Why do we need this? Perception and integration of basic and clinical sciences by dental hygiene students

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Junior students need scaffolding support in their clinical education to make connections with foundational science knowledge.
- Coordination between foundational science and clinical educators to integrate concepts aids junior students in making appropriate, clinically relevant connections.
- While students integrate their foundational science knowledge with their clinical expertise to a moderate extent, clinical instructors do not necessarily make those connections explicit for them.

ABSTRACT

Background: Integrating the basic sciences into a clinical curriculum is critical for students' understanding of physiological processes in patient care. Health professional students with a better understanding of basic science principles have better diagnostic accuracy and a more comprehensive understanding of clinical cases. Traditional health professional curricula offer discrete basic science and clinical courses, resulting in students who struggle to recognize the relevance of the material and incorporate fundamental science knowledge into their later clinical education. This study examined student perceptions of integrating foundational sciences into their health professional program and evaluated the extent of that integration with clinical oral medicine and pathology knowledge using a knowledge integration scale. **Methods:** Students in the second to fourth years of the Dental Hygiene Program at the University of Alberta, Canada, were invited to participate in an anonymous survey regarding their perceptions of the integration of sciences in teaching. In a separate invitation, third- and fourth-year dental hygiene students were invited to complete a graded measure of knowledge integration. **Results:** Significant differences were found between year cohorts in the perceptions of integrating basic sciences into the clinical curriculum. Content analysis of descriptive student comments revealed the benefits of integrating clinical and foundational science knowledge. There were no significant differences between third- and fourth-year dental hygiene students in measured integration of foundational science and clinical knowledge. **Conclusions:** Further studies are needed to shed light on faculty perceptions and identify strategies to facilitate curricular integrations at the faculty level.

RÉSUMÉ

Contexte : Il est essentiel d'intégrer les sciences fondamentales dans un programme d'études cliniques pour que les étudiants comprennent les processus physiologiques liés aux soins des patients. Les étudiants des professions de santé qui comprennent mieux les principes fondamentaux des sciences ont une meilleure précision dans les diagnostics et une compréhension plus approfondie des cas cliniques. Les programmes traditionnels pour les professionnels de la santé proposent des cours distincts de sciences fondamentales et de clinique, ce qui conduit les étudiants à avoir des difficultés à reconnaître la pertinence de ces matières et à intégrer les connaissances scientifiques fondamentales dans leur formation clinique ultérieure. Cette étude a examiné les perceptions des étudiants sur l'intégration des sciences fondamentales dans leur programme professionnel de santé et a évalué l'étendue de cette intégration dans leurs connaissances cliniques en médecine et en pathologie buccodentaires à l'aide d'une échelle d'intégration des connaissances. **Méthode :** Les étudiants de la deuxième à la quatrième année du programme d'hygiène dentaire de l'Université de l'Alberta, au Canada, ont été invités à participer à un sondage anonyme sur leurs perceptions de l'intégration des sciences dans l'enseignement. Dans une invitation distincte, les étudiants de la troisième et de la quatrième année en hygiène dentaire ont été invités à compléter une mesure graduée de l'intégration des connaissances. **Résultats :** L'enquête a révélé des différences significatives entre les cohortes d'années en ce qui concerne les perceptions de l'intégration des sciences fondamentales dans le programme d'études cliniques. L'analyse du contenu des commentaires descriptifs des étudiants a révélé les avantages d'intégrer les connaissances cliniques et de sciences fondamentales. Il n'y avait aucune différence significative entre les étudiants en hygiène dentaire de la troisième et de la quatrième année dans la mesure de l'intégration des connaissances en clinique et en sciences fondamentales. **Conclusions :** D'autres études sont nécessaires pour mieux comprendre les perceptions du corps professoral et trouver des stratégies pour faciliter l'intégration des programmes au niveau du corps professoral.

Keywords: basic sciences assessment; dental hygiene education; professional attitudes
CDHA Research Agenda category: capacity building of the profession

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INTRODUCTION

Like many health professional curricula, the Dental Hygiene Program at the University of Alberta, Canada, heavily emphasizes the biomedical sciences early in the curriculum, with increasing prominence of clinical practice as the program progresses. This basic science knowledge is a foundation upon which preclinical and clinical understanding are built. The challenges, however, are integrating these seemingly disparate components of the curriculum effectively and helping students see the importance of understanding foundational science for their clinical practice.

