

CHUNK Learning: A Tool that Supports Personalized Education

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ABSTRACT

The modern educational ecosystem is not one-size fits all. Students are accustomed to personalization in their everyday life and expect the same from education systems. Additionally, the COVID-19 pandemic placed us all in an acute teaching and learning laboratory experimentation which now creates expectations of self-paced learning and interactions with focused educational materials. Consequently, we examine how learning objectives can be achieved through a learning platform that offers content choices and multiple modalities of engagement to support self-paced learning and propose an approach to personalized education based on network science and data mining. This framework brings attention to learning experiences, rather than teaching experiences, by providing the learner engagement and content choices supported by a network of knowledge based on and driven by individual skills and goals. We further discuss the proposed prototype of such a learning platform, called CHUNK Learning. In this work, we present this tool, its benefits for students, challenges in personalized education, and future plans.

Keywords

CHUNK Learning Prototype, Personalized Education, Network of Knowledge, Network Data Mining.

1. INTRODUCTION

Education must meet the changing needs of a complex environment where learners are expected to contribute as creative problem-solvers. Education solutions must satisfy the specific educational needs of each learner while meeting the rapidly changing learning objectives for each degree or job in a resource-efficient way. Consequently, the educational ecosystem must also provide a flexible and rich cognitive

environment, supported by adaptable high-quality content for academic performance and complemented by effective learning analytics, as well as social networking for strong emotional support of students.

We identify the current shortcomings of learning platforms and propose solutions to improve personalized learning using data mining and network science techniques. At the content level, we focus on exploring the relevance of content by anchoring it to each learner's existing knowledge and how content connects to the skills of each learner. Additionally, we discuss how interconnecting people, content, goals, and skills support student learning outcomes and collaborative learning and what is the impact of these interactions on educational experiences.

Our goal is to facilitate a learning culture that cultivates curiosity and inquiry. While learners interact with different content to show the same proficiency, learning differentiation is based on branching off the main knowledge thread driven by each student's unique attributes, such as experience, existing skills, and learning goals. In this work, we propose a personalized education model driven by data science and network science, and present a solution, a prototype called CHUNK Learning [12]. We create this agile system by interconnecting the content, skills, and learners that creatively address learning theory while supporting an ecosystem that motivates students and improves learning outcomes. Our focus is on creating a network of knowledge, individualized education pathways, and a social network of users to improve personalized education.

2. OUR VISION AND STATE-OF-THE-ART

We present our vision for personalized education and the synthesis of state-of-the-art research in support of personalized education using network science and data mining.

2.1 The Design of a Network of Knowledge

Traditional education is linear, one chapter after another through a whole course or course after the course through a degree. An interconnected model of education brings an interconnected (non-linear) view of the knowledge, where a user can navigate through a network of knowledge built

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based on an ontology, pre-requisites, or dependency. Recent research identifies the benefit of interconnecting the knowledge for the learners, seeking models for a network of knowledge. For example, one way to model it is by “quantifying and analyzing the structure of students’ knowledge of a given discipline as a knowledge network of interconnected concepts”. Once this network is created, we can capture the learning pattern and retrieve the information of learners’ interactions over time [7, 17].

We propose a model that supports the interconnected world of 21st-century education, where subject matter experts co-create a network of knowledge as a curated collection of networked learning modules [1, 10]. A successful prototype was built and used since 2018, namely the Curated Heuristic Using a Network of Knowledge for Continuum of Learning (CHUNK Learning), i.e., a real-time, adaptive teaching-learning modular method for enhanced and personalized education.

2.2 The Education Pathways for Personalized Learning

Education is improving, but not as fast as our aspirations. Learners bring distinct backgrounds, learning style preferences, and different motivations for engaging with the content. This surfaces the need for personalized learning that assesses each learner’s gaps, skills, and prior experience before bringing in new information, thus preventing more gaps creation or repeat of lessons already learned.

It also requires that a variety of learning styles be available for learners when engaging with an instructor or the asynchronous content. Content and applications of the newly learned content must differ based on each learner’s experience and background; for example, learning and using a mathematical concept for an economist versus a mathematician is different. Content must have applications that are relevant to the learner’s background to anchor it to the learner’s experience since they will be applying it in the future. Besides this, some learners are directed to learn specific content for certification as needed by a job or degree, while some learners explore the network of knowledge for personal indulgence to up-skill their existing expertise. With the goal of providing a personalized experience to each student, choices of learning paths for each student need to be dynamically created. A method to create these learning paths can utilize network science and data mining techniques on the annotated network of content and users [7].

