JKSDH

Original Article

Increase in dental hygienists' competency and self-directed capacity after capstone design course on community dental hygiene

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ABSTRACT

Objectives: This study aimed to verify the effect on students' competency and self-directed capacity after a capstone design teaching method with community dental hygiene class. **Methods:** The study participants were 34 dental hygiene students taking a 4-year community dental hygiene course at a university located in City C. The research tool consisted of 52 questions on major competency and 20 questions on self-directed capacity. **Results:** After the capstone design class, overall dental hygienists' competency increased ($p<0.05$), and competencies of clinical dental hygiene and community health promotion showed a high increase ($p<0.001$). As a result of analyzing the increase in dental hygienists' competency according to self-directed learning ability, the group with low self-directed capacity showed high improvement in clinical dental hygiene competency and community oral health promotion competency. **Conclusions:** This study confirmed that the capstone design course in community dental hygiene improved students' competency and self-directed capacity, and suggests that it is an excellent teaching method for training competencies required for future society.

Key Words: Capstone design, Community dental hygiene, Competency, Dental hygienists, Oral health, Self-directed capacity

Introduction

In the evolving landscape of dental care, dental hygienists are expected to possess a diverse range of competencies. Dental hygiene education incorporates various learning and teaching methods to cultivate the skilled workforce demanded by industry 4.0 [1,2]. The educational paradigm is shifting toward emphasizing problem-solving abilities through creative and original thinking. Additionally, there is a growing emphasis on self-directed learning methods that encourage learners' voluntary participation, as opposed to traditional lecture-based teaching [3].

Competencies are intrinsic characteristics that manifest as observable and measurable behaviors aimed at achieving individual and organizational performance [4]. With the advent of industry 4.0, university education is increasingly focusing on nurturing individuals who possess not only knowledge but also core competencies such as problem-solving, creativity, communication skills, and personality [5]. The dental field is also advocating for a competency-based education system to prepare individuals capable of performing in clinical settings. In 2012, the United States highlighted the significance of dental hygienists' competencies by proposing standards for dental hygiene education accreditation and evaluation [6]. In Korea, previous studies have underscored the

importance of competency-based education by redefining the competencies essential for dental hygienists as "integrated and comprehensive problem recognition and problem-solving skills, attitudes, and behaviors that incorporate professional values" [7]. Bae et al. [8] suggested 8 core competencies and 52 specific competencies that dental hygienists should achieve.

In recent years, many universities have introduced capstone design classes to develop a range of practice-oriented competencies. The term "capstone" originates from architecture, where it refers to a stone placed at the top of a wall or building. In the academic context, it represents a process where students create innovative works based on their accumulated knowledge [9]. The adoption of capstone design classes in universities has expanded from engineering majors in one university to multiple disciplines across many universities, including medicine and humanities, as a course centered on solving various field-based problems [10,11]. To systematize capstone design classes for nursing students, a qualitative study involving a small number of students who experienced the capstone design was conducted. The study reported that students' communication skills, teamwork skills, spontaneity, and problem-solving skills improved [12]. In dental hygiene, the application of the capstone design method to oral health education was reported to enhance students' understanding of subject knowledge and communication skills [2]. Several studies have documented the effectiveness of capstone design courses in improving learners' academic performance, problem-solving skills, communication skills, interpersonal skills, learning satisfaction, and self-efficacy [11–13].

The significance of capstone design pedagogy in dental hygiene as a comprehensive design education program has been emphasized to prepare students for the competencies required by the industry. Dental hygiene education should aim to equip students with the necessary knowledge, attitudes, skills, and values to address a variety of clinical problems, thereby, preparing them to become competent dental healthcare professionals [14]. Dental hygienists play a crucial role in promoting oral health among the population by providing education, coordinating dental care, delivering preventive dental services, and offering administrative support to individuals and communities affected by oral diseases. Moreover, they are expected to plan, implement, and evaluate oral health promotion projects to address community oral health issues [15].

Self-directedness is a process through which learners diagnose their own learning needs, set goals, identify learning resources, create learning strategies, and evaluate learning outcomes [16]. It is emphasized to enhance nursing students' clinical practice skills and adaptability to the fast-paced healthcare environment [17]. Similarly, self-directedness is emphasized for dental hygiene students, as it positively impacts their ability to navigate the rapidly changing dental healthcare landscape and perform various tasks [18,19]. Self-directedness is closely related to problem-solving skills [20] and is considered an important ability for capstone designing in that it involves analyzing the current situation, identifying problems, solving them, and evaluating the results [18].

