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Original Article

The implication of instructional design for deciduous tooth identification in a dental morphology course for undergraduate dental students

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Abstract *Background/purpose:* The pediatric dentistry courses are lacking in our six-year undergraduate dental education. The purpose of this study was to evaluate the implication of instructional design for deciduous tooth identification in a dental morphology course for undergraduate dental students through students' perspectives.

Materials and methods: A total of 34 s-year dental students who took this dental morphology course were invited to fill out the questionnaire for survey of instructional design for deciduous tooth identification after the class.

Results: Of the 34 dental students, 32 of them participated in the survey with a valid response rate of 94.1%. The results showed that most students found the learning activity of instructional design for deciduous tooth identification to be helpful for improving their knowledge

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about deciduous dentition. Most of them also had positive attitude towards this instructional design.

Conclusion: Since the proportion of pediatric dentistry courses in the undergraduate dental education is very low and children's oral problems are indeed faced by all dentists, it is important to add learning units of pediatric dentistry-related knowledge in different undergraduate dental professional courses or to propose strategies to promote students' awareness of self-directed learning about pediatric dentistry. This study may serve as a model for other undergraduate dental courses in Taiwan.

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Introduction

In recent years, the dental community and the general public have paid great attention to children's oral health care.¹ In addition to the development of new treatment technologies, the most important focus of pediatric dentistry remains to be the improvement of the oral health of all children and their accessibility to oral care and treatment. In fact, since Taiwan implemented national health insurance (NHI) in 1995, the demand for dental treatment for children in both outpatient clinic and emergency service has increased.^{2–5} All frontline dentists, regardless of their specialties, are likely to deal with pediatric patients on a regular basis. In other words, not all pediatric patients have immediate access to a specialist of pediatric dentistry when they need it.

Most parents attach great importance to the dentist's clinical ability to handle children to enhance their confidence in the dentist's overall clinical ability. With the declining birthrate and the maturity of the health care system, the field of pediatric dentistry is destined to play a more prominent role in general medical care. Obviously, society's concern for children's health is not limited to systemic health, but oral health is also an integral part. However, it is a pity that pure pediatric dentistry courses are surprisingly lacking in our six-year undergraduate dental education.⁶

The differences in the assessment of dental treatment needs for children between general dentists and pediatric dentistry specialists can certainly create problems in overall treatment planning. Therefore, with limited undergraduate courses, how to stimulate undergraduate dental students' interest in learning knowledge about pediatric dentistry will be a big challenge. Medical education should be more student-centered and encourage future undergraduate students to become active and self-directed participants in their learning.^{7,8} Learning is important, and it is especially important to understand the learning experiences that lead to knowledge transfer, which is defined as the ability to extend knowledge learned in one context to new ones. Knowledge transfer can be improved by helping students to become more aware of themselves as learners who actively monitor their learning strategies and assess readiness for specific tests and performances.⁹

Teachers should change their traditional methods and become facilitators of learning.¹⁰ Based on the fact that contemporary dentists are in an environment where dental

knowledge is exploding, the concept of this study was to respond to the accelerating pace of technological changes in dental care and to contribute to their future self-directed learning for knowledge about pediatric dentistry through a cultural change within traditional didactic dental education towards student-centered learning by development and implementation of instructional design to make a positive impact. The dental school of National Taiwan University (NTU) offers a two-credit compulsory dental morphology course for the second-year undergraduate dental students. The course is conducted through classroom lectures and involves a number of dental teachers. Among them, only one teacher with expertise in pediatric dentistry is assigned a lecture to teach the deciduous dentition. In this study, a tentative instructional design for deciduous tooth identification was presented through a short learning activity. The goal of this instructional design was to hopefully prepare dental students to become dentists with a more comprehensive consideration of self-directed learning for knowledge about pediatric dentistry in the future. Therefore, the purpose of this study was to evaluate dental student learning outcomes by assessing dental student perceptions towards this learning activity of the instructional design.

