Exemplifying Computational Thinking Scenarios in the Age of COVID-19: Examining the Pandemic's Effects in a Project-Based MOOC

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Abstract

The rapid, global spread of COVID-19 has led to an unprecedented rise in enrollments in online learning experiences among learners of all ages. In this paper, we explore the impact of the global pandemic on a massive open online course, *Problem Solving Using Computational Thinking*, with a particular focus on the topics learners chose for their final projects. The *Computational Thinking* MOOC was designed using a project-based learning approach and aims to provide learners with an introduction to the "big ideas" of computational thinking using a range of case studies that encompass topics such as airport surveillance, epidemiology, and human trafficking. Beyond observing a sharp increase in enrollment and engagement at the time the pandemic began, we discuss ways in which the course's project-based pedagogy allowed learners to bring their present experiences and concerns together with the course's subject matter in order to meet the learning objectives for the course. Many learners chose to address aspects of the pandemic in the course's final project and applied ideas about computational thinking to peer-graded assignments that conveyed an individualized sense of importance and urgency. We assert that this approach, along with the inclusion of a timely epidemiology case study, enabled learners to more deeply internalize the role that computational thinking can play in their own lives and in society as a whole.

Introduction

The COVID-19 pandemic has thrust online learning environments into the global spotlight. The sudden shift to emergency remote teaching (Hodges et al., 2020) has forced educators and students to adjust their educational routines using digital platforms and even pedagogical approaches with which they were previously unfamiliar (Quintana & Quintana, 2020). Schools and universities have confronted this new reality, while lifelong learners have sought new online options for advancing their education.

One of the outcomes of these events has been an unprecedented rise in enrollments in massive open online courses (MOOCs), leading to a series of publications on the subject (Lohr, 2020). In this paper, we explore the impacts of the pandemic on one MOOC: *Problem Solving Using Computational Thinking*. We give special attention to the educational benefits of a pedagogical approach that is rarely used in courses of this scale: project-based learning (PBL). We identify particular benefits of this approach that current events have highlighted, and we offer implications for teaching computational thinking in online settings.

Course Description

Audience and Scope

The *Computational Thinking* MOOC was developed by an interdisciplinary team from a large public university in the Midwestern United States. The course was designed for a target audience of pre-college learners and early college learners who intend to pursue STEM careers and would thus need to develop fluency in the computational tools used in STEM. It aims to equip students with the modes of thinking needed to set up problems and potential solutions as a foundation for being able to eventually use computational tools and programming to address those problems.

Given this perspective, the course is based on one particular definition of computational thinking (CT). CT has been described and discussed in some form for decades (Papert, 1996), but it has received increased attention in recent years, with an especially sharp rise in relevant scholarship since 2015 (Hsu et al., 2018). The definition of CT adopted in this course draws heavily on the work of (Wing, 2006), who presents CT as the practice of conceptualizing problems, complementing and combining mathematical and engineering thinking. (Wing, 2006) argues that CT should not become a synonym for computer programming and notes that there are a range of skills necessary for CT, including the ability to define problems, reformulate seemingly intractable problems into solvable ones, use abstraction and decomposition when approaching a complex task, and use massive amounts of data and computation for problem solving.

While the *Computational Thinking* MOOC similarly emphasizes the problem-solving aspect and many of the skills that Wing highlights, it does so without requiring learners to make use of actual data or computer programming. In the course introduction, CT is defined in the following approachable way:

> "Before you can think about programming a computer, you need to work out exactly what it is you want to tell the computer to do. Thinking through problems this way is Computational Thinking. Computational Thinking allows us to take complex problems, understand what the problem is, and develop solutions. We can present these solutions in a way that both computers and people can understand."

The goals of the MOOC, therefore, focus on helping learners to specifically define and decompose problems through abstraction while teaching them to use insights from similar problems in other domains to guide potential solutions.

Project-Based Pedagogy

This MOOC was designed around a "project-based learning" (PBL) approach, which integrates instructional activities within projects motivated by students' own interests and contexts (Krajcik & Blumenfeld, 2005). PBL is popular in K-12 classrooms, but there are questions of its utility in other settings, especially in MOOCs, which typically adopt a didactic, lecture-based format with instructional videos, quizzes, discussions, and graded assignments. However, some early work has found positive attitudes among learners in a project-based MOOC and has emphasized the importance of learner autonomy in these contexts (Barak & Watted, 2017).

The *Computational Thinking* MOOC centers much of its pedagogy around a final project in which learners identify a problem to solve *computationally*, and then use the knowledge and techniques they learned throughout the course to iteratively develop an algorithmic approach towards a solution. They are asked to submit both a graphic organizer that displays the multiple iterations of their work and a diagrammed algorithm of their final solution for peer evaluation. This approach affords learners a level of flexibility rarely found at the scale of MOOCs since they are able to select the topic that will define their final projects.

