environment has already recreated key improvement views from the legacy system, allowing designers to more easily identify areas to be refined (Bier & Jerome, 2012). The system also provides direct connections to DataShop and LearnSphere, expanding analytic capabilities. New features include an audit framework to support detailed pre-release analysis of courseware; existing pedagogical, accessibility, and content audits are already in place and being actively refined, and new equity audit approaches are in development. The platform also addresses the legacy platform's analytics implementation, which offered a rigid approach that made expansion of and research into learning analytics a challenge (Bier, et al., 2014). Torus is designed to support a modular approach, separating prediction engine, domain and learner models, and visualization components to support a broader set of approaches and investigations.

3   LOOKING AHEAD AND GETTING INVOLVED

The Torus codebase,issue tracking, documentation, etc.. are available on GitHub[4]. OLI's production Torus instance is available to Interested developers, educators, and researchers are encouraged to explore the codebase and system[5]. A host of current projects ensure that the platform is rapidly developing and evolving. Support from Schmidt Futures and NSF are driving more instrumentation, A/B testing, and adaptive capabilities planned for 2023.[6] Investments from the Bill and Melinda Gates

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[4] see https://github.com/Simon-Initiative/oli-torus
[5] can be accessed at http://proton.oli.cmu.edu
[6] See https://www.cmu.edu/news/stories/archives/2022/september/classroom-experimentation-stamper.html for details.

Foundation are also supporting new platform innovations, emphasizing equity-advancing features.[7] Support from NSF is also allowing research on learner sourcing content (Moore et al., 2021b) and integrating large language models (LLMs) like GPT3 (Moore et al., 2022). Monthly community meetings are held to announce new efforts, refine the Torus roadmap, and explore community needs. Interested educators, researchers, and developers are encouraged to participate.[8] This testbed for deploying and investigating learning analytics will be of ongoing interest to the LAK community.

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[7] https://www.cmu.edu/news/stories/archives/2022/june/asu-cmu-chemistry.html

[8] See https://oli.cmu.edu/oli-communities/torus-community/ for schedule and additional information.