

# Patterns of Topic Acquisition: When, Where, and in What Order?

Kevin Sevilla and Jim Morgan  
Charles Sturt University  
Corresponding Author Email: [ksevilla@csu.edu.au](mailto:ksevilla@csu.edu.au)

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## CONTEXT

The CSU Engineering Program is the first of its kind in Australia. Abstaining from traditional methods of admission, content delivery, and assessment, in favour of a hybrid content delivery system (RealizeIT) that enables students to access technical content both online and on site. The RealizeIT system contains content within the CSU Engineering “Topic Tree” which is an online interface comprised of topics spanning approximately three-hours of effort containing technical content in civil engineering. Student Engineers are given the freedom to select content from over 800+ topics, and are expected to complete them at a rate of approximately 80 per semester in place of traditional subjects. This study focuses on the data collected through the RealizeIT system to identify when student engineers are completing topics, and at what rate they are doing so.

The motivation for this study is to understand when students’ complete topics and at what rate. Uncovering the realities of the student experience in the CSU Engineering program has the potential to affect the recruitment and admissions process for the program, how topics are created, and how accommodations can be made to improve both the on-site and remote experience for students in the future.

## PURPOSE

The purpose of this study is to identify how students engage with the Topic Tree, and identify the factors that correlate to topic completion and success.

## APPROACH

This quantitative study collected and analysed data from the RealizeIT system to illustrate topic completion across the first 22 weeks of the course. Data was mapped chronologically across the semester and into the semester break (Week 0 through Week 22). With 28 participants, topic completion was analysed within four groups of seven student engineers and displayed accordingly.

## RESULTS

The results of this study show clear distinctions between quartiles of performance regarding topic completion. With three primary phases of topic completion being identified, it is apparent that higher performing students not only complete more topics during the semester, but also during semester breaks and after the conclusion of the first semester. Alternatively, the combined lack of effort towards completing topics during semester and semester breaks explains the longitudinal differences in total topic completion seen across the cohort.

## CONCLUSIONS

Based on the results of this study, it is apparent that the challenges of self-directed learning and the Topic Tree approach on student motivation and performance are ongoing. With a disparity in topic completion both during the semester and through the semester breaks, understanding the underlying mechanisms for these behavioural differences between high- and low-performing student engineers will be crucial to the ultimate success of the CSU model of engineering education. Means of scaffolding topic completion during the semester and educating student engineers on how to self-regulate their learning across the calendar year are currently under way.

## KEYWORDS

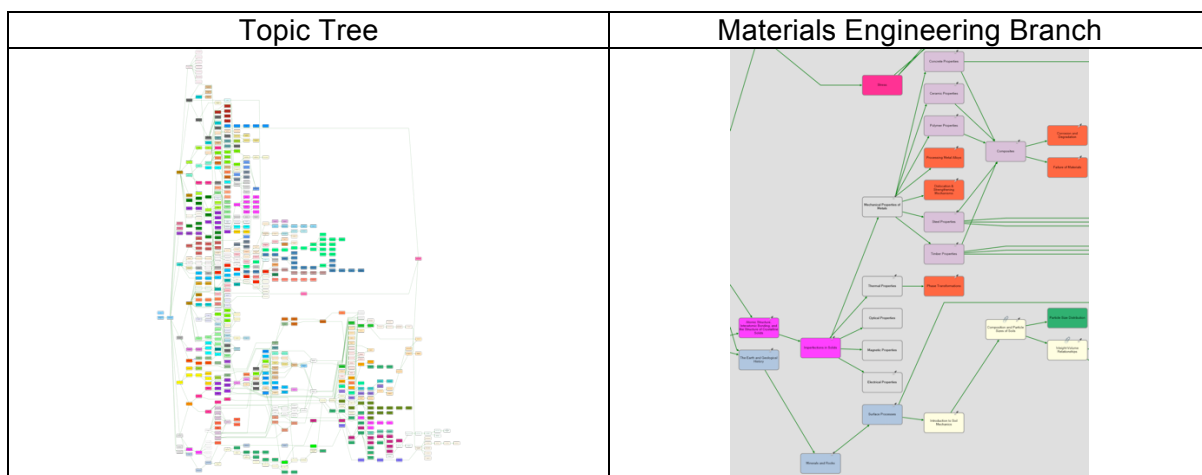
Self-Directed Learning, Student Success, Unique Content Delivery, Degree Progress.