Cognitive flexibility theory discusses learning within complex and ill-structured knowledge domains through the inability of linear educational structures to support meaningful learning experiences [6]. In these environments, the network of knowledge demonstrates complex concepts’ interconnections and supports semantic memory. Additionally, the use of nodes and edges creates visual learning pathways that provide an avenue for supporting and tracking learners’ knowledge acquisition [17].

The use of network science to create a structural representation of learning paths supporting knowledge acquisition allows educators to determine if there is an optimal path. Networked education pathways provide the necessary envi-

ronment to examine the average length of paths between two nodes in the network and the relationship to students’ understanding of material [16]. This also presents an opportunity to examine the use of bridging concepts within a complex knowledge structure [17]. This will also provide a feedback mechanism to inform educators about how to improve educational experiences for learners, filling in gaps within the knowledge structure as needed in order to support desired learning outcomes. Once users have navigated even a portion of the network of knowledge, their experiences create a database of learning paths, which can be analyzed to understand the learning patterns based on gender, age, background, learner type (directed versus exploratory learner), or other attributes of the learners [13]. These findings can be used to further improve the personalized learning platform by suggesting what content should be added and designing a better recommendation system for learners.

2.3 Incorporating Online Social Networking in Learning Platforms

Online learning platforms complement or replace classroom learning for students; however, they usually lack students’ engagement. One way to support students’ engagement in such educational platforms is by incorporating social networking into the learning platform. Researchers have studied the benefits of networking the learners in learning and professional development [15]. Various existing platforms, such as Coursera [3], Moocs [4] provide the ability for students and instructors to communicate with each other. While this supports modern students’ learning, they lack social networking among students for content recommendation or live collaboration.

A learning platform can provide a service to maintain social connections for increasing users’ engagement in the following ways. First, users can follow or be friends with people they know or want to connect with for personal interest. Secondly, the platform should suggest new users to connect with based on similar backgrounds and same learning interests. Additionally, to incorporate group learning, the platform should suggest the teams either for instant collaboration or group projects based on users’ current learning paths. The recommendation system must be adaptive in recommending such teaming patterns based on the past performance of the students and their interests.

CHUNK Learning includes the vision for such a platform that is empowered by social networking to support meaningful learning timely and respectful of each learner’s time in a cost-effective manner [1]. Research on the CHUNK Learning platform considered the social network to recommend similar content to similar learners, as well as connecting similar learners based on their learning paths, background, and mentor-mentee type relationships [11].

3. A WORKING EXAMPLE: CHUNK LEARNING PLATFORM

We have designed a prototype of personalized education using the network of knowledge, learning pathways, and network of students, called CHUNK (Curated Heuristic Using a Network of Knowledge) Learning platform [1, 10, 12]. We now point out how CHUNK Learning fulfills some of the

CHUNK Explorer (right): A curated collection of networked learning modules, organized to meet strategic objectives (academic or professional). Prerequisites directed by yellow arrows on the right.

Chunk (below): A self contained knowledge module.

