Generation Z's Learning Experience in Engineering Classroom: Qualitative Study of Lack of Critical Thinking in the Classroom Activities

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With the influx of a new workforce (Generation Z) into the construction industry and their dominance in higher education, whether the current educational experience is suitable for this new cohort has been investigated focusing on terminal applications such as IT applications (VR) and software usages (Revit). Limited attention is given to the cognitive process of learning of Generation Z despite their different knowledge acquisition practices – learning is to learn "where to find information" rather than analyzing and synthesizing information. This study did qualitative research and identified driving factors using the Girvan Newman algorithm. From the community analysis, the study found that seeking assistance coupled with the lack of construction fundamentals and limited understanding of construction project documents does not help improve learning. The right interpretation of the problem statement and enough understanding of the process are required for the successful execution of activities in the project, which can be obtained through the preparation of basic knowledge such as plan reading and construction fundamentals. In addition, providing opportunities for self-assessment through metacognition questions should be counted in to promote active learning and exercising critical thinking skills that are analyzing arguments, inferencing, judging information, and making decisions.

Key Words: Construction Education, Graph Theory, Girvan Newman Algorithm, Critical Thinking, Qualitative Research

Introduction

In the prior study assessing the Generation Z students' learnings through the investigation of quantitative data from students' works, observations suggested that Generation Z students showed limited critical thinking skills (An & Ryoo, in review). Misinterpretation of problem statements, identifying wrong inputs due to misjudgment, and blindly following and applying the value from calculations without thinking about industry common senses were the main issues identified, and they

are comparable to what Lai (2011) defined as components of critical thinking skills: analyzing arguments, making inferences, making judgments, and making a decision or solving problems. Holding the qualitative approach, this study investigated the driving factors of the limited critical thinking skills of today's students.

Grand changes in the industry have been predicted with the mass retirement of baby boomers and the influx of a new generation equipped with digital gear (Flood, 2020). In addition to the expected workforce changes, the outbreak of the worldwide pandemic resulted in increased flexibility in workplace practices (Prager, Rhoads, & Martínez, 2022). This flexibility of workplace practices affected teaching and learning in higher education institutions. Emergency remote teaching was executed during the pandemic (Masuku, 2021). The students who were heavily affected by this abrupt change and who will occupy the industry soon are Generation Z.

Efforts have been made to understand and to support a cohort of students called Generation Z. Generation Z is expected to be the dominant workforce in the 2020s and is currently in college (Seemiller & Grace, 2016). Rothman (2016) argued that instructors teaching this generation should be prepared to incorporate Information Technology (IT) in their classrooms such as software, hardware, and even social media. Revit (BIM), Navisworks, and Primavera 6 or Microsoft Project are common examples in today's classroom in construction education, and incorporating VR or MR is in its experimental stage (Vasilevski & Birt, 2020). Even a virtual construction field trip was attempted in place of actual field trips to the construction site (Dada, Seifan, & Berenjian, 2020).

Generation Z is known to be deviant from the previous generation, and their discrepant characteristics are attributed to the environment they grow up. The year in which Generation Z began to be born was also incidentally the year in which the term, the Internet was awarded its definition by the Federal Networking Council (Leiner et al., 2009). Thereafter, the Internet became the preferred medium of information (Coelho, 1998). Generation Z is said to be connected to the network all the time placing any information a click away through smartphones on the road, broadband Internet access at home, and online connection at school (Francis & Hoefel, 2018; Seemiller & Grace, 2017).

The Generation Z cohort is said that they are visual learners. With a more developed area in the brain part responsible for visual ability (Rothman, 2016), they are found to learn by observing (Seemiller & Grace, 2017), which has its basis in their affinity to learn from watching videos mainly on YouTube. Rothman (2016) found that the Generation Z cohort has a limited span of attention, and he finds its cause in the Internet usage. Being accustomed to being bombarded with constant changes every several seconds from social media, they switch from one task to another rather than focusing for a long time (Rothman, 2016).

