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INFLUENCING FACTORS ON UNIVERSITY STUDENTS' LEARNING EXPERIENCES AND COGNITIVE OUTCOMES IN ONLINE LEARNING ENVIRONMENT IN KOREA

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ABSTRACT

The COVID-19 pandemic has forced higher education institutions to rapidly transition to online learning, significantly changing traditional teaching methods and campus organization. Despite these challenges, universities must prioritize students' learning experiences, changes, and development, as these are key factors in verifying their effectiveness and improving teaching and learning. This study analyzed data from the National Assessment of Student Engagement in Learning (NASEL) in Korea to investigate the effect of personal background and learning experiences on the cognitive outcomes of 2,086 university students in the online learning environment. Results of the study showed significant mean differences by major for the variables of university students' learning experience and performance. It also showed that major, grade, learning attitude, challenging learning experiences, interaction with professors, and interaction with campus community members had significant effects on knowledge acquisition, while major, gender, active class participation, learning attitude, thinking activities, challenging learning, interaction with students from different backgrounds, and interaction with campus community members had significant effects on cognitive capacity. These results highlight the need for universities to identify effective teaching and learning methods in the online learning environment and implement appropriate improvement plans.

Keywords: Online learning environment, Cognitive outcomes, Major, Learning experiences

Introduction

The COVID-19 pandemic has profoundly affected the global education landscape, necessitating significant changes in university education and accelerating the adoption of online learning. Previously, online education was applied to certain subjects. Still, the complete shutdown of face-to-face education forced students and instructors to adapt to various online platforms for emergency remote teaching rapidly (Pokhrel & Chhetri, 2021). Adedoyin and Soykan (2020) highlight that the transition to distance education during COVID-19 was not grounded in established learning theories and models, suggesting that these would have been implemented gradually under normal circumstances. Consequently, the impact of distance education on learning outcomes likely varied depending on students' and instructors' adaptability to the changing environment.

Analyzing learning experiences and outcomes in the context of fully online education during COVID-19, identifying problems, and proposing improvements will significantly contribute to higher education research, especially as distance learning remains a promising educational format post-pandemic. Unlike the pre-COVID-19 era, where online learning was managed on a pilot or policy basis, the pandemic necessitated all professors to engage in distance learning, revealing its advantages and disadvantages and leading to effective integration strategies in their courses. Initially, there was apprehension and a need for adjustment, but now the focus has shifted to evaluating whether online learning enhances the efficiency and effectiveness of university education.

Reflecting on the COVID-19 era, it is evident that the means and speed of the transition to distance education, along with proactive university support and quality control, significantly influenced students' learning experiences and outcomes. Prior research presents mixed results regarding the impact of COVID-19 on learning outcomes and experiences. Some studies indicate a reduction in crucial learning experiences due to course redesign, inadequate preparation for online classes, traditional teaching methods' limitations, and insufficient university support (Bae et al., 2021). In contrast, others suggest that educational effectiveness improved as professors could respond to questions and provide real-time feedback, overcoming time and distance constraints (Oliveira et al., 2021). These findings imply that COVID-19's impact on learning experiences and outcomes is not uniform but varies based on students' backgrounds, university support, and country-specific circumstances.

Earlier studies have demonstrated that students' participation in diverse educational activities and active interactions with university-affiliated individuals significantly influence academic persistence and learning outcomes (Astin, 1993; Pace, 1987; Tinto, 1990). Quality interactions between students and professors, peer cooperation, and an active learning attitude are pivotal learning experience factors that enhance knowledge acquisition and motivate students to engage actively in learning (Chickering & Gamson, 1987). In addition, individual-level variables such as major, gender, and grade level have also been shown to be associated with student engagement and performance (Duke, 2002; Gadzella & Mastern, 1998; Ko et al., 2011; Pike, 2004). This study investigates the relevance of these learning

experience factors during COVID-19 and explores necessary preparations for future education.

As higher education evolves, with diminishing time and space constraints, universities must continue focusing on providing effective learning experiences for student learning outcomes. Research primarily discussed in traditional face-to-face education settings must now be diversely analyzed in the online learning context. This study investigates the differences in learning experiences and outcomes according to students' majors in an online education environment. It further examines the factors that affect knowledge acquisition and cognitive capacity, considering students' diverse backgrounds and learning experiences in Korean universities where distance education has become prominent. The study also offers practical implications for improving teaching and learning strategies in online higher education.