Community dental hygiene is a course design to prepare dental hygienists to meet community needs. Community dental hygiene classes in American universities have been reported to develop students' capabilities as professionals who can promote oral health among local residents by planning and evaluating projects [21]. In the case of G university in Korea, students reported improved confidence in their problem-solving and teamwork skills after their community dental hygiene practicum course [1]. However, dental hygiene curricula in Korea rarely include capstone design classes and there is a lack of research related to the role of dental hygienists. Therefore, this study aimed to verify the effects of students' dental hygienist competencies and self-directedness on planning, implementing, and evaluating a community-based capstone design oral health promotion project as part of the dental hygiene curriculum.

Methods

1. Participants

Written informed consent was obtained from the participants who expressed willingness to participate in this study. The study population was selected from 60 dental hygiene students enrolled in a 4-year community dental hygiene course at a university

located in C City. Of them, 34 students who were evaluated on dental hygienist competency and self-directedness before and after the course were enrolled, and data were collected from April 26 to June 21, 2023. This study was approved by the Institutional Review Board of Baekseok University (BUIRB-202304-HR-006).

2. Methods

1) Instruments

(1) Dental hygienist competencies

Dental hygienist competencies can be defined as behaviors that incorporate the professional values of dental hygienists, and Bae et al. [22] proposed 8 core competencies and 52 behavioral indicators. This study used a survey developed based on the detailed competencies developed by Bae et al. [22] and finalized through expert consultation [23]. The questionnaire comprised eight core competencies: ethical decision-making, professional conduct, communication, clinical dental hygiene, hospital management, dental practice, evidence-based decision-making and problem-solving, and community and health promotion. The definitions of the eight core competencies are shown in <Table 1>. For the 52 behavioral indicators, a 5-point Likert scale (1–5) was used, with a higher score indicating a higher level of competency. Unclear statements were explained by the researcher in detail. Internal consistency reliability was measured for 52 competencies. The internal consistency (Cronbach's α) for the overall scale was high at 0.980, and the internal consistency of the 8 core competencies was also high <Table 1>.

(2) Self-directedness

Self-directedness was measured using an instrument developed to measure nursing students' self-directed learning abilities [14,15,24]. The content validity of the instrument was established through a literature review in the first stage and a Delphi study in the second stage. Then, an exploratory factor analysis was conducted on university students to verify construct validity. The reliability of the scale was analyzed to finalize the 20-item questionnaire. The internal consistency (Cronbach's α) was 0.920, and the internal consistency (Cronbach's α) in this study was 0.985.

Table 1. The definitions and the reliability of dental hygienists' competencies

Dental hygienists' competencies	Definition	Cronbach's α
Professional conduct	• Competency to understand critical thinking, evidence-based recent clinical knowledge, and the overall flow of health and medical field	0.885
	• To improve professional knowledge and skills through lifelong education, equipping a wide range of skills and collaboration capabilities	
Ethical decision-making	• Providing health guidance to patients and the public to fulfill moral and ethical responsibility with knowledge	0.678
	• To know the current act on medical technicians and the oral health act	
Evidence-based decision-making & problem-solving	• Ability to understand the overall trend of the health and medical industry with critical thinking	0.913
	• Research ability to understand the latest evidence-based clinical knowledge and health status and prepare continuous evidence	
Communication	• Capacity to communicate and interact effectively with patients, their families, colleagues, supervisors, other health professionals, and diverse populations.	0.854
Clinical dental hygiene	• Ability to perform dental hygiene management led by a dental hygienist for patients/subjects in the clinic	0.967
Dental practice	• Competency in knowledge and skills related to basic and clinical work required for the job	0.901
Hospital a dministration	• Ability to manage documents and hospital management as a professional	0.820
	• Ability to demonstrate leadership within the organization and create a positive organization with progressive thinking	
Community and health promotion	• Capacity to identify oral health needs in community-based projects	0.969
	• Ability to plan oral health-related projects in activities for health promotion and disease prevention	
	• Ability to carry out planned projects and evaluate the effectiveness of project execution	

2) Methods

B university evaluates the appropriateness of its capstone course each semester in accordance with the four conditions for accreditation under the University Information Disclosure Accreditation: 1. Recognition of the capstone course as a regular course, 2. capstone design in the course name, 3. provision of lab fees for developing prototypes, and 4. outcomes. Community Dental Hygiene and Practice is a major course with a capstone design at B university with client-specific oral health promotion projects developed as a prototype; it has been annually certified by the Curriculum Accreditation Center. In the 15-week class, students identify the needs of the local community, plan a customized oral health promotion project, implement the project, and evaluate it. Dental hygienists' competency and self-directedness were evaluated twice before and after the capstone design oral health promotion project, and the evaluation was conducted from April 26 to June 21, 2023. Data from a total of 34 students were used for the final analysis.