Research has been done to accommodate and serve better this Generation. A study to learn the current campus environment focusing on digital or network connection (Seemiller & Grace, 2017) and an investigation on teaching and learning materials to meet the preference for visual learning materials (Clarke III, Flaherty, & Yankey, 2006) are good examples. As such, researchers pay more attention to incorporating technology into the classroom. Little attention has been given to the cognitive process of Generation Z students' learning although their way of information acquisition is known to be non-identical to the previous learners; they learn to know "where to find information about" (Ivanova, 2009, p.IV.2-1) rather than undergoing the process of critical thinking: analyzing and synthesizing new information (Dede, 2005). This study investigated the driving factors that impact Generation Z students' learning in terms of cognitive processes in higher education institutes so that it examines possible solutions that support today's students to have better educational experiences.

Literature Review

Today's students in higher education – Generation Z

Generation Z is those who were born between 1995 and 2012 (Andheska, Suparno, Dawud, & Suyitno, 2020; Chicca & Shellenbarger, 2018; Francis & Hoefel, 2018; Seemiller & Grace, 2019). Each generation (e.g., Veterans and Baby Boomers) grew up in different conditions and has different styles and expectations of learning (Rothman, 2016). When talking about styles and expectations of learning in Generation Z, the influence of the Internet is undeniable. Seemiller & Grace (2016) found that growing up in a world shaped by the Internet, Generation Z students come to class digitally connected, so reference materials are just a click away, and YouTube videos can supplement their academic classes; online search gives answers in a few seconds whether the answers are right or wrong. According to Rothman (2016), due to the external environment (information technology advances), the brains of Generation Z have become wired to visual imagery, so they have far more developed brain parts responsible for visual abilities, and this trait makes them visual learners, or at least they have a preference on visual materials.

According to Cilliers (2017), they use PC recordings instead of note takings opting for electronic learning materials for record keeping, raise questions online using Learning Management System (LMS) even in face-to-face course administrations, and demand instant information and communications rather than waiting for a response. However, in contrast to online (remote) communication preference, Generation Z students prefer more contact (synchronous) sessions and lectures. Then, does the current campus provide enough support for the current students? Seemiller & Grace (2016), former student affairs professionals, studied Generation Z students to learn the styles, motivations, and perspectives of Generation Z students, and they concluded that the current campus environment does not meet the needs, the interests, and the learning preferences of Generation Z students.

Rothman (2016) also suggested that Generation Z suffers from the inability to focus and analyze complex information or issues due to "Acquired Attention Deficit Disorder (AADD)," which is developed by information technology advance. The brain expects short and rapid bursts of information due to a bombardment of small bits of information from being connected to the virtual world such as YouTube, Twitter, and Facebook. This trait casts doubt on whether they could reflect their learnings, one component of critical thinking.

Critical Thinking & Metacognition

Jackson (2020) suggested that decision-making and problem-solving are the most critical skills that should be trained for construction managers, and he also asserted that "the solutions to many construction issues cannot be found in a book or relayed in a seminar - they are discovered by using critical and creative thinking skills" (p. 59). Bloom's taxonomy hierarchically presents information processing skills with "comprehension" at the bottom and "evaluation" at the top, and the three highest (analysis, synthesis, and evaluation) represent critical thinking skills (Kennedy, Fisher, & Ennis, 1991). Lai (2011) defined what to include in critical thinking skills; Lai argues that analyzing arguments, making inferences, making judgments, and making decisions or solving problems are abilities that should be included. Mathiasen & Andersen (2020) defined critical thinking as reasonable, reflective thinking focusing on the given tasks.

Metacognition is defined as "awareness or analysis of one's own learning or thinking process" (Merriam-Webster), and more metacognitive awareness is found among high-achieving students (Hartman, 2001). Incorporating metacognitive tools was effective even in Generation Z students (Caratozzolo & Á, 2018). Tanner (2012) showed the possibility of overall academic success when having metacognition questions on their learning.