Review of Literature

Online Learning in University Education

Online learning, a variant of distance learning, utilizes digital platforms and the Internet, ensuring that at least 80% of instructional material is accessible online (Allen & Seaman, 2008; Shelton & Saltsman, 2005). As personal computers and the Internet became more widely available in the 1990s, information technology became a pivotal educational tool within higher education, leading to the evolution of distance online learning as a new educational paradigm (Madjidi et al., 1999). With ongoing technological advancements, online education tools and platforms have been increasingly incorporated into traditional university education, enhancing the role and significance of online programs. Consequently, instructors have adopted hybrid education models combining face-to-face and fully online instruction (Jaggars & Bailey, 2010; Larreamendy-Joerns & Leinhardt, 2006; Sun & Chen, 2016).

The COVID-19 pandemic in 2020 necessitated a complete transition from traditional face-to-face education to online education, compelling the education system and instructors to quickly adapt to various online platforms and tools for emergency remote teaching. This transition posed several challenges, such as redesigning courses, low readiness among instructors and learners for online classes, and limited university support (Aguilera-Hermida, 2020; Pokhrel & Chhetri, 2021). Additionally, underserved students lacking access to the Internet or online devices faced educational disparities (Jaggars & Bailey, 2010), and overall, students experienced decreased motivation, self-efficacy, and cognitive engagement (Aguilera-Hermida, 2020).

Conversely, online education offers unique advantages in faculty-student interaction. Professors can use more channels for communication, enabling quicker and higher-quality feedback, thus engaging students in more productive educational activities while eliminating travel time (Oliveira et al., 2016). Online platforms like Zoom or LMS allow classes to be conducted regardless of time and location, providing opportunities for repetitive learning and active exploration of materials (Park, 2020). For some students, these new learning environments can increase motivation and the likelihood of meaningful learning (Gonzalez

et al., 2020; Lim & Morris, 2009). Therefore, distance education is a viable method for continuing education during emergencies like COVID-19, and the adaptability of instructors and students to online learning tools, combined with well-designed courses, can enhance higher education effectiveness. To maximize the benefits of online education, it is essential to design thorough courses and employ teaching methods that motivate students and accommodate new technologies (Aguilera-Hermida, 2020; Lim & Morris, 2009).

Cognitive outcomes of university students

Numerous studies have examined students' learning outcomes to address various issues in university education and identify factors affecting the development of cognitive abilities necessary for effective teaching and learning. The focus on students' learning outcomes has intensified due to growing concerns about the underdevelopment of higher-order cognitive skills among university students (Mayhew et al., 2016). Learning outcomes in university education are generally categorized into cognitive and non-cognitive domains. Cognitive outcomes encompass higher-order thinking skills, including knowledge in specific majors, liberal arts, problem-solving skills, analytical skills, critical and logical thinking skills, and communication skills. These outcomes are positively associated with factors such as professors' motivation, effective lectures, active class participation, cooperative learning, and interaction with the campus community (Choi & Lee, 2009; Seo, 2003).

Ko et al. (2011) define knowledge acquisition as a crucial cognitive outcome that indicates students' increased knowledge about specific majors, liberal arts, and social issues. Students perceive the growth of such knowledge when involved in various on-campus learning and social experiences, and studies show that active class participation and both in-class and out-of-class interactions with professors positively impact knowledge acquisition (Choi & Shin, 2010; Ko et al., 2011).

Cognitive capacity, another essential cognitive outcome, involves the development of critical thinking and the ability to reflect on one's thinking activities through judgment. Kuh et al. (2006) emphasized that cognitive competence is a significant higher education outcome determined by the quality of students' individual learning efforts and their psychological and social engagement within the university. Active participation in intellectual and cultural activities and a university culture that promotes learning in various settings contribute to the development of cognitive competence (Astin, 1984; Pascarella & Terenzini, 1991; Yu et al., 2014). This study focuses on knowledge acquisition and cognitive competence as two major cognitive outcomes students are expected to gain in a university setting involving online learning. The importance of cognitive outcomes emphasizes the need for research on the effect of the different educational settings on students' learning experiences and eventual cognitive outcomes.