(1) Design of a capstone design community dental hygiene course

The capstone design community dental hygiene course is design to identify the oral health status of the target population in a real-world setting, plan, implement, and evaluate a customized oral health promotion project, and then present the outcomes in a capstone competition. In developing a site-specific oral health promotion project, the students were encouraged to develop the necessary competencies of dental hygienists through creative and collaborative methods in the process of diagnosing and solving problems. Sites were selected based on community needs and included preschools, daycare centers, elementary schools, welfare centers for the disabled, nursing homes for older adults, and corporate offices.

(2) Implementation of a capstone design community dental hygiene course

The course was offered in the first semester of 2023 and was a 15-week, 3-hour lab class. Through this course, students engaged in self-directed and active learning, and each team consisted of about 4–5 members. The teams received feedback from the instructor every week to reflect on their oral health promotion projects. The entire course was centered on the introduction of capstone design community dental hygiene, identification of community needs and status, project planning to solve the problem, project implementation, project evaluation, and capstone product competition; the lesson plan for each week is shown in <Table 2>.

3) Data analysis

This study was analyzed using SPSS WIN/PC 23.0. Dental hygienists' competencies were presented as mean and standard deviation. The differences in each variable according to the characteristics of the participants were analyzed using paired t-test and independent sample t-test, and the reliability of the instruments was calculated using Cronbach's α. All statistical significance levels were set at 5%.

Results

1) Increased dental hygienist competency and self-directedness after the community dental hygiene capstone design course

The overall dental hygienist competencies increased after the capstone design class ($p<0.001$), with greater improvements in clinical dental hygiene and community and health promotion competencies ($p<0.001$) <Table 3>. Self-directedness increased after the community dental hygiene capstone design class ($p<0.001$) <Table 4>.

2) Dental hygienist competency based on learner self-directedness

The study examined dental hygienist competencies according to learner self-directedness at the beginning of the study and

Table 2. Lecture schedule with the capstone design method

Week	Theme	Class contents
1	Review of class	• Orientation • Analysis of learner's characteristics • Formation of the learning team • Introduction of capstone design class
2	Review of industry preferences and task performance	• Discussion and presentation on project performance topics by team • Role division by team • Draft a task performance plan
3	Industrial visits and interviews	• Interview with industry representative • Identification of industry requirements • Assessment for industrial needs with papers • Inspection of specific industrial status and educational environment
4-5	Writing an implementation plan for tasks required by the industry	• Preparation of task performance plan for each industry • Development of media to carry out tasks for each industry
6-7	Announcement of the community oral health project	• Announcement of task performance details by industry • Announcement of project performance media by industry
8	Final inspection of task performance	• Final inspection of training plan contents • Inspection of produced educational media • Self-presentation on campus for oral health education by target group
9-13	Project performance	• Task performance by the team - Infant oral health education - Student oral health education - Oral health education for the disabled - Oral health education for the elderly - Adult oral health education • Monitoring and discussion of projects
14	Writing final report	• Submission of final report • Presentations and competitions • Advisor evaluation and industry evaluation
15	Submission and exhibition of results	• Summary of semester contents • Selection of excellent teams • Reflection: personal reflection, peer review

found that overall dental hygienist competencies were higher in the self-directed group. The sub-competencies of professional behavior, ethical decision-making, evidence-based decision-making and problem-solving, communication, clinical dental hygiene, dental practice, hospital management, and community and health promotion were all higher ($p<0.05$) <Table 5>.

3) Increased dental hygienist competency based on self-directed learning after capstone design class

The group with low self-directed learning showed greater improvements in clinical dental hygiene competencies and community and health promotion competencies ($p<0.05$) <Table 6>.

Discussion

The purpose of this study was to assess the impact of a community dental hygiene course with a capstone design pedagogy on dental hygienist competencies and self-directedness, as well as to examine the relationship between self-directedness and dental hygienist competencies. The findings indicated an overall increase in dental hygienist competencies following the capstone design

Table 3. Improvement of dental hygienists' competency level after capstone learning class

| Dental hygienists' competency | Capstone design class | | t | p^* |
	Before (Mean±SD)	After (Mean±SD)		
Total	3.92±0.69	4.40±0.57	-4.247	<0.001
Professional conduct	3.98±0.64	4.38±0.64	-3.551	0.001
Ethical decision-making	3.76±0.71	4.17±0.67	-3.066	0.004
Evidence-based decision-making & problem-solving	3.68±0.78	4.16±0.77	-3.014	0.005
Communication	3.85±0.88	4.40±0.72	-3.528	<0.001
Clinical dental hygiene	3.89±0.65	4.37±0.62	-4.255	<0.001
Dental practice	3.92±0.76	4.31±0.65	-3.473	0.001
Hospital administration	3.94±0.95	4.25±0.67	-2.061	0.047
Community and health promotion	4.27±0.99	4.90±0.66	-4.019	<0.001