Qualitative Research

Qualitative research is an interpretive activity of the population (Denzin & Lincoln, 2011) and gives an in-depth understanding of reality (Kuckartz & Kuckartz, 2002). Interviews, observations, and documents are the data source of qualitative research (Patton, 2005). How many data sets are required for data saturation has been an issue, and Guest, Bunce, & Johnson (2006) experimented to learn how many interviews are enough for quality research and showed that data saturation was reached in 12 interviews, and the meta-theme presented with 6 interviews regarding non-probabilistic, purposive sample sizes.

The generalizability of research outcomes is another issue in qualitative research (Smith, 2018), and the use of a software tool has arisen as a powerful complement (Kuckartz & Kuckartz, 2002). Multiple tools exist, among which MAXQDA is a more reliable tool (Wolff, 2021). MAXQDA covers not only qualitative data but also quantitative data in mixed methods data analysis (Marjaei, Yazdi, & Chandrashekara, 2019). MAXQDA allows even a systematic analysis of qualitative data increasing research reliability (Rädiker & Kuckartz, 2020).

MAXQDA can do content analysis and thematic analysis (Kuckartz & Kuckartz, 2002; Marjaei et al., 2019). According to Marjaei et al. (2019), by interpreting and coding textual material and evaluating texts by counting words and phrases, the research can convert qualitative data to quantitative data using MAXQDA; in addition, through the relationship between the sentences and phrases, thematic analysis can be performed. In combination with MAXQDA, UCINET is a software to analyze social network data, and it comes with NetDraw, a visualization tool (Borgatti, Everett, & Freeman, 2002).

The Girvan Newman algorithm, an algorithm of Graph theory which is to construct communities from networks, in UCINET constructs communities/clusters by removing edges from the original network; the betweenness of all edges in the network is calculated, and the edge with the highest betweenness is removed. Until no edges remain, calculating betweenness and removing edges is repeated. After removing edges – when communities/clusters were detected, the Girvan Newman algorithm calculates the modularity (Q value) of the graph; a higher value suggests a more significant community structure, and in most cases of successful community detection, Q is between 0.3 and 0.7 (Despalatović, Vojković, & Vukič ević, 2014). Betweenness is defined as the number of shortest paths between pairs of vertices. The betweenness centrality is a measure of the influence of a node over the flow of information, leading factors of communities (Girvan & Newman, 2002).

Methodology

As illustrated in Figure 1, this qualitative research consisted of three parts: (1) interviewees' experience in problem-solving in a construction project control, (2) data collection through interviews, and (3) data analysis. A purposeful sampling was adopted to recruit the interviewees that represent the class. Students in the Construction Estimating course in FA 2022 were pre-defined into three ranges according to the points in Exam I, and four students from each point range were invited; 12 students in total were invited to achieve data saturation, but only 6 students accepted reaching the meta-theme.
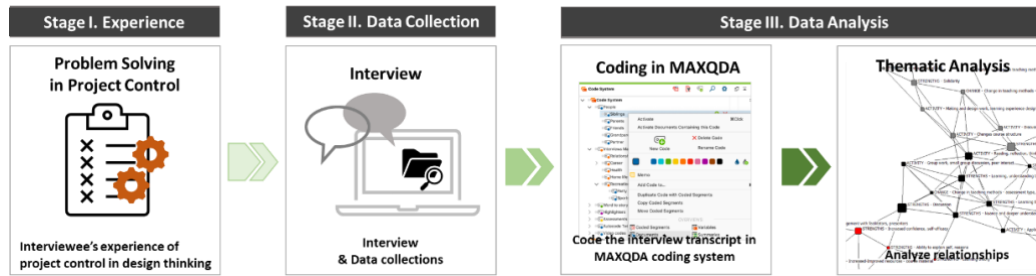
Figure 1. Study Workflow of Interview Analysis