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## Context

The CSU Engineering Program is the first of its kind in Australia. Abstaining from traditional methods of admission, content delivery, and assessment, in favour of an online content delivery system (RealizeIT) that enables students to access technical content at a time and place of their choosing (Lindsay and Morgan, 2015). The overall structure of the course as a 5 ½-year program has student engineers complete 240 topics in the first 18 months before moving on to 4 year-long industry placements. In addition to topic completion, student engineers are required to complete 3 semester-long design challenges to apply the technical content from these topics.

The RealizeIT system is the backend support for the CSU Engineering “Topic Tree” (see Figure 1) which is comprised of approximately 3-hour topics containing technical content in civil engineering. The green arrows highlight the connections between topics, some as prerequisites, and others simply to show associations at equal levels of complexity.



**Figure 1: The CSU Engineering Topic Tree**

Content within the Topic Tree comes from three primary sources including Khan Academy Maths, Open Learning Initiative (Carnegie Mellon), and CSU Engineering topics. Table 1 illustrates these categories, their major branches, and some example topics from these branches.

Student engineers are given the freedom to select content from over 800+ topics, and are expected to complete them at a rate of approximately 80 per semester in place of traditional courses. Once student engineers gain access to the RealizeIT system, they may complete topics regardless of whether or not university is in session. At the conclusion of each topic is a short assessment task in which a score of at least 75% is needed to earn credit.

Learning is very self-directed in nature, as students are set only two primary goals for the first 18 months of the course, including passing their 4 design challenge subjects and completing 240 topics. Self-directed learning does not mean that it is highly individualized or that it is done in isolation, but that “[most] decisions about how and what to learn, and how or whether to consult external resources, rest with the learner” (Brookfield, 2009, pp. 2615). While the greater body of self-directed learning literature focuses on the importance of learning networks (Brookfield, 2009) consultation with peers (Knowles, 1975), personality type, learner’s previous experience in the domain, availability of resources, and the perception of cultural constraints or enhancers (Caffarella, 1999), this paper will only focus on the outcome of the self-directed learning process, namely, topic completion, and at what rate.

**Table 1: Topic Breakdown by Category**

<b>Category</b>	<b>Major Branches</b>	<b>Example Topics</b>
<b>Khan Academy Maths</b>	<ul style="list-style-type: none"><li>- Probability and Statistics</li><li>- Differential Calculus</li><li>- Integral Calculus</li><li>- Linear Algebra</li><li>- Differential Equations</li></ul>	<ul style="list-style-type: none"><li>- Normal Probability Distribution</li><li>- Limits at Infinity</li></ul>
<b>Open Learning Initiative Statics</b>	<ul style="list-style-type: none"><li>- 2D Statics</li><li>- 3D Statics</li></ul>	<ul style="list-style-type: none"><li>- Free Body Diagrams</li><li>- Equilibrium of Bodies with Engineering Connections</li></ul>
<b>CSU Engineering</b>	<ul style="list-style-type: none"><li>- Structural Engineering</li><li>- Water Engineering</li><li>- Geotechnical Engineering</li><li>- Project Management</li><li>- Materials Science</li><li>- CAD Modelling</li></ul>	<ul style="list-style-type: none"><li>- Stress vs. Strain</li><li>- Soil Compaction</li><li>- Failure of Materials</li></ul>