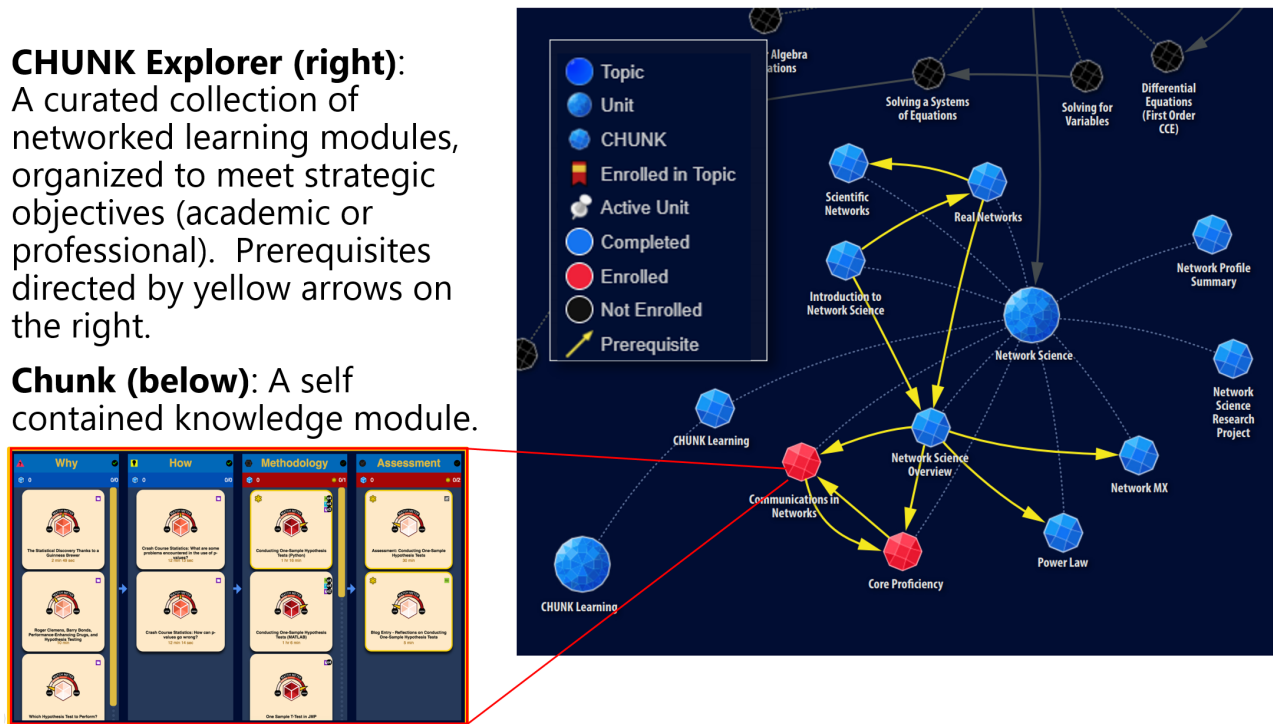


Figure 1: The network explorer and a chunk's content in CHUNK Learning [1]

identified needs for personalized education. Since the existing CHUNK Learning system is in its infancy stage, we will conclude this section with ideas that can extend the current version based on the discussion in Section 2.

The CHUNK Learning prototype offers several features identified in this work: (i) a personalized learning journey by using the information provided in the learner's profile to automatically recommend the most relevant-to-you content, (ii) content mapping that illustrates how a learner can progress through the network of knowledge by including the choices of learning paths through the network, and (iii) a framework to support social network of learners based on their profile and content they are engaging with at each time they log into CHUNK Learning. CHUNK Learning platform focuses on empowering students by ensuring that the learning journey is cohesive, flexible, and respectful of learners' time and interests. This personalized education is accomplished through the use of the following components.

- Content is chunked into intense, short, and focused educational modules (chunks) that are interconnected in the network of knowledge to provide (a) learner's choices and platform's recommendation to build personalized learning paths, (b) view of the learning path choices through the content, and (c) a big picture of cohesive learning.
- Choices of interchangeable and reusable content stimulate each learner's interest and provide relevance of each topic to each learner [10].
- Learners' are placed into a social network to support each other, such as pairing senior learners as mentors

for junior ones, based on their automatically updated profiles [14].

- Personalized content driven by implicit recommendations from a user's social network based on tie strength between learners [8].

Based on the learner's profile, CHUNK Learning optimizes both the content and the methodology delivery to meet the needs of each learner. It is intended to fit typical academic needs, much like curriculum mapping, while personalizing the content within the chunk of knowledge. Therefore, the content is organized hierarchically using Topics, Units, Chunks, and Chunklets to index content in a way that meets and improves the overall coherence of a course of study (more information on CHUNK Learning Wiki [2]).

Figure 1 shows the personalized adaptive learning framework by displaying a portion of the network of knowledge on the right and the personalized content of a chunk of knowledge on the bottom left of the figure. Within a chunk, the top row of content reveals the system's recommendations based on the learner's profile, and the other tiles are the choices of the ranked alternatives. The system displays content in a manner that can be viewed in a network format through the CHUNK Learning explorer at the topic, unit, and chunk levels. The explorer view at the topic-unit-chunk level is a concept mapping that follows a logical order to provide each learner a well-rounded and comprehensive educational experience, with choices for deeper dives and connections to other topics-unit-chunk. At the chunklet level, a learner can see the choices for all the building blocks needed to attain any specific academic competency