Major and learning experiences of university students

Majors have been largely treated as individual-level variables, such as gender and grade level, that measure student learning engagement and outcomes. Efforts to measure the effect of student majors on learning outcomes have yielded varied results due to differences in

research subjects, types of learning outcomes studied, definitions of majors, and teaching and learning methods. Some studies report significant differences in learning outcomes between majors (Duke, 2002; Gadzella & Mastern, 1998), while others find no significant differences (Money, 1997; Sebrell & Erwin, 1998). Additionally, while some research indicates that major has little effect on cognitive learning outcomes (Ko et al., 2011), other studies highlight significant differences in subject knowledge and competencies, particularly with engineering students showing higher development of academic knowledge and skills compared to humanities students (Ko & Park, 2016). For natural science majors, there is a statistically significant relationship between being in a collaborative classroom and being in a social science classroom (Pike, 2004; Pike & Killian, 2004).

Given the increased importance of online education post-pandemic, it is crucial to explore ways to improve teaching and learning methods to maximize the effectiveness of online learning. Learning experiences encompass academic experiences within the curriculum and social experiences outside the curriculum related to cognitive, emotional, and psychological growth (Astin, 1993; Choi & Lee, 2009). These experiences can be categorized into academic and social engagement, closely linked to students' time on learning and educational activities and how universities structure their curricula and support services (Kuh et al., 2006).

Academic engagement, such as active learning, class participation, and challenging learning activities, significantly impacts university learning outcomes. Hong and Ryu (2020) argue that in a non-face-to-face learning environment, meaningful learning involving active thinking and utilizing learned material greatly affects learning outcomes, including competence in students' majors, core competencies, and communication skills. Studies consistently show that cognitive performance improves when students can apply what they learn in class, perform challenging tasks, and engage in active or collaborative learning (Mayhew et al., 2016).

Social engagement, including participation in student activities, peer interactions, and student-professor interactions, also plays a crucial role in learning outcomes. Pascarella and Terenzini (2005) found that social engagement extends academic knowledge by allowing students to interact with peers and encounter diverse interests, values, and cultures, leading to cognitive outcomes such as analytical and communication skills. Interactions with professors provide feedback and discussion opportunities that directly or indirectly affect students' learning processes and academic achievements (Choi & Shin, 2010; Kuh et al., 2006; Pascarella & Terenzini, 2005). Ko et al. (2011) highlighted that the college environment, student-faculty interaction, and class participation significantly impact learning outcomes, showing the importance of both academic and social engagement.

Conceptual Framework

This study aims to investigate the impact of major and learning experiences on learning outcomes in the online learning environment, providing insights for future educational strategies. In traditional face-to-face learning environments, academic and social engagement variables have been emphasized as key determinants of learning outcomes. Given the shift to virtual settings, examining whether these same engagement factors can

still effectively predict learning outcomes in an online learning context is vital. For this purpose, we mainly adopted a research model used by Pike et al. (2003), Pascarella (1985), and Ko et al. (2016). Pike et al. (2003) emphasized two critical features, involvement based on Astin's involvement theory and integration based on Pascarella's integration model, in the relationship between college student engagement and learning outcomes. While Astin's (1991) model emphasized the quality and quantity of student involvement in student experiences, Pascarella (1985) focuses more on integrating student involvement, educational experiences, and the college environment. Ko et al.'s (2016) work is especially important in a Korean context. They reinforced previous theories by Pike et al. (2003) and Pascarella (1985) and demonstrated that Western theories were useful in an Eastern, particularly Korean context. Based on the previous studies (Pascarella & Terenzini, 2005; Ko et al., 2016), we developed three models for regression analysis. The first model, the base model, consists of only personal background characteristics and major. The second model, the academic engagement model, included active class participation, learning attitude, cooperative learning, thinking activities, active learning, and challenging learning in addition to the variables in the base model regression. The third model, the full model or learning experience model, consists of all independent variables, including social engagement variables.