## Research Questions

1. At what rate are student engineers completing topics?
2. Are there any trends to topic completion across the cohort?

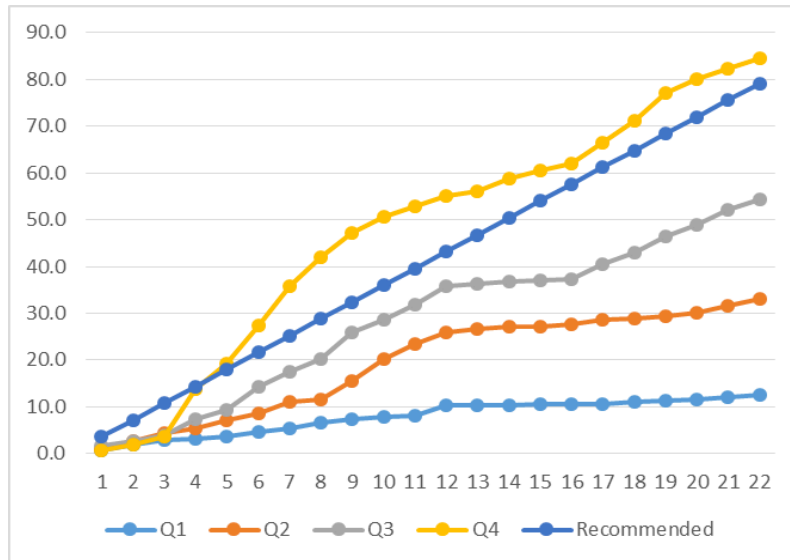
## Methods

Data was collected through three primary sources including Khan Academy, Open Learning Initiative (OLI) Statics, and CSU Topics offered through the RealizeIT system. Khan Academy is the home of the maths topics for the CSU Engineering program, housing Pre-Calculus, Probability & Statistics, Differential Calculus, Integral Calculus, Linear Algebra and Differential Equations content. OLI Statics is a series of 20 topics developed by Carnegie Mellon, and CSU Topics are those developed in-house by the CSU Engineering staff that cover all civil engineering content. The topic completion data from these sources was combined and mapped collectively across a 22-week period and the results were compared to four potential models of topics completion.

The Topic Tree is available throughout the year, so students may access content at a time of their choosing. With the goal of 240 topics to be completed in the first 18 months (66 weeks), the number of potential methods for achieving this is limitless.

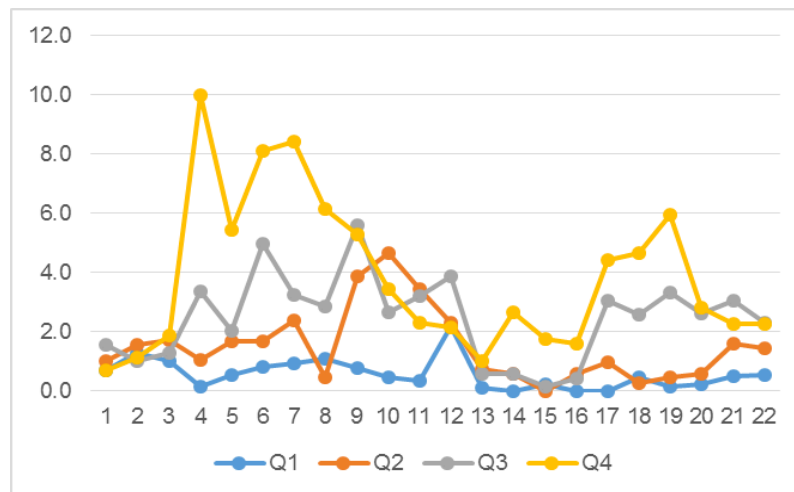
## Results

The results of this study highlight performance differences across the four quartiles defined within the cohort. Figure 2 illustrates the total topic completion trends across the first semester and the mid-semester break over time.



**Figure 2: Total Topic Completion vs. Time in Calendar Weeks**

Alternatively, Figure 3 highlights the differences between the average amount of topics completed across the quartiles week-to-week.



**Figure 3: Average Topic Completion/Calendar Week/Quartile**

What each of these figures shows is that the difference in performance between high- and low-achieving student engineers occurred in three main stages. The first stage occurred during weeks 1-9 in which the higher performers showed a consistent effort both while class was in session and through the first mid-semester break. The second stage occurred between weeks 9-13 which represented the high intensity point of the semester in terms of project work being due including final reports and presentations. During this stretch of time, the highest performing quartile seems to have put aside topic completion to focus on these major course milestones. The third and final stage between weeks 14-22 shows that during the semester break, higher performing student were back to completing topics on a regular basis, while the lower half of the cohort did not. The net results of these three stages of behaviour are highlighted in Figure 2 as only the top quartile of student engineers were on pace for their first industry placement as of the 22<sup>nd</sup> week of the course. The following section offers four possible philosophies to explain how student engineers may be conceptualising the task of completing their first 240 topics.

## Topic Completion Plans

Plan A assumes completion of topics at an equal rate across all weeks of the calendar year regardless of whether or not CSU is in session. Using this plan, student engineers would have to complete 3.58 topics per week. Plan B stipulates that student engineers only complete topics during the weeks when CSU is in session. Under this plan, student engineers would have to complete 6 topics per week. This plan excludes each mid-semester break, the midyear break, holidays, and the summer session.

In addition to Plans A and B, Plan C assumes an equal amount of effort year round if you combine efforts towards design challenges and topic completion. More specifically, student engineers that follow Plan C complete fewer topics during to semester as they wish to focus on their design work. This plan stipulates the completion of more topics in summer as there isn't any project work to complete. Under this plan, completing 2.5 topics per week during session and 6.5 topics per week when CSU is not in session would yield the desired outcome of 240 topics at the end of 18 months.

The last plan under consideration is Plan D which assumes a steady increase in effort towards completing topics throughout the semester. More specifically, Plan D assumes that student engineers take a semester to adjust to university life without falling too far behind on their topics. This plan involves completing one topic per week for the first ½ semester, 3 topics per week during mid-semester break, two topics per week for the second half of the semester, and finally, 4 topics per week during the midyear break.