*by paired t-test

Table 4. Improvement of self-directed capacity after capstone learning class

| Variable | Capstone design class | | t | p^* |
	Before (Mean±SD)	After (Mean±SD)		
Self-directed capacity	3.89±0.64	4.28±0.69	-4.305	<0.001

*by paired t-test

Table 5. Dental hygienists' competency level according to self-directed capacity in baseline

| Dental hygienists' competency | Self-directed capacity | | F | p^* |
	Low	High		
Professional conduct	3.54±0.40	4.32±0.59	18.979	<0.001
Ethical decision-making	3.23±0.47	4.42±0.60	24.986	<0.001
Evidence-based decision-making & problem-solving	3.36±0.57	3.93±0.84	4.946	0.033
Communication	3.37±0.88	4.24±0.69	10.460	0.003
Clinical dental hygiene	3.48±0.55	4.22±0.54	15.322	<0.001
Dental practice	3.39±0.67	4.33±0.54	21.042	<0.001
Hospital administration	3.42±1.03	4.35±0.65	10.212	0.003
Community and health promotion	3.61±0.85	4.80±0.75	18.616	<0.001

*by independent sample t-test

Table 6. Improvement of dental hygienists' competency level according to self-directed capacity after capstone design class
Unit: Mean±SD

| Dental hygienists' competency | Self-directed capacity | | F | p^* |
	Low	High		
Improvement of professional conduct	0.52±0.74	0.32±0.61	0.795	0.379
Improvement of ethical decision-making	0.52±0.87	0.32±0.68	0.572	0.455
Improvement of evidence-based decision-making & problem-solving	0.45±0.92	0.51±0.96	0.025	0.875
Improvement of communication	0.83±0.75	0.32±0.96	2.940	0.096
Improvement of clinical dental hygiene	0.69±0.62	0.31±0.66	2.975	0.094
Improvement of dental practice	0.71±0.51	0.15±0.68	7.048	0.012
Improvement of hospital administration	0.60±0.88	0.09±0.85	2.959	0.095
Improvement of community and health promotion	1.04±0.63	0.31±0.99	6.177	0.018

*by independent sample t-test

class, particularly in clinical dental hygiene and community health promotion competencies. Additionally, self-directedness improved after the capstone design class, with higher levels of dental hygienist competencies observed in students who had higher self-directedness at the baseline.

The study revealed a significant enhancement in various dental hygienist competencies post-capstone design class, particularly in clinical dental hygiene competencies and community and health promotion competencies. Particularly, professional behavior, ethical decision-making, evidence-based decision-making and problem-solving, communication skills, clinical dental hygiene skills, dental practice skill, hospital administration skills, and community health promotion skills were improved significantly (p<0.001). These competencies align with those valued in industry 4.0, suggesting that capstone design pedagogy is an effective approach for preparing dental hygienists for the future healthcare workforce. The improvement was particularly notable in clinical dental hygiene competencies and community health promotion competencies. Although some dental hygiene students have reported an increase in clinical practice and communication skills after a capstone design clinical dental hygiene course [25], this study is more meaningful because it analyzed and measured the overall improvement of dental hygienist competencies after a capstone design course. Community dental hygiene is a course in which dental hygiene students work in groups to identify community needs, survey the community, diagnose oral health conditions, plan and implement oral health promotion projects for the community, and evaluate such projects. In every session, students communicated and collaborated with their teammates and utilized their competencies as dental hygienists to carry out oral health promotion projects. Feedback from the instructor was also provided at each session, and students monitored their oral health promotion projects to ensure effective implementation and progress in meeting their goals. Such a process is believed to cultivate creative problem-solving, communication, and collaboration skills that are emphasized in modern society.

Self-directedness improved after the capstone design course. The significance of self-directedness in dental hygiene education has been emphasized to develop individuals with integrated thinking skills capable of handling various clinical situations [15]. The importance of self-directed learning lies in its aim to nurture problem-solving individuals who can independently direct their learning. At the baseline, students with high self-directedness exhibited greater dental hygienist competencies. Additionally, students with lower self-directedness at the baseline showed great improvements in dental hygienist competencies overall, but clinical dentistry and community health promotion competencies were the domains that improved significantly. This suggests that the capstone design-based community dental hygiene course significantly enhanced competencies in this group as they engaged in identifying, planning, implementing, and evaluating community projects. Given the importance of boosting academic achievement among students with lower self-directedness, the capstone design course is deemed an effective teaching method [18].