Methods

Sampling and Data Collection

This study utilized data from the National Assessment of Student Engagement in Learning (NASEL) survey, an annual survey administered by the Korea Educational Development Institute (KEDI), to inform policies to improve the quality of higher education in South Korea. The survey questionnaire developed by the KEDI was distributed to 16,826 students at a large private university in Seoul, and 2,246 students responded. Of these, 69 responses were deleted because the survey was incomplete or major information was missing. In addition, 38 responses from medical schools and 31 responses marked as 5th year or higher were deleted because they may not actively participate in many undergraduate programs. Finally, data from 2,086 students were analyzed by major. The survey was administered online over six weeks from June 14 to July 30, 2021.

Respondent characteristics were as follows: 834 (40.0%) were male and 1,252 (60.0%) were female. The distribution by grade was: 553 (26.5%) first grade, 436 (20.9%) second grade, 556 (26.7%) third grade, and 541 (25.9%) fourth grade. By major, respondents were distributed as follows: 712 (34.1%) in engineering, 602 (28.9%) in social sciences, 296 (14.2%) in natural sciences, 249 (11.9%) in humanities, 150 (7.2%) in arts and physical education, and 77 (3.7%) education.

Measurement Tools

Dependent Variables: The dependent variables in this study are knowledge acquisition and cognitive capacity, which are outcomes of student learning in universities. Knowledge acquisition was measured by the perceived knowledge and skills necessary for the major and the world of work that students are expected to acquire through undergraduate education and was measured by a single question. Cognitive capacity was measured by four items: critical

thinking, creativity/integration, problem-solving, and liberal arts knowledge. All items were measured on a 4-point Likert scale (See Table 1).

Independent Variables: Table 1 presents the variables used, the coding scheme, and the composite outcome variables' internal reliability (Cronbach's alpha). Personal background factors included gender (male=0, female=1), major (engineering as the reference group; humanities, social sciences, education, natural sciences, and arts and physical education), and grade level (ranging from first grade=1 to fifth grade and above=5).

Table 1: Variables and Coding Scheme

Variable	Coding Scheme	*M*	*SD*	Reliability (α)
Dependent Variables				
Learning outcomes	Knowledge acquisition (Single item)	2.709	0.879	
	Cognitive capacity (4 items)	2.833	0.523	.720
Independent Variables				
Gender	0=Male, 1=Female			
Grade Level	5 point scale, 1=first grade, 2=second grade, 3=third grade, 4=fourth grade, 5=fifth grade and above			
Learning experience				
Academic engagement	Active class participation (3 items)	2.240	0.805	.734
	Learning attitude (2 items)	2.776	0.813	.857
	Cooperative learning (3 items)	2.178	0.878	.846
	thinking activities (3 items)	2.578	0.755	.869
	Active learning (5 items)	2.469	0.723	.840
	Challenging learning (13 items)	2.615	0.596	.904
Social engagement	Interaction with students (6 items)	2.073	0.749	.859
	Student activities (4 items)	1.661	0.673	.697
	Study group activities (3 items)	1.715	0.785	.848
	Student-faculty interaction (6 items)	1.571	0.580	.871
	Community member interaction (4 items)	1.983	0.804	.839

The learning experience was divided into academic engagement and social engagement variables. In the academic engagement variable group, active class participation refers to participation in answering questions, asking questions, and participating in discussions; learning attitude refers to falling asleep or being distracted in class; cooperative learning experience refers to discussing class content with peers, helping with test preparation, thinking activities include connecting concepts learned in other classes and doing critical reviews, active learning experiences includes exploring new ideas and seeking feedback, and challenging learning experiences includes applying class material to real-world situations, including diverse perspectives, and understanding the opinions of others. Social engagement variables include interacting with students from diverse backgrounds, being involved in student activities, participating in study group activities, and interacting with campus community members.

Analysis method

This study intended to examine differences in learning experiences and outcomes by students' majors in online education environments and factors affecting knowledge acquisition and

cognitive capacity. Post-hoc analysis was conducted using Scheffe's and Tamhane's tests to identify specific differences between majors, depending on the assumption of equal variance. A hierarchical regression analysis was also conducted to examine the factors affecting university students' knowledge acquisition, cognitive capacity, personal background, and learning experience online.