Materials and methods

Participants

A total of 34 s-year undergraduate dental students (22 males and 12 females) who took the compulsory course entitled "dental morphology" in the dental school of NTU in 2022 were included in this study.

Teaching process

The course of "dental morphology" was a subject for dental students in the first semester of the second academic year of the Department of Dentistry, NTU, which was a two-credit course and was taught in the form of classroom lectures and discussions. Although there was a one-credit dental morphology laboratory course in the same semester, the laboratory course only covered permanent teeth, and the standard model provided by the school only had permanent teeth and no deciduous teeth. In the lecture course, the learning topics were mainly about permanent teeth. Among 14 learning topics, deciduous dentition was only taught in

one lecture. In this lecture, the teacher spent about 90 min giving an introduction of the deciduous tooth morphology, and the learning activity of instructional design for deciduous tooth identification was carried out in the last 10 min of the lecture. The purpose of this instructional design was to enhance students' interest in learning the deciduous tooth morphology, and to guide them to become aware of independent learning in pediatric dentistry. This activity was conducted by the teacher providing actual intraoral photos of mixed dentition to allow students to identify the tooth positions of the teeth marked in the photos. In addition, the teacher also used the extracted deciduous teeth collected from the clinic to allow students to inspect and identify the tooth positions. The teacher asked students to answer and state the reasons of their judgments. Through the process of discussion, students could be guided to apply the knowledge they had learned about deciduous teeth to the actual identification of deciduous teeth and permanent teeth in the mixed dentition. This activity might improve students' sensitivity to knowledge about pediatric dentistry in their future dental studies.

Survey tool

All dental students who took the course of "dental morphology" were invited to fill out the questionnaire for the survey of instructional design for deciduous tooth identification after the semester of this course was finished. The purpose of this survey was to analyze students' cognition for concepts of learning related to deciduous dentition after this course. All students were invited to join in this survey at their free will to fill out the questionnaires without the pressure from the investigators. A structured questionnaire was used as the survey tool. The questions included the basic data such as students' gender, weekly studying time, and learning experience by their self-assessment. The investigated questions included 1) the experience of learning knowledge about deciduous dentition (question 1), 2) the self-assessment of students' cognition for knowledge about deciduous dentition (questions 2 and 3), 3) the attitude towards knowledge about deciduous dentition (questions 4–9), and 4) personal viewpoints for this instructional design for deciduous tooth identification (questions 10–12).

In the investigated questions, the answer was designed to let the student to raise a score ranging from 1 to 5. If the intensity or response for each question was extremely agreed, the score was 5. If the intensity or response for each question was neutral, the score was 3. In contrast, if the intensity or response for each question was extremely disagreed, the score was 1. The mean score of 3 or more meant that the students agreed the investigated questions on average, and the higher the score, the higher the degree of their agreement. The participating students were suggested to fill the score in their fresh memory.

Statistical analysis

All data obtained from dental students were stored in excel files and used for statistical analysis. The differences in the mean scores (the degree of agreement) of various

investigated questions were compared between two different groups of dental students by independent sample *t*-test. The result was considered to be significant if the *P*-value was less than 0.05.

Results

Basic data of participants

Among 34 dental students who took the course of "dental morphology", a total of 32 students filled out the questionnaires with a valid response rate of 94.1% in this study (Table 1). Of the 32 students, there were 20 (62.5%) males and 12 (37.5%) females. For weekly studying time of the course, there were 25 (78.1%) students who studied less than 1.5 h per week, while 7 (21.9%) students who studied more than 1.5 h per week. By their self-assessment, 24 (75%) of the 32 students did not have sufficient learning experience about deciduous dentition before, while 8 (25%) had sufficient learning experience about deciduous dentition before. Of the 8 students who specifically mentioned the opportunities of learning the relevant knowledge before, 6 learned through the pre-execution training of oral hygiene service team, one through school health education course, and one through self-learning (Table 1).