We did each interview through a video conferencing application (Zoom) so that the interview transcript was automatically obtained by using the embedded speech-to-text function in Zoom. The interview transcript was processed to make it sound reasonable before being fed into MAXQDA. Once fed into MAXQDA, the transcript was coded in the MAXQDA coding system. Applying the statistical tools embedded in MAXQDA to the coded data, the qualitative data was converted into a quantitative one, which was mapped for thematic analysis (relationship analysis) and from which a diagram was generated. UCINET was used to map the coded data. The Girvan Newman algorithm in UCINET was used to identify communities, and betweenness centrality was calculated, through which the factor(s) with considerable influence within a community were identified.

Result

Three communities were identified, whose modularity (Q value) is 0.488 indicating that the communities are significant enough. As shown in Figure .2, the three communities have differences. Students in the black community have a limited understanding of the activity goal. Although they have a reasonable understanding of documents like drawings and specifications of the given project, they tend to be dependent on instructors in their learning; their learning materials are mostly from instructors (lecture and lecture notes). It is reasonable to suggest that they have a limited affinity to active learning. The value of betweenness centrality in Figure 3 indicates that *"Whole Understanding-Dependent on the instructor"* and (2) *"Activity Goal-Limited understanding"* are leading factors in this community.

The blue community in Figure 2 indicates an assistance-seeking characteristic. The learning materials are different from that of assistance. They use instructor-provided learning materials such as textbooks, In-Class-Exercises (ICE), and homework, but they google for quick information search. Students in this community understand problem statements, but they have a limited understanding of the process, which suggests that they lack discipline-specific fundamentals. They also seek extra assistance from peers to overcome difficulties. The highest betweenness centrality of "*Whole Understanding-Understand prob statement not process*" in Figure 3 confirmed that improving the understanding of how to solve the given problem (process) through expanding their learnings to include materials other than ICE and homework is required.

Students classified in the red community in Figure 2 defined the goal of the activity wrong. They are independent learners; they seek online assistance (online search and tutoring); to overcome learning obstacles, they spend time on tasks, but all limited understanding of drawings and specifications, limited fundamentals, and poor problem statement understanding combined attribute to a low level of learning – too general or too direct for thorough understanding on process. Self-learning approaches (high betweenness centrality for *"Obstacles – Overcoming strategies-spending time, experience"* and *"Assistance – Online search and tutorials"* in Figure 3) in isolation with ways that confirm whether their learning is on the right way is discouraged according to findings in red communities.
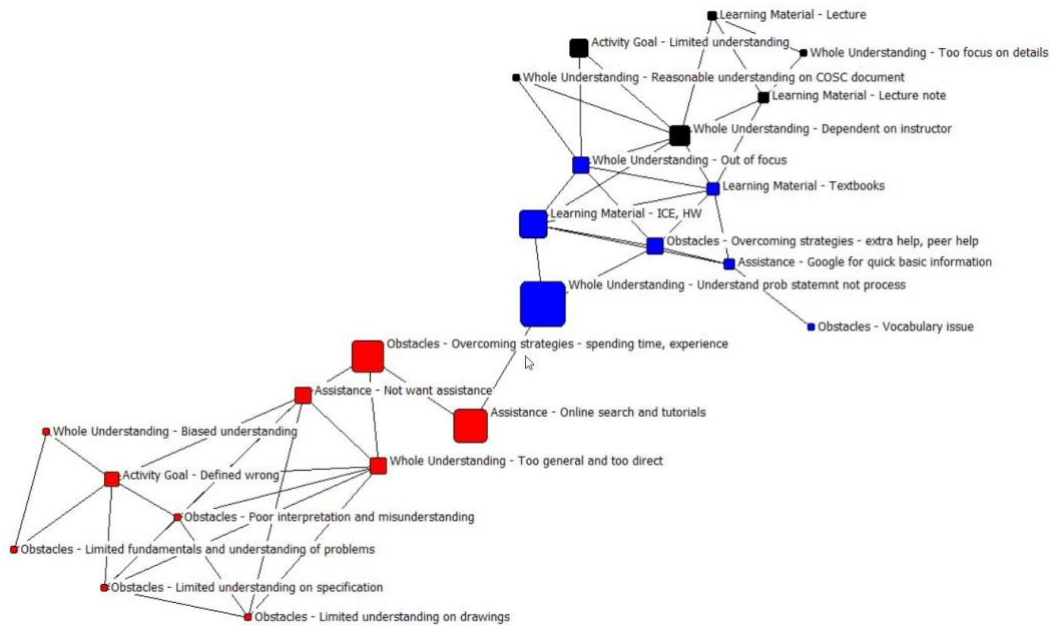
Figure 2. Communities Identified Using the Girvan Newman Algorithm in MAXQDA and UCINET