Each regression model was entered stepwise with personal background, major, academic engagement, and social engagement variables as the dependent variables, with knowledge acquisition and cognitive capacity. The Durbin-Watson statistic was checked during this process to determine whether the residuals were independent. A Durbin-Watson statistic close to 2 indicates that the assumption of independence of residuals is satisfied and that there is no autocorrelation.

Results

Results of ANOVA on learning experiences and learning outcomes by major

An ANOVA was conducted to determine whether there were differences in university students' learning experiences and cognitive outcomes during the online learning period. The result shows that differences in group means were statistically significant in all areas except challenging learning, student-faculty interaction, and cognitive capacity (See Table 2).

Table 2: Mean differences in learning experiences and learning outcomes by majors

Variable	Humanities (a)	Social Sciences (b)	Education (c)	Engineering (d)	Natural Science (e)	Arts and Physical Education (f)	*F*	*p*	*Scheffe*
Active class participation	2.581	2.182	2.771	2.095	2.128	2.547	28.081	0.000	a>b, d, e c>b, d, e, f f>b, d, e
Learning attitude	2.823	2.718	2.812	2.801	2.819	2.710	1.305	0.259	-
Cooperative learning	2.047	2.001	2.502	2.221	2.347	2.413	13.187	0.000	c>a, b d>b e>a, b f>a, b
Thinking activities	2.699	2.565	2.541	2.511	2.582	2.749	4.029	0.001	a>c f>c
Active learning	2.640	2.382	2.470	2.427	2.488	2.699	8.224	0.000	a>b, d f>b, d
Challenging learning	2.687	2.621	2.598	2.594	2.596	2.618	1.005	0.413	-
Interaction with students from different backgrounds	2.290	2.020	2.093	2.013	2.111	2.130	6.114	0.000	a>b, d
Student Activities	1.755	1.638	1.698	1.630	1.784	1.480	5.666	0.000	a>f e>f
Study group activities	1.712	1.704	1.675	1.733	1.773	1.582	1.319	0.253	-
Student-faculty interaction	1.567	1.546	1.630	1.550	1.621	1.648	1.549	0.172	-
Student-campus community member interaction	1.942	1.861	2.169	1.972	2.152	2.157	7.899	0.000	e>b f>b
Knowledge acquisition	2.530	2.734	2.753	2.691	2.720	2.940	4.376	0.001	f>a
Cognitive capacity	2.926	2.831	2.808	2.797	2.795	2.947	4.022	0.001	a>d

As a result of Scheffe's test conducted to identify specific differences between the sample groups, the mean for active class participation was higher among education majors than other majors, and cooperative learning was higher for education, natural sciences, and arts and physical education majors than humanities and social sciences majors. The mean for active learning was higher for humanities and arts and physical education majors than social sciences and engineering majors, interaction with students from different backgrounds was higher among humanities majors than social sciences and engineering majors, and student activities were higher among humanities and natural science majors than arts and physical education majors. The mean for student-campus community member interaction was higher for natural sciences and arts and physical education majors than for social majors. Meanwhile, the mean for knowledge acquisition was higher for arts and physical education majors than for humanities majors.

Regression analysis on knowledge acquisition

The hierarchical regression model with knowledge acquisition as the dependent variable was statistically significant for all three models (Table 3). The explanatory power of the regression model was low at 0.038 (R^2) when the personal background variable was included in Model 1 but increased to 0.197 with the addition of academic engagement variables in Model 2 and further to 0.209 with the inclusion of social engagement variables in Model 3. The independent variables in the final model were estimated to explain approximately 21% of the variance in knowledge acquisition as a learning outcome.

Table 3: Results of hierarchical regression analysis model on knowledge acquisition