Using Case Studies to Shape Student Work

Using case studies is a way to ground CT in real-life scenarios. This provides a concrete, actionable foundation for CT that can more effectively lead to learning, retention, and application (Weintrop et al., 2015). For this purpose, the *Computational Thinking* course revolves around a series of three case studies.

Most pertinent here is the case on epidemiology, which was incidentally developed before the events surrounding the global pandemic. This case presents a large, complex problem: how do we prepare for the seasonal flu and make sure we are ready for the next pandemic? The expert who presents this case—an associate professor of epidemiology—breaks this down into a more specific sub-problem and then walks learners through an algorithm that centers around four categories of people: vaccinated, susceptible, infected, and recovered. Finally, a series of computational modeling tools specific to epidemiology are offered to learners interested in diving more deeply into this problem.

Enrollment and Engagement Trends

As a reflection of the recent spike in attention that online education has garnered, the *Computational Thinking* MOOC experienced a sharp increase in enrollment around the time that many countries began to experience the full force of the COVID-19 pandemic. We found that most new learners who reported their educational attainment and employment status hold a bachelor's degree and are unemployed (see Figure 1). As expected, this suggests that the rise in overall enrollments is likely due to a combination of more people working from home, universities shifting to remote teaching, and rising unemployment rates.

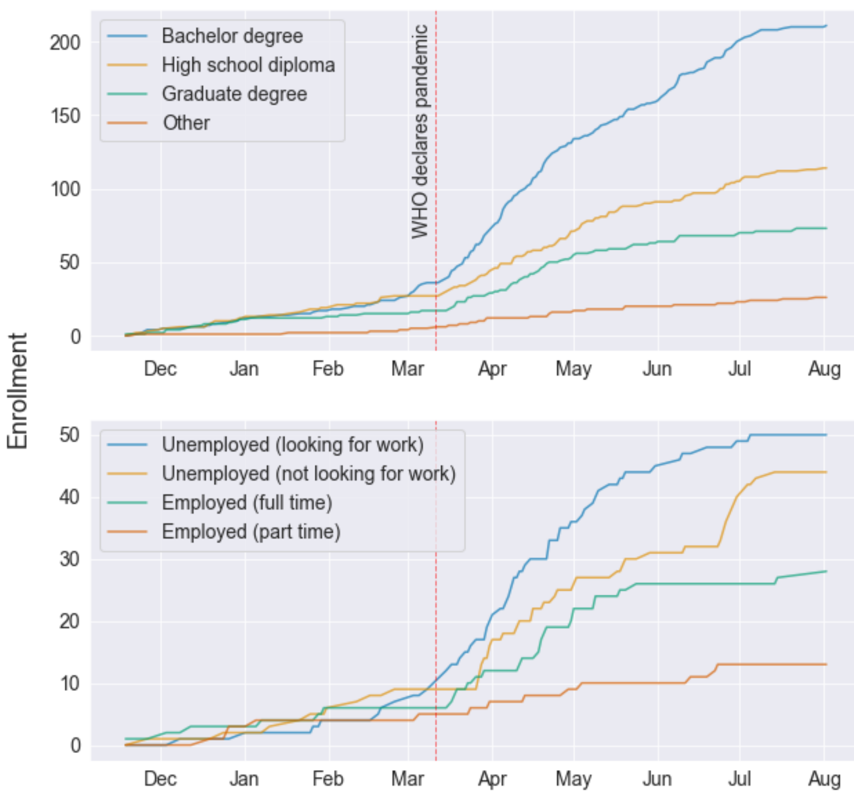

Figure 1: Enrollments by educational attainment (top) and employment status (bottom).

Since MOOCs are notorious for having high numbers of enrollments with few learners actually engaging in the material or completing the course, we also explored learner engagement trends, calculated as the number of learners who completed at least one item (lecture video, quiz, discussion post, etc.) during the previous week. We discovered an even sharper rise coinciding with the spread of the virus, suggesting an impressive surge of learners actively engaged in course activities.

Student Final Projects

The course's peer-graded final assignment requires students to identify a location and natural disaster—either hypothetical or real—and create a preparation plan to address a specific aspect of this disaster. The plan must involve the main elements of CT described throughout the course, namely *problem identification*, *decomposition*, *pattern recognition*, and *abstraction*. Learners' final submissions consist of a descriptive problem statement, a graphic organizer, and an algorithm diagram. Examples of the wide range of disasters learners chose include floods (by far the most common), cyclones, earthquakes, tsunamis, tornadoes, and droughts.

With the circumstances surrounding the global pandemic influencing enrollment and engagement in the MOOC, we were interested in whether its impact would also be realized in topics learners chose for their final projects. Furthermore, we were interested in the specific problems that learners identified related to the pandemic which they deemed "solvable" using computational thinking approaches.

Methods for Identifying Projects Related to the Pandemic

In order to accurately measure the number of final projects submitted and those related to the COVID-19 pandemic, we first used a series of Jupyter Notebooks to clean the data. We discarded a total of 61 projects that were missing attachments, were exact duplicates of previously submitted projects, or skipped by peer reviewers due to incomplete submissions. This left us with 164 final projects to analyze, submitted between November 18, 2019 (course launch date) and August 11, 2020.

To identify projects related to the pandemic, we first extracted those that contained any of the following words in their title or description: *COVID*, *corona*, *virus*, *pandemic*, *epidemic*, *Wuhan*, and *social distanc(e)*. We then performed the same search through all PDF, DOCX, and PPTX project attachments. In total, we found 32 final projects that related to the events surrounding the pandemic.

Findings

The timing of pandemic-related final projects clearly corresponds with the rise in coronavirus cases outside of China, with the first related project submitted on March 24th and quickly increasing from there. Since that date, 20% of submitted projects have been related to COVID-19 in some way.

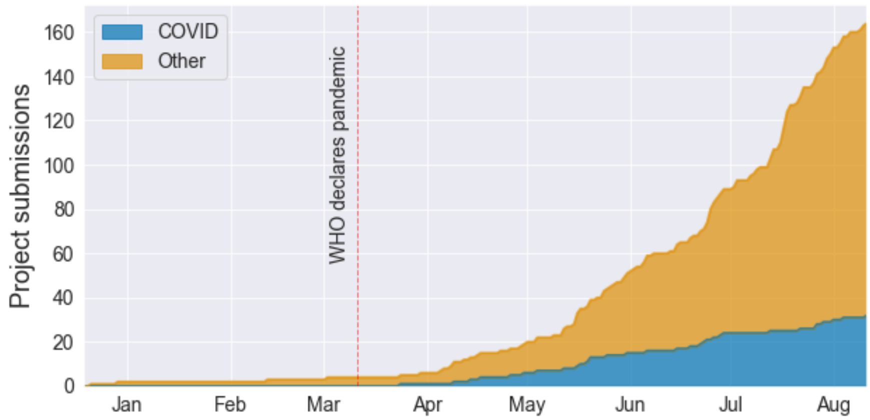

Figure 2: Proportion of pandemic-related final project submissions over time (stacked).

We were interested in exploring whether learners in regions that were first heavily affected by the pandemic, such as East Asia or Europe, chose to write about the pandemic before others. However, we found that the first pandemic-related project was submitted in the United States, followed by India, Thailand, and then Germany, in that order (based on self-reported demographic data and tracked IP addresses).

As issues and problems surrounding the pandemic unfolded in real time, learners articulated specific dimensions that could be addressed using approaches advanced in the course. Some of the overarching topics in these projects include being wise about treatment, finding ways to prevent further spread, dealing with life in quarantine, managing school, and how to adequately distribute resources to those most affected. Interestingly, early projects were mostly about deciding to enforce stay-at-home orders and social distancing measures, while later projects largely focused on whether and when to begin reopening society.

Some learners who chose to write about the pandemic articulated that they recognized COVID-19 did not cleanly fit within the category of *natural disaster*:

> "Rather than focusing on a 'natural disaster' like too much snow or flooded streets, I've chosen COVID-19 since it has limited people's access to proper nutrition and healthy diet."

> "COVID-19 is a pandemic the whole world is talking about right now. This may not be a natural disaster but is more effective than a natural disaster."

These excerpts—along with learners' decisions to choose a different path than instructed—highlight the weight of the pandemic in their personal lives.

Implications and Conclusion

Our findings in this case study have highlighted the benefits of a PBL approach to teaching problem-solving methods and skills such as computational thinking. Though providing learners with a high degree of agency in online courses that are offered at scale may not always be feasible, doing so can empower them and help them establish personal ties to the subject matter. This heightened level of buy-in from learners, created through a combination of greater autonomy and personal interest in the subject, has been shown to lead to more robust learning (Patall, 2013).

In the case of the *Problem Solving Using Computational Thinking* MOOC, learners were able to choose project topics closely related to their interests, their experiences, and the large problems currently on their minds. For those who chose to look at the COVID-19 pandemic through a CT lens, we expect that the ongoing nature of the problem will lead to many additional opportunities to reflect on the skills they have learned. We assert that the PBL approach adopted in this course, along with the inclusion of a timely epidemiology case study, enabled learners to more deeply internalize the role that CT can play in their own lives and in society as a whole.

Author Biographies

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