The capstone design course is a dynamic, creative, and self-directed learning process where learners analyze problems using foundational knowledge from their major and apply this knowledge to solve real-world issues, thereby, fostering individuals capable of adapting to the industry [10]. As oral health promoters, dental hygienists are expected to possess the ability to identify the needs of diverse communities and target populations, diagnose oral health issues, and propose oral health promotion projects through the planning, implementation, and evaluation stages of capstone design courses in college.

This study analyzed the outcomes of a capstone design class involving 34 students and 8 teams at B University. However, there are several limitations to consider. First, it is challenging to generalize that the results of the capstone design class activity will have the same effect on the entire dental hygiene department and all learners. Second, the results of this study were analyzed after the students participated in the oral health promotion project at the start of the semester, which may introduce some deficiencies in the study design, such as the homogeneity between groups and the establishment of a control group. Finally, this study did not account for the possibility that differences in understanding of curriculum content other than the capstone design course may influence learners' self-directedness and dental hygienist competence. Despite these limitations, this study is significant as it is the first one to analyze the impact of the capstone design course on self-directedness and dental hygienist competence, building on

studies that have highlighted the importance of industrial field experiences and community-based courses for professional learning [9,10]. Future studies are recommended to expand the analysis of capstone design courses in dental hygiene curricula by exploring the common characteristics and structural linkages of capstone design courses in other colleges.

This study confirmed the effectiveness of the capstone design community dental hygiene practicum in promoting learner self-directedness and dental hygienist competencies as well as in leading to marked improvements of dental hygienist competencies among students who exhibited low self-directed learning at the baseline.

Conclusions

This study applied a capstone design to a community dental hygiene class to investigate improvements in dental hygienist competencies and self-directedness, as well as to analyze differences in the improvement of such competencies according to the level of self-directedness. The key findings are summarized below:

1. Dental hygienist competencies and self-directedness increased after the capstone design-based community dental hygiene course compared to the baseline ($p<0.001$).

2. Overall dental hygienist competencies were higher in the high self-directedness group ($p<0.05$).

3. The improvement in clinical dental hygiene competencies and community and health promotion competencies was higher in the low self-directedness group ($p<0.05$).

Based on the findings that demonstrate improvements in dental hygienist competencies and self-directedness following a capstone design-based community dental hygiene course, this teaching method is recommended to develop competencies required in industrial workplaces in the industry 4.0 era.

Notes

Author Contributions

Conceptualization: SJ Sim, SM Lee; Data collection: SJ Sim; Formal analysis: SJ Sim, SM Lee; Writing-original draft: SJ Sim, SM Lee; Writing-review&editing: SJ Sim, SM Lee

Conflicts of Interest

The authors declared no conflicts of interest.

Funding

None.

Ethical Statement

This study was approved by the Institutional Review Board of Baekseok University (BUIRB-202304-HR-006).

Acknowledgements

None.

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캡스톤 디자인 지역사회치위생학 수업이 치과위생사 역량 및 자기 주도력 증가에 미치는 효과

초록

연구목적: 본 연구는 캡스톤 디자인 설계 지역사회 치위생학 수업 후 학생들의 역량과 자기주도력 증가에 미치는 효과를 검증하고자 하였다. **연구방법:** 연구 참여자는 C시에 소재한 4년제 대학에서 지역사회 치위생학 수업을 이수한 치위생 전공 34명이었다. 설문도구는 치과위생사 역량 52문항과 자기주도력 20문항으로 구성되었다. **연구결과:** 캡스톤 디자인 수업 후 전반적인 치과위생사의 역량이 증가하였고($p<0.05$), 임상치위생 및 지역사회 건강증진 역량도 높은 증가를 보였다($p<0.001$). 자기주도력에 따른 치과위생사의 역량 증가를 분석한 결과, 자기주도력이 낮은 집단일수록 임상 치위생 역량과 지역사회 건강증진 역량이 높은 향상을 보였다. **결론:** 본 연구를 통해 캡스톤 디자인 설계 지역사회 치위생학 수업이 학생들의 치과위생사 역량과 자기주도력을 향상시켰음을 확인하였고, 캡스톤 디자인 수업법은 미래사회에서 요구되는 역량을 배양하는데 탁월한 교수법임을 시사하였다.

색인: 캡스톤 디자인, 지역사회보건, 역량, 치과위생사, 구강보건, 자기주도력