The students' cognition for concepts of deciduous dentition learning after the class of dental morphology

There were 12 investigated questions for analyzing the students' cognition for concepts of deciduous dentition learning after the class as follows: 1) the experience for deciduous dentition learning, 2) the self-assessment of their cognition for knowledge about deciduous dentition, 3) the attitude towards knowledge about deciduous dentition, and 4) personal viewpoints for this instructional design for deciduous tooth identification (Table 2). According to students' experience, 2 (6.3%) of the 32 students agreed that they had acquired sufficient knowledge about deciduous dentition before. The mean score was 2.53 ± 0.80 , indicating that they generally did not think they had sufficient knowledge about deciduous dentition before (Table 2). For the questions 2 and 3 (Table 2) about knowledge, 30 (93.8%) students found this course to be helpful for improving their knowledge about deciduous dentition, and 27 (84.4%) students acquired a good understanding of the difference between deciduous dentition and permanent dentition. The mean scores for questions 2 and 3 were 4.13 ± 0.71 and 4.09 ± 0.73 , respectively (Table 2).

For the questions 4–9 (Table 2) about attitude, except for the question 7 which stated that deciduous teeth disease is a matter for pediatric dentists, so it does not need to teach knowledge about deciduous dentition in the undergraduate dental courses (only 6.3% of students agreed), most dental students agreed all other statements (questions 4, 5, 6, 8 and 9) about their attitude towards learning of deciduous dentition and the learning activity of instructional design for deciduous tooth identification. All dental students agreed the statement that deciduous teeth disease is a matter for all dentists, so it is necessary to

Table 1 Gender distribution of dental students ($n = 32$) who took the compulsory course of dental morphology and completed the survey in the dental school of National Taiwan University (NTU) in 2022, the weekly studying time of the course (including pre-class preview, after-class review, and related reading), and the learning experience about deciduous dentition by their self-assessment.

| Category | Number (proportion) of students | | | |
|---|---|--|---------------------------------------|---------------------------------------|
| | Male | | Female | |
| Gender | 20 (62.5%) | | 12 (37.5%) | |
| Weekly studying time | Less than 1 h | 1–1.5 h | 1.5–2 h | More than 2 h |
| | 8 (25%) (8 males) | 17 (53.1%) (7 males and 10 females) | 5 (15.6%) (4 males and one female) | 2 (6.3%) (One male and one female) |
| | Less than 1.5 h | | More than 1.5 h | |
| | 25 (78.1%) (15 males and 10 females) | | 7 (21.9%) (5 males and 2 females) | |
| With sufficient learning experience about deciduous dentition | Yes | | No | |
| | 8 (25%) (3 males and 5 females) ^a | | 24 (75%) (17 males and 7 females) | |

^a Of the 8 students who specifically mentioned the opportunities of learning of oral hygiene service team, one through school health education coursening the relevant knowledge before, 6 learned through the pre-execution tra, and one through self-learning.

teach knowledge about deciduous dentition in the undergraduate dental courses, which will be helpful for treating children in the future (question 8 in Table 2). However, for the statement that it is necessary to add more learning topics on deciduous teeth to the undergraduate dental courses, their responses tended to be conservative (17 (53.1%) of the 32 students agreed). The mean scores for the questions 4, 5, 6, 8 and 9 were between 3.63 and 4.38. The numbers (rates) of dental students who answered as agree were between 17 (53.1%) and 32 (100%) (Table 2). Moreover, for the questions 10–12 (Table 2) about personal viewpoints, only 4 (12.5%) of the 32 students agreed that the learning topic of deciduous dentition was helpful for raising their interest in taking pediatric dentistry as the future career (question 11). Although only 9 (28.1%) of the 32 students agreed that the learning topic of deciduous dentition was helpful for raising their interest in learning more about deciduous teeth (question 10 in Table 2), the mean score for the question 10 was 3.25 ± 0.80 (question 10), indicating that most of their responses tended to be neutral. Overall, 25 (78.1%) of the 32 students satisfied with the learning topic of deciduous dentition (question 12 in Table 2). The mean score of this question was 3.97 ± 0.65 (Table 2).