Independent variables	Model 1 (Base Model)		Model 2 (Academic Engagement Model)		Model 3 (Full Model)	
	B	β	B	β	B	β
(constant)	2.370		0.667		0.529	
Gender	-0.006	-0.003	0.022	0.012	0.033	0.019
Grade	0.127	0.165***	0.118	0.153***	0.119	0.154***
Humanities	-0.157	-0.058*	-0.231	-0.085***	-0.238	-0.088***
Social Sciences	0.045	0.023	0.049	0.025	0.045	0.023
Education	0.048	0.010	0.004	0.001	0.004	0.001
Natural Sciences	0.036	0.014	0.012	0.005	-0.004	-0.002
Arts and physical education	0.273	0.080*	0.206	0.061**	0.190	0.056*
Active class participation			0.027	0.025	0.005	0.004
Learning attitude			0.105	0.097***	0.100	0.093***
Cooperative learning			0.048	0.048	0.002	0.002
Thinking activities			0.060	0.051	0.063	0.054
Active learning			0.065	0.053	0.048	0.039
Challenging learning			0.366	0.248***	0.346	0.234***
Interaction with students					0.046	0.039
Student Activities					-0.017	-0.013
Study group activities					-0.010	-0.009
Student-faculty interaction					0.138	0.091***

Student-campus community member interaction			0.059	0.054*
R^2	0.038	0.197	0.209	
F	11.605***	39.064***	30.387***	
ΔR^2		0.159	0.012	
ΔF		68.462	6.482	

*Durbin-Watson = 2.045, *p<.05. **p<.01, ***p<.001*

To summarize the regression analysis results with knowledge acquisition as the dependent variable, in the final Model 3, the perceived knowledge acquisition of humanities major was lower than that of engineering major. In comparison, the perceived knowledge acquisition of arts and physical education majors was higher. In addition, higher grades, positive learning attitudes, and challenging learning experiences positively affected knowledge acquisition, and interactions with professors and other campus community members affected learners' knowledge acquisition. On the other hand, when the learning experience variables were introduced and personal background was controlled, the effects of major and grade variables on learners' knowledge acquisition were significant. The variable with the largest relative effect on learners' knowledge acquisition was a challenging learning experience (β=.234).

Regression Analysis on cognitive capacity

All three hierarchical regression models with cognitive capacity as the dependent variable were statistically significant (Table 4). The explanatory power of the regression model was very low at 0.013 (R^2) when the personal background variable was included in Model 1 but increased significantly to 0.261 with the inclusion of academic engagement variables in Model 2 and further to 0.291 with the addition of social engagement variables in Model 3. The independent variables in the final model were estimated to explain about 29% of the variance in cognitive capacity.

Table 4: Results of hierarchical regression analysis model on cognitive capacity

Independent variables	Model 1 (Base Model)		Model 2 (Academic Engagement Model)		Model 3 (Full Model)	
	B	β	B	β	B	β
(constant)	2.818		1.599		1.490	
Gender	-0.063	-0.059**	-0.038	-0.035	-0.042	-0.040*
Grade	0.003	0.007	-0.004	-0.009	-0.010	-0.022
Humanities	0.146	0.091***	0.065	0.040	0.043	0.027
Social Sciences	0.041	0.036	0.026	0.023	0.024	0.021
Education	0.024	0.009	-0.022	-0.008	-0.020	-0.007
Natural Sciences	0.010	0.007	-0.006	-0.004	-0.022	-0.015
Arts and physical education	0.179	0.089***	0.114	0.056**	0.113	0.056**
Active class participation			0.054	0.083***	0.044	0.067**
Learning attitude			0.049	0.076***	0.049	0.076***
Cooperative learning			-0.002	-0.003	-0.053	-0.089***
Thinking activities			0.080	0.115***	0.079	0.114***

Active learning		0.024	0.033	0.023	0.032
Challenging learning		0.278	0.316***	0.244	0.278***
Interaction with students				0.079	0.112***
Student Activities				0.023	0.030
Study group activities				0.005	0.008
Student-faculty interaction				0.010	0.011
Student-campus community member interaction				0.068	0.104***
R^2	0.013		0.261		0.291
F	3.870***		56.242***		47.018***
ΔR^2			0.248		0.030
ΔF			115.845		17.290

*Durbin-Watson = 2.003, *p<.05. **p<.01, ***p<.001*

The regression analysis results with cognitive capacity as the dependent variable(Model 3) show that students in engineering majors have higher perceived cognitive capacity than those in arts and physical education majors have higher perceived cognitive capacity than engineering majors. Male students have higher perceived cognitive capacity than female students, and active class participation, learning attitude, thinking activities, challenging learning experiences, interaction with students from different backgrounds, and interaction with campus community members positively affect cognitive capacity. On the other hand, cooperative learning experiences were found to have a negative effect on students' perceived cognitive capacity. Meanwhile, when the learning experience variables were introduced and personal background was controlled, the effects of major and gender variables on students' perceived cognitive capacity were significant. The variable with the largest relative effect on students' perceived cognitive capacity was challenging learning experiences (β=.278).