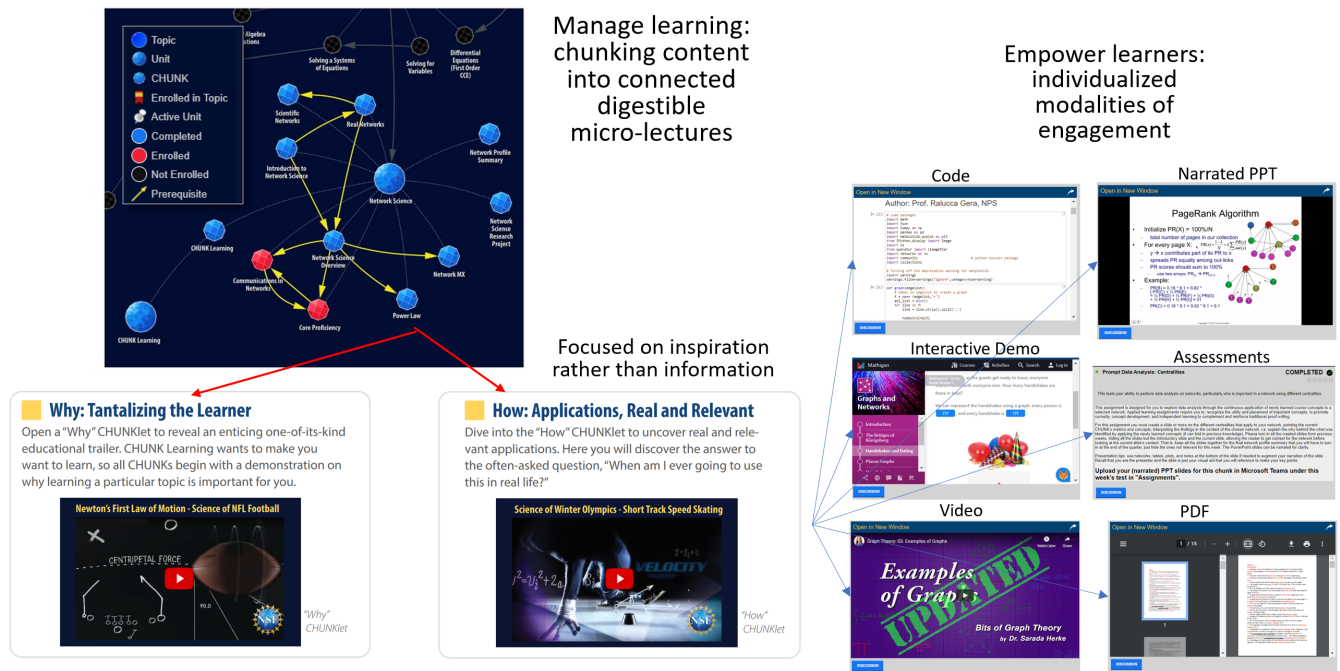


Figure 2: A view of personalized learning pathway in CHUNK Learning [1]

while being recommended the most relevant one based on that learner’s profile. Each column of a chunk provides the recommended chunklet at the top, followed by rank-ordered choices to complete that part of the chunk before heading to the assessment.

Figure 2 shows an example of personalization in CHUNK Learning achieved through (i) interchangeable chunklets that personalize the application of the content (on the left side of the figure) and (ii) personalized interchangeable activities for different styles of learning, such as video, PDF, code, demo, interactive activity (on the right side of the figure).

CHUNK Learning is a prototype used for hybrid teaching at our university. For these classes, students learn part of the content asynchronously using CHUNK Learning, complemented by synchronous practice and discussions. The assessment of students’ experience in these classes shows promising benefits in using CHUNK Learning for hybrid teaching. Besides the self-paced environment, students valued the mix of modalities of engagement with the content available on CHUNK Learning, supporting meaningful and engaging interactions with the class while enhancing their learning experience.

3.1 Extending the CHUNK Learning Platform

How can this prototype be further extended using network data mining? We see four primary areas of extension, and some progress has already been made in each of the areas: (i) the network of knowledge’s explorer view, (ii) the content within a chunk, (iii) the social network of users, and (iv) create a network-driven recommendation system and learning analytics. Below we expand on the existing work on each of these extensions.

CHUNK Learning’s explorer view of the Network of Knowledge in CHUNK Learning is static and identical for all users (except the color coding based on the enrolled and completed chunks). To focus and place the learner on a meaningful learning path, we propose a personalized display of the network of knowledge based on assessment and relevancy to the user’s learning objectives. Complementing the personalizing of the explorer view, we can personalize each chunk’s content. Currently, it is performed using the content’s tags compared to a learner profile’s tags, in addition to the ranking of the content based on the user’s rating of each chunklet. The two existing rankings are based on the quality of the content and relevance to the learner.

Currently, the recommender system updates the learning plan based on each learner’s activities (learned, viewed, tested), keyword searches, and content ratings [5, 9, 11]. We aim to update further the recommendation system using the social network of learners and their learning history.

4. CONCLUSION

In this paper, we introduced a prototype named CHUNK Learning to improve personalized education at scale using network data mining. The proposed prototype is based on the network of knowledge, education pathways, the network of learners, and the content recommendation system. We presented this tool, its existing features, and further plans. We also discussed some challenges to consider in creating and using such a personalized learning ecosystem. We aim to extend the tool further by including a social network of users to support personalized and collaborative learning. We share this work to promote conversations and research towards a new field of personalized education driven by network data mining.

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