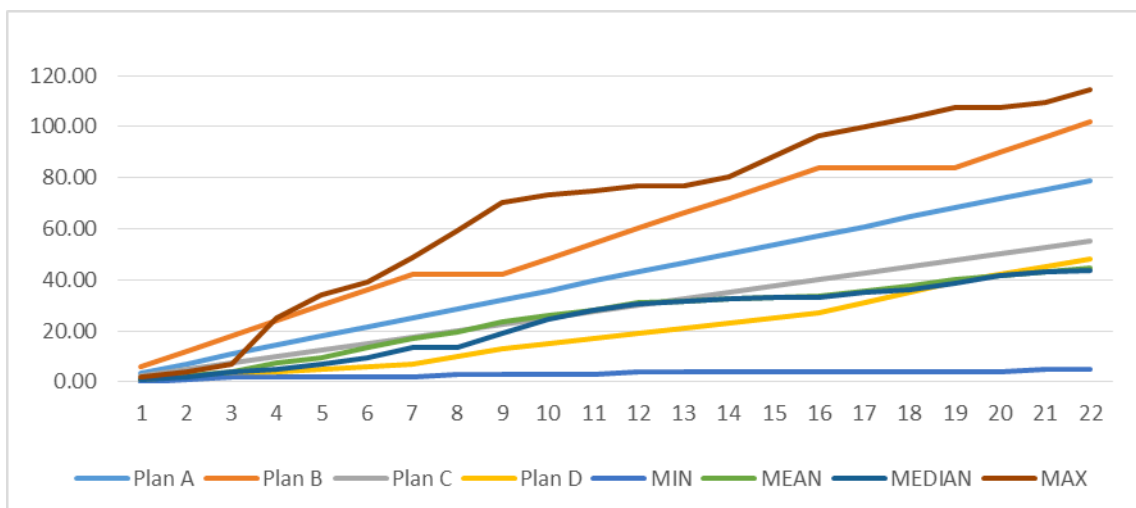


Figure 4: Topic Completion Plans

The student engineer with the maximum number of topics completed went straight into Plan A before shifting into a higher gear after Week 3. While this individual shows no plateaus across the 22-week period, there are slight decreases in output after each of the session breaks rather than during the breaks themselves. In contrast, the student engineer with minimum number of topics completed less than 0.5 topics per week through the first 22-weeks of the course, meaning that in order to reach the 240 topic goal, he would have to complete more than 7 topics per calendar week or greater than 10 topics per week when CSU is not in session. Lastly, the mean and mode fall almost entirely between plan C and plan D. As Figure 3 illustrates, a majority of student engineers appear to have started on Plan D, shifted to Plan C, before finally falling back to Plan D. In simple terms, students slowly adapted to the realities of topic completion, before increasing their efforts after the mid-year break.

## Conclusion

There is much work that still needs to be conducted on this cohort as they progress through the course to assess the effectiveness of the Topic Tree method of content delivery for student engineers and academic staff. While the data presented in this paper shows only a first glimpse at the topic completion behaviours, the potential to understand the factors and motivation behind these behaviours has the potential to make a significant contribution to the body of knowledge on self-directed learning. As the research on self-directed learning continues to develop, the interplay of on-site and online enabled methods as drivers of this learning will continue to progress as well.

In addition to understanding the student engineers' experience, further work in assessing the feasibility of the Topic Tree method of content delivery on the academics will need to be conducted. With the potential to develop content in smaller "topic-sized" increments and assess them individually, there is no limit to the size that the Topic Tree can grow, who can access it, and how it can best be optimised.

As the graduate learning attributes for most institutions include life-long and/or self-directed learning, the continuation of this research will lead to evidence of effectiveness for generating graduates with these attributes. As stated by Engineers Australia (2012) successful engineers "display a personal sense of responsibility" for their work. In the case of a student engineer, this would include the acquisition of knowledge when needed, as well as satisfactory progress on their primary project – their own learning.

While this paper highlights only the first 22 weeks of the CSU course, additional data has been collected across the same population for the following 22-week period. The goal of monitoring progress toward topic acquisition is to determine the effectiveness of various mechanisms to improve the self-motivation and all learning outcomes for CSU Student Engineers. As this research focused exclusively on the quantitative metric of raw topic completion, further qualitative inquiry will help explain the underlying mechanisms that lead to these behaviours. Overall, this research serves to continue the conversation regarding the value of self-directed learning and start the conversation about the Topic Tree method of content delivery in engineering education.

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