Discussion and conclusion

The COVID-19 pandemic caused inevitable changes in the university education environment, forcing universities to adapt to online education through trial and error. This study aimed to analyze whether the existing learning experience theory is valid in the changed educational settings and examine the factors that affect university students' cognitive outcomes, especially knowledge acquisition and cognitive capacity in the online education environment. Through analysis, this study examined which learning experiences should be focused on regarding learners' growth and development and which elements need to be emphasized in the changing educational environment.

First, this study found significant differences between majors in knowledge acquisition and cognitive performance in the online learning setting attributed to variations in educational content and teaching methods. Notably, majors with a higher proportion of practical exercises, such as engineering and arts and physical education, had higher perceived levels of knowledge acquisition even in an online setting. These results are consistent with previous studies showing that engineering students had higher academic knowledge and skills development compared to humanities students in traditional (Ko & Park, 2016). This finding

emphasizes the critical role of course content and instructional methods in knowledge acquisition, particularly in distance education environments.

Second, academic and social engagements are significant influencing factors on students learning outcomes in an online education environment, as previous studies suggested in a traditional educational setting (Ko & Park, 2016; Kuh et al., 2006; Mayhew et al., 2016; Pascarella & Terenzini, 2005). This study confirms that teaching and learning methods, particularly those involving challenging learning experiences, have the most substantial impact on knowledge acquisition and cognitive capacity, even when controlling for other factors. Developing and applying methods that encourage students to examine course material from multiple perspectives, apply it to real-life situations, and understand diverse viewpoints are essential in online education. In particular, interactions with campus community members and interactions with professors regarding cognitive capacity were found to be significant. This suggests that social participation and interactive learning with diverse individuals should be emphasized in online learning environments to foster cognitive skills such as critical thinking, creativity, integration, and problem-solving.

However, contrary to previous research suggesting that cooperative learning fosters various cognitive skills (Lee, 2013; Park, 2007; Yu, 2014), this study found that it negatively affects cognitive capacity. This discrepancy might be due to the improper planning and application of cooperative learning models in the online education context (Adedoyin & Soykan, 2020). Effective cooperative learning requires appropriate theories and meticulous planning, which may have been lacking during the rapid transition to online education caused by the pandemic. Thus, poorly implemented cooperative learning experiences can adversely impact learning outcomes. Despite the potential benefits of online learning, problem-solving may not be effectively realized without adequate course preparation among cognitive skills (Garris & Fleck, 2020; Hong & Ryu, 2020; Jung & Hur, 2020). However, as collaborative learning can enhance students' self-efficacy and overall learning effectiveness, it is vital to explore innovative ways to improve the effectiveness of academic collaborative learning experiences in online educational contexts.

Learning experience, positive learning attitude, active and challenging learning experiences, interaction with professors, and interaction with campus community members positively affected learners' knowledge acquisition. This emphasizes the importance of active engagement and the role of instructional methods in enhancing learning outcomes, even in online environments.

Implications and suggestions

The results of this study found that major factors significantly influence knowledge acquisition. However, further studies are required to investigate the relationship between major and learning outcomes. For example, engineering students demonstrated higher knowledge acquisition levels than humanities students, while arts and physical education students exhibited higher levels than engineering students. Although these results are consistent with previous studies showing that engineering students had higher academic knowledge and skills development compared to humanities students in traditional (Ko &

Park, 2016), when we consider online environments, these are somewhat unexpected results because engineering is a field with substantial practical and laboratory components, which may not be suitable through online teaching and learning.

This study also found that the perceived cognitive learning outcomes for humanities and social sciences majors, prioritizing critical thinking, creativity, integration, problem-solving, and liberal arts knowledge, were lower than those for engineering and arts and physical education majors. This discrepancy may result from the curriculum and teaching strategies of humanities and social sciences not being promptly adapted to online educational contexts. Further research is required to analyze the specific course content and teaching methods contributing to these differences.

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