The comparisons of cognition for concepts of deciduous dentition learning after the class of dental morphology

The differences in the mean scores of investigated questions were compared between male and female dental students (Table 3), between dental students with weekly studying time of less than 1.5 h and those with weekly studying time of more than 1.5 h (Table 4), and between

dental students with and without sufficient learning experience about deciduous dentition by their self-assessment after the class (Table 5).

For the comparison between male and female dental students (Table 3), female dental students were more likely to consider that they had acquired knowledge about deciduous dentition (question 2) and acquired a good understanding of the difference between deciduous dentition and permanent dentition after this course (question 3). Furthermore, female dental students also had more positive attitude towards knowledge about deciduous dentition, because they were more likely to agree that the learning topic of deciduous dentition and instructional design for deciduous tooth identification are arranged in this course (questions 4 and 5), and this course design is helpful for improving the learning effect of deciduous teeth morphology (question 6). They were also more likely to agree the statements that deciduous teeth disease is a matter for all dentists and it is necessary to add more learning topics on deciduous teeth (questions 8 and 9). Overall, female dental students were more satisfied with the learning topic of deciduous dentition. The differences in the mean scores of questions 4 and 7 were significant between male and female dental students (both P -values < 0.05 , Table 3).

For the comparison between dental students with weekly studying time of less than 1.5 h and those with weekly studying time of more than 1.5 h (Table 4), dental students with less weekly studying time were more likely to consider that they had acquired knowledge about deciduous dentition (question 2). Furthermore, dental students with less weekly studying time also had more positive attitude towards knowledge about deciduous dentition, because they were more likely to agree that it is appropriate to arrange the learning topic of deciduous dentition

Table 2 Question content and question type used in the survey for the self-assessment by dental students (n = 32) for concepts of deciduous dentition learning after the class of dental morphology and the survey results.

| Question content | Question type | Mean score \pm SD | Number (rate) of students who answered as agree |
|--|---------------------------------|---------------------|---|
| 1. Before taking this course, I have acquired sufficient knowledge about deciduous dentition. | For experience, multiple choice | 2.53 \pm 0.80 | 2 (6.3%) |
| 2. After taking the learning topic of deciduous dentition, I have acquired knowledge about deciduous dentition. | For knowledge, multiple choice | 4.13 \pm 0.71 | 30 (93.8%) |
| 3. After taking this course, I have acquired a good understanding of the difference between deciduous dentition and permanent dentition. | For knowledge, multiple choice | 4.09 \pm 0.73 | 27 (84.4%) |
| 4. In addition to the learning topics related to permanent dentition, I consider that it is appropriate to arrange the learning topic of deciduous dentition in the dental morphology course. | For attitude, multiple choice | 4.09 \pm 0.96 | 28 (87.5%) |
| 5. I agree with this course design which combines two parts – the lecture on knowledge about deciduous dentition and the learning activity of identification of deciduous teeth. | For attitude, multiple choice | 4.09 \pm 0.78 | 28 (87.5%) |
| 6. I consider that the learning activity of identification of deciduous teeth is helpful for improving the learning effect of deciduous tooth morphology. | For attitude, multiple choice | 4.22 \pm 0.55 | 30 (93.8%) |
| 7. I consider that deciduous teeth disease is a matter for pediatric dentists, so it does not need to teach knowledge about deciduous dentition in the undergraduate dental courses. | For attitude, multiple choice | 1.78 \pm 0.79 | 2 (6.3%) |
| 8. I consider that deciduous teeth disease is a matter for all dentists, so it is necessary to teach knowledge about deciduous dentition in the undergraduate dental courses, which will be helpful for treating children in the future. | For attitude, multiple choice | 4.38 \pm 0.49 | 32 (100%) |
| 9. I consider that it is necessary to add more learning topics on deciduous teeth to the undergraduate dental courses. | For attitude, multiple choice | 3.63 \pm 0.83 | 17 (53.1%) |
| 10. After taking the learning topic of deciduous dentition, I am interested in learning more about deciduous teeth. | For viewpoint, multiple choice | 3.25 \pm 0.80 | 9 (28.1%) |
| 11. After taking the learning topic of deciduous dentition, I am interested in taking the pediatric dentistry as my future career. | For viewpoint, multiple choice | 2.63 \pm 1.04 | 4 (12.5%) |
| 12. Overall, I am satisfied with the learning topic of deciduous dentition. | For viewpoint, multiple choice | 3.97 \pm 0.65 | 25 (78.1%) |

SD = standard deviation.

Table 3 The comparison of dental students' concepts of deciduous dentition learning between male and female students after the class of dental morphology.

| Questions | Male (n = 20) | | Female (n = 12) | | <i>t</i> -test |
|-------------|---------------------|---|---------------------|---|--------------------|
| | Mean score \pm SD | Number (rate) of students who answered as agree | Mean score \pm SD | Number (rate) of students who answered as agree | <i>P</i> -value |
| Question 1 | 2.50 \pm 0.95 | 2 (10%) | 2.58 \pm 0.15 | 0 | 0.391 |
| Question 2 | 4.05 \pm 0.60 | 19 (95%) | 4.25 \pm 0.87 | 11 (91.7%) | 0.224 |
| Question 3 | 4.05 \pm 0.83 | 16 (80%) | 4.17 \pm 0.58 | 11 (91.7%) | 0.335 |
| Question 4 | 3.80 \pm 1.06 | 16 (80%) | 4.58 \pm 0.51 | 12 (100%) | 0.012 ^a |
| Question 5 | 4.00 \pm 0.73 | 17 (85%) | 4.25 \pm 0.87 | 11 (91.7%) | 0.194 |
| Question 6 | 4.15 \pm 0.49 | 19 (95%) | 4.33 \pm 0.65 | 11 (91.7%) | 0.186 |
| Question 7 | 2.00 \pm 0.86 | 2 (10%) | 1.42 \pm 0.51 | 0 | 0.021 ^a |
| Question 8 | 4.30 \pm 0.47 | 20 (100%) | 4.50 \pm 0.52 | 12 (100%) | 0.136 |
| Question 9 | 3.60 \pm 0.75 | 11 (55%) | 3.67 \pm 0.98 | 6 (50%) | 0.415 |
| Question 10 | 3.30 \pm 0.73 | 7 (35%) | 3.17 \pm 0.94 | 2 (16.7%) | 0.328 |
| Question 11 | 2.60 \pm 0.82 | 2 (10%) | 2.67 \pm 1.37 | 2 (16.7%) | 0.432 |
| Question 12 | 3.85 \pm 0.59 | 15 (75%) | 4.17 \pm 0.72 | 10 (83.3%) | 0.092 |

^a $P < 0.05$; SD = standard deviation.

in dental morphology course (question 4), and this course design combines the lecture on knowledge about deciduous dentition and the learning activity of identification of deciduous tooth (question 5). On the other hand, dental students with more weekly studying time were more likely to agree that they had acquired a good understanding of the difference between deciduous dentition and permanent dentition after this course (question 3), and the learning activity of identification of deciduous teeth is helpful for improving the learning effect of deciduous teeth

morphology (question 6). Overall, dental students with less weekly studying time were more satisfied with the learning topic of deciduous dentition (question 12). The differences in the mean scores of questions 5 ($P < 0.01$) and 12 ($P < 0.05$) were significant between dental students with less weekly studying time and dental students with more weekly studying time (Table 4).

For the comparison between dental students with and without sufficient learning experience about deciduous dentition (Table 5), dental students with sufficient learning

Table 4 The comparison of dental students' concepts of deciduous dentition learning between students with weekly study time of less than 1.5 h and those with weekly study time of more than 1.5 h after the class of dental morphology.

| Questions | Weekly study time of less than 1.5 h (n = 25) | | Weekly study time of more than 1.5 h (n = 7) | | <i>t</i> -test |
|-------------|---|---|--|---|--------------------|
| | Mean score \pm SD | Number (rate) of students who answered as agree | Mean score \pm SD | Number (rate) of students who answered as agree | <i>P</i> -value |
| Question 1 | 2.56 \pm 0.87 | 2 (8%) | 2.43 \pm 0.53 | 0 | 0.354 |
| Question 2 | 4.20 \pm 0.65 | 24 (96%) | 3.86 \pm 0.90 | 6 (85.7%) | 0.132 |
| Question 3 | 4.04 \pm 0.79 | 20 (80%) | 4.29 \pm 0.49 | 7 (100%) | 0.221 |
| Question 4 | 4.20 \pm 1.00 | 22 (88%) | 3.71 \pm 0.76 | 6 (85.7%) | 0.122 |
| Question 5 | 4.28 \pm 0.61 | 23 (92%) | 3.43 \pm 0.98 | 5 (71.4%) | 0.004 ^b |
| Question 6 | 4.20 \pm 0.58 | 23 (92%) | 4.29 \pm 0.49 | 7 (100%) | 0.362 |
| Question 7 | 1.76 \pm 0.72 | 1 (4%) | 1.86 \pm 1.07 | 1 (14.3%) | 0.390 |
| Question 8 | 4.44 \pm 0.51 | 25 (100%) | 4.14 \pm 0.38 | 7 (100%) | 0.081 |
| Question 9 | 3.64 \pm 0.86 | 12 (48%) | 3.57 \pm 0.79 | 5 (71.4%) | 0.425 |
| Question 10 | 3.28 \pm 0.84 | 7 (28%) | 3.14 \pm 0.69 | 2 (28.6%) | 0.348 |
| Question 11 | 2.60 \pm 1.12 | 3 (12%) | 2.71 \pm 0.76 | 1 (14.3%) | 0.401 |
| Question 12 | 4.08 \pm 0.57 | 22 (88%) | 3.57 \pm 0.79 | 3 (42.9%) | 0.032 ^a |

^a $P < 0.05$

^b $P < 0.01$; SD = standard deviation.

Table 5 The comparison of dental students' concepts of deciduous dentition learning between students with and without sufficient learning experience about deciduous dentition by their self-assessment after the class of dental morphology.

| Questions | With sufficient learning experience about deciduous dentition (n = 8) | | Without sufficient learning experience about deciduous dentition (n = 24) | | <i>t</i> -test |
|-------------|---|---|---|---|--------------------|
| | Mean score \pm SD | Number (rate) of students who answered as agree | Mean score \pm SD | Number (rate) of students who answered as agree | <i>P</i> -value |
| Question 1 | 2.50 \pm 0.53 | 0 | 2.54 \pm 0.88 | 2 (8.3%) | 0.451 |
| Question 2 | 4.13 \pm 0.35 | 8 (100%) | 4.13 \pm 0.80 | 22 (91.7%) | 0.500 |
| Question 3 | 4.13 \pm 0.35 | 8 (100%) | 4.08 \pm 0.83 | 19 (79.2%) | 0.446 |
| Question 4 | 4.38 \pm 0.52 | 8 (100%) | 4.00 \pm 1.06 | 20 (83.3%) | 0.174 |
| Question 5 | 4.13 \pm 0.99 | 7 (87.5%) | 4.08 \pm 0.72 | 21 (87.5%) | 0.449 |
| Question 6 | 4.25 \pm 0.71 | 7 (87.5%) | 4.21 \pm 0.51 | 23 (95.8%) | 0.428 |
| Question 7 | 1.38 \pm 0.52 | 0 | 1.92 \pm 0.83 | 2 (8.3%) | 0.047 ^a |
| Question 8 | 4.63 \pm 0.52 | 8 (100%) | 4.29 \pm 0.46 | 24 (100%) | 0.049 ^a |
| Question 9 | 3.38 \pm 0.92 | 3 (37.5%) | 3.71 \pm 0.81 | 14 (58.3%) | 0.168 |
| Question 10 | 3.25 \pm 0.46 | 2 (25%) | 3.25 \pm 0.90 | 7 (29.2%) | 0.500 |
| Question 11 | 2.50 \pm 0.76 | 0 | 2.67 \pm 1.13 | 4 (16.7%) | 0.351 |
| Question 12 | 4.00 \pm 0.53 | 7 (87.5%) | 3.96 \pm 0.69 | 18 (75%) | 0.439 |

^a *P* < 0.05; SD = standard deviation.

experience were more likely to consider that they had acquired a good understanding of the difference between deciduous dentition and permanent dentition after this course (question 3). Furthermore, dental students with sufficient learning experience also had more positive attitude towards knowledge about deciduous dentition, because they were more likely to agree that the learning topic of deciduous dentition and instructional design for deciduous tooth identification are arranged in this course (questions 4 and 5), and this course design is helpful for improving the learning effect of deciduous teeth morphology (question 6). They were also more likely to agree the statement that deciduous teeth disease is a matter for all dentists (question 8). They were also more likely to disagree the statement that deciduous teeth disease is a matter for pediatric dentists (question 7). It should be noted that most of these students specifically mentioned that they learned the relevant knowledge before through pre-execution training of oral hygiene service team. Overall, dental students with sufficient learning experience were more satisfied with the learning topic of deciduous dentition (question 12). The differences in the mean scores of questions 7 and 8 were significant between dental students with and without sufficient learning experience about deciduous dentition (both *P*-values <0.05, Table 5).

Discussion

In short, instructional design is the creation of teaching materials. However, it should also be carefully to consider how students learn and what materials and methods are most effective in helping learners to achieve their academic goals. The principles of instructional design should consider how educational tools are designed, created, and

delivered to any group of learners, from elementary school students to adult workers in various industries.¹¹ Therefore, in the field of dental education or medical education, it is important to consider how the created educational tools are delivered to learners of dentistry or medicine through instructional design to effectively help learners to achieve their academic goals and the educational purposes.

The results of this study showed that the learning activity of instructional design for deciduous tooth identification could improve dental students' knowledge about deciduous dentition. Most dental students achieved a positive attitude towards learning knowledge related to deciduous teeth and had a good understanding of the difference between deciduous dentition and permanent dentition after this class. In addition, most of them did not agree the statement that deciduous teeth disease is a matter for pediatric dentists, so it does not need to teach knowledge about deciduous dentition in the undergraduate dental courses. All of them agreed the statement that deciduous teeth disease is a matter for all dentists, so it is necessary to teach knowledge about deciduous dentition in the undergraduate dental courses, although in comparison, their responses tended to be conservative for the statement that it is necessary to add more learning topics on deciduous teeth to the undergraduate dental courses.

The principle of student-centered learning is contrary to the traditional view of education which emphasizes the role of teachers as providers and students as passive receivers for absorbing and being shaped by knowledge. Student-centered learning means a new way of teaching and learning for teachers and students. For teachers, this may involve relinquishing power and authority to become facilitators of learning. For students, this means accepting responsibility, actively participating in learning, and giving up passivity and dependence. For both, it involves

collaboration and communication.¹² The conceptual framework of the important principles of instructional design for deciduous tooth identification implemented in this study involved student-centered learning and self-directed learning. Most studies of instructional design theories would agree that it is necessary for effective and efficient teaching and learning.⁹

In our study, the learning activity of instructional design required students to use what they had learned about deciduous tooth morphology to identify the positions of deciduous teeth from actual intraoral photos of the mixed dentition and extracted deciduous teeth and to explain the reasons of their judgments. This prompted them to be more insightful into the difference between deciduous and permanent teeth. This learning activity is different from the traditional classroom teaching method. It is a more vivacious educational activity. Although it is short, students are the protagonists of the entire activity. During the process, through students' thinking and discussion of the problems, it has the effect on enhancing their interest in learning and deepening their memory on relevant knowledge. This activity might improve students' self-directed learning for knowledge about pediatric dentistry in their future dental studies. Indeed, we hope to build a bridge for students' self-directed learning for knowledge about pediatric dentistry in other dental courses which do not have the content of pediatric dentistry.

Compared to the permanent dentition, the deciduous dentition and mixed dentition exist in a short period of a person's life, but the morphology of deciduous teeth is different from that of permanent teeth and the mixed dentition is more complex than permanent dentition. If the content related to deciduous teeth can be integrated into the undergraduate dental professional courses at an early stage to let students be exposed to relevant knowledge of pediatric dentistry early, this will help them to enhance their awareness of autonomous learning in pediatric dentistry. Therefore, the learning activity of instructional design for deciduous tooth identification in the dental morphology course is exactly for this educational purpose, especially when pediatric dentistry courses are rare in current undergraduate dental program.⁶ Moreover, those students who had participated in the oral hygiene service team had a more positive attitude towards this instructional design, indicating that the self-directed learning works well. The oral hygiene service team is a spontaneous activity and its service targets are mainly children. Thus, we consider that these students have developed an attitude of independent learning.

Since undergraduate dental education provides very few pediatric dentistry courses, it is important to help dental students build their knowledge system of pediatric dentistry before graduation. Because the courses provided by the dental school alone may not be enough, it is even more important to provide opportunities or environments of independent learning to promote them to construct their knowledge system of pediatric dentistry. Therefore, when they are exposed to the knowledge related to pediatric dentistry for the first time through introducing the morphology of deciduous teeth in the dental morphology course, this instructional design may trigger their awareness of learning how to learn pediatric dentistry and establish the concept of self-directed learning of pediatric

dentistry among them. It has special significance in this instructional design.

On the other hand, female dental students, dental students with less weekly studying time and dental students with sufficient learning experience about deciduous dentition had more positive attitude towards knowledge about deciduous dentition. On the other hand, dental students with more weekly studying time were more likely to agree that they had acquired a good understanding of the difference between deciduous dentition and permanent dentition, and the learning activity for deciduous tooth identification is helpful for improving their learning effect. This means that the gender, weekly studying time, and previous learning experience may affect dental students' cognition for concepts of deciduous dentition learning after the dental morphology course. However, the above differences still need further researches to explore the reasons why we obtained these results.

Furthermore, through the learning activity of deciduous tooth identification, we hope to convey to the students a correct concept that pediatric patients and deciduous teeth are definitely not the reduced versions of adult patients and permanent teeth, but they are two completely different systems. Therefore, what students learn in other dental professional courses cannot be applied invariably to the pediatric dentistry. Although there is no part about pediatric dentistry in other dental professional courses, students can actively think about and self-directedly learn the differences of other dental professional applications in pediatric dentistry. Even if they become dentists or other dental specialists in the future, when dealing with children, they can first consider that children's deciduous dentition, physiology, and psychology are another system different from those of adults. This will help them to make the most appropriate judgment when treating pediatric patients to reduce the differences in the assessment of dental treatment needs for children between general dentists and pediatric dentistry specialists.

Preliminarily, the implementation of this instructional design has good results. Most students did not think that they have sufficient knowledge about deciduous dentition before, and most of them also thought that their knowledge about deciduous teeth would be improved after taking the learning unit of deciduous dentition. All students believed that children's oral problems are the responsibility of all dentists and it is necessary for dental students to learn knowledge about deciduous teeth. This learning unit in dental morphology course aroused students' interest in learning about pediatric dentistry, but it did not arouse their interest in developing their career as a specialist in pediatric dentistry. Overall, dental students are satisfied with the arrangement of the learning unit of deciduous dentition in the dental morphology course. Since the proportion of pediatric dentistry courses in undergraduate dental education is very low, and children's oral problems are indeed faced by all dentists.⁶ It is important to add learning units of pediatric dentistry-related knowledge in different undergraduate dental professional courses or to propose strategies to promote students' awareness of independent learning about pediatric dentistry. This study may serve as a model for other undergraduate dental courses in Taiwan.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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