The distance between nodes is not scaled. The different color represents different communities/clusters. The different sizes of nodes represent the difference in betweenness centrality; the bigger the nodes are, the higher the value of betweenness centrality is.
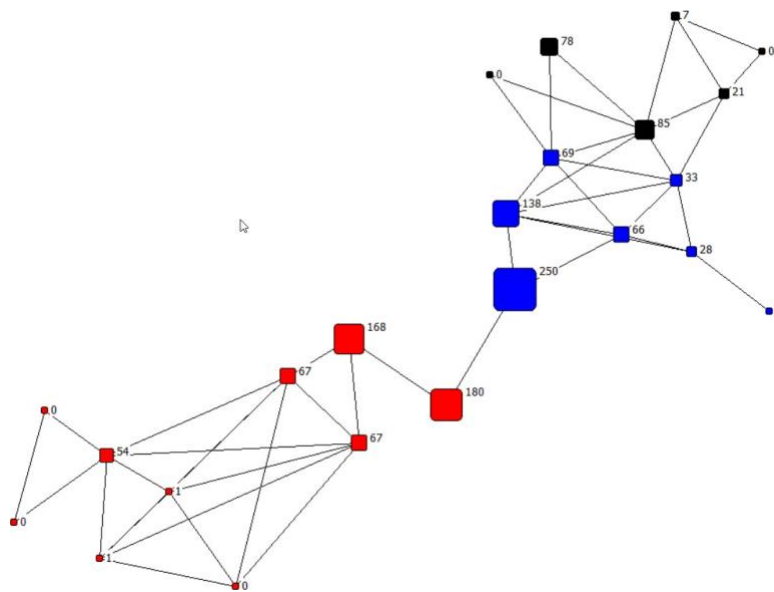

Figure. 3. Betweenness Centrality of the Leading Nodes in the Communities

Conclusions and Discussions

This study identified driving factors that adversely impact critical thinking (reasoning) in learning about Generation Z in the Construction Estimation course through qualitative research. In the assistance-seeking practices, distinct groups are identified: one is seeking in-person assistance and the other is seeking online assistance. The two distinct groups show different types of adverse impacts on learning; online assistance seeking coupled with the lack of construction fundamentals and limited understanding of construction project documents led to adverse impacts on learning. Although students in this community try to learn by spending time on tasks, their work is not fruitful. It is reasonable to suggest that students try to learn, but it is skeptical whether they are actually moving toward the right direction.

Educating students to be equipped with the basics of construction fundaments is essential; obstacles identified are related to the fundamental knowledge in construction. When students are knowledgeable enough in construction fundamentals, they are able to think, reason, and make judgments in their learning activities. In addition, having metacognition questions can be a good strategy. Metacognition questions provide students with self-assessment, which promotes active learning. They also give a chance to instructors to assess whether their educational services work as intended, which makes ever-improving educational experiences for students.

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