Integration of the basic sciences into a clinical curriculum is increasingly recognized as critical for student understanding of physiological and pathological processes and patient care. Studies have shown that health professional students who have a better understanding of the basic sciences and can apply these principles have superior diagnostic accuracy, as well as a more comprehensive understanding of clinical presentations.[1] Traditional health professional education consists of discrete science courses that are separate from clinical courses. Consequently, students frequently fail to recognize the relevance of the material they are learning and instructors are often frustrated by the students' failure to recall and incorporate fundamental science knowledge into their later clinical education.[2,3] This situation has ultimately led to curricular evolutions that attempt to integrate foundational knowledge both within and across years in training programs.[4]

Contemporary curriculum development in health professional programs attempts to more seamlessly integrate basic science education with clinical applications earlier in learning to facilitate the retention and transfer of this knowledge into clinical settings.[2,3] Understanding student perceptions of this integration is important for helping them bridge the gap between their didactic and clinical training. When students appreciate the relevance of the foundational sciences to their clinical practice, their understanding and retention of this information may improve and their engagement with the material may be deeper. This could ultimately improve both learning and clinical outcomes.

Though there have been investigations into basic science and clinical integration in the medical field, there do not appear to be any studies of this integration in dental hygiene programs. Examining whether such attempts were successful in the University of Alberta Dental Hygiene Program was the purpose of this study. The following two objectives were set by the research team:

- To examine student perceptions of the degree and importance of integrating foundational sciences in their health professional education program.
- To measure the extent of foundational science knowledge integration in clinical oral medicine and pathology knowledge as measured by the knowledge integration scale.

METHODS

A descriptive study was conducted aiming to describe the perceptions and performance of dental hygiene students in integrating foundational science knowledge with their clinical practice. By definition, a descriptive study takes a systematic approach to describe a population, situation or phenomenon by answering questions of what, where, when, and how.[5,6] This study was reviewed and approved by the University of Alberta Research Ethics Board 2 (REB 2) (Pro00125219).

Perceptions of foundational science-clinical knowledge integration

Students in years 2 (Y2), 3 (Y3), and 4 (Y4) of the University of Alberta Dental Hygiene Program were recruited via email listserv in the middle of their winter 2023 semester. Participants completed a brief, anonymous, online survey adapted from Van der Hoeven et al.[7] using Google Forms regarding their perceptions of the integration of sciences in teaching. The 5 statements in the modified survey were as follows:

1. It is important to integrate clinical examples/relevance in basic science teaching.
2. The basic science educators incorporate clinical relevance in their lectures on a regular basis.
3. It is important to integrate basic sciences in the clinical curriculum.
4. The clinical dental hygiene instructors incorporate basic sciences into their clinical teaching on a regular basis.
5. Basic science knowledge aids me in diagnosis and treatment planning in the clinic.

Students were asked to rank each statement on a Likert scale, with 1 being "strongly disagree" and 5 being "strongly agree". They were also provided with an opportunity to give narrative responses to identify challenges to integration. Content analysis of these descriptive comments was conducted. Two authors (AC and NS) independently and repeatedly reviewed the comments left by students until common content categories and subthemes emerged. Following an independent review, these authors discussed disparate categories and subthemes until consensus was reached. Categories and subthemes were confirmed by the third author (RF).

Integration of foundational science concepts with clinical knowledge

A separate invitation was sent to the students in Y3 and Y4 of the Dental Hygiene Program 6 weeks following the

perceptions survey, inviting them to complete a graded measure of knowledge integration, with items designed similarly to the measures published by Lee et al.[8] for primary and secondary school students. This test consisted of 15 multiple-choice questions that were designed to determine how well the students integrated the basic science concepts taught in Y2 with clinical oral medicine and pathology examples. The choices that were presented to the students included answers that were incorrect (scored as 0), correct with a partial link between basic science and clinical concepts (scored as 1), or correct with a complete link between the basic science and clinical concepts (scored as 2). The scoring of the choices was established by 3 content experts with expertise in both the basic science and clinical realms. The test was based on the theory behind the Rasch Partial Credit models, which have been shown to be effective in discriminating different levels of knowledge integration using multiple-choice questions.[9] This type of test measures a wider range of knowledge integration than multiple-choice questions with a single correct answer.[8] The polytomous measure was administered anonymously online using Google Forms. Sample questions for knowledge integration are provided in the appendix. An outline of the study design is shown in Figure 1.

Statistical analysis was performed using the online calculators available on Statistics Kingdom.[10] The between-year comparisons from the perceptions survey were analyzed using Kruskal-Wallis H tests with Bonferroni correction, followed by Dunn's test post hoc. Results comparing the 2 sets of questions that compare basic science versus clinical education were analyzed statistically using the Wilcoxon signed-rank test. Heteroscedastic t-tests were conducted on the integration tests to look for differences between Y3 and Y4. *P* values ≤0.05 were deemed to be significant.

RESULTS

Perceptions of foundational science–clinical integration

A total of 38 students completed the survey regarding perceptions of foundational and clinical knowledge integration (Y2, n = 12 [28% of 45 Y2 students]; Y3, n = 11 [26% of 43 Y3 students]; Y4, n = 15 [37% of 41 Y4 students]). Kruska-Wallis tests with Bonferroni and Dunn's test post hoc revealed significant differences between year cohorts with regards to the importance of integrating basic sciences into the clinical curriculum (p = 0.026), with differences between Y2 and Y3, as well as between Y3 and Y4. Students from Y3 felt that it was more important to integrate basic sciences into the clinical curriculum than their flanking cohorts (Figure 2A).

Wilcoxon signed-rank -tests compared 2 sets of questions that compared basic science and clinical education, and significance was demonstrated with both sets:

- "It is important to integrate clinical examples/ relevance in basic science teaching." vs "It is important to integrate basic sciences in the clinical curriculum." (p = 0.0008419)
- "The basic science educators incorporate clinical relevance in their lectures on a regular basis." vs "The clinical dental hygiene instructors incorporate basic sciences into their clinical teaching on a regular basis." (p = 0.016) (Figure 2B)

Content analysis[11] involved initially separating the student comments into two groups: 1) comments regarding the integration of clinical examples into basic science teaching and 2) comments regarding the benefits of incorporating the basic sciences into the clinical curriculum. The subthemes that emerged from the benefits of integrating clinical examples into foundational teaching were that a) it helps to make teaching more relevant to the learners and b) it helps them to remember facts learned in class. The subthemes that emerged from the benefits of integrating basic sciences into the clinical curriculum were that a) it helps students make sense of their clinical observations, b) it helps students understand the reasoning behind a diagnosis, and c) it helps provide the foundational knowledge for their clinical practice (Table 1).

Figure 1. An outline of the study design

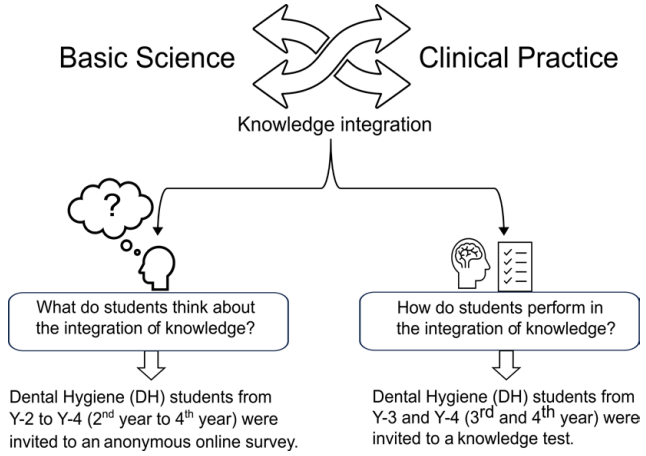
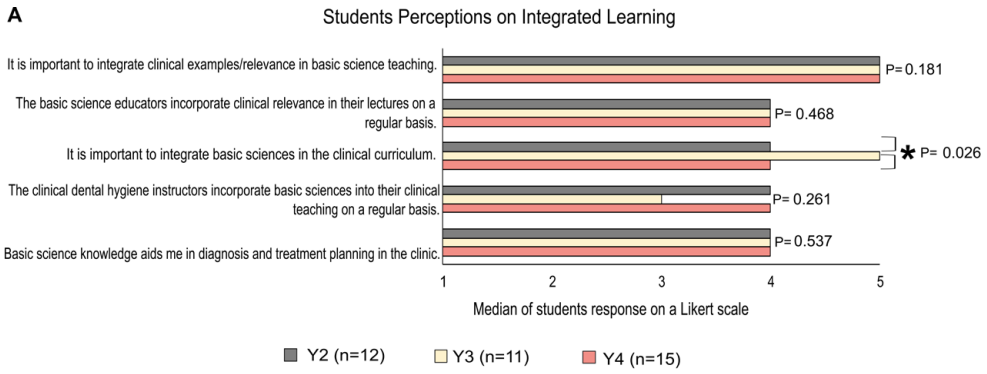


Figure 2. Student responses to the anonymous, online survey



B

Item analysis by question	Wilcoxon Signed Rank	Interpretation
It is important to integrate clinical examples/relevance in basic science teaching *vs* It is important to integrate basic sciences in the clinical curriculum.	0.0008419	Students think having clinical examples in foundational classes is more important than having basic science in clinic.
The basic science educators incorporate clinical relevance in their lectures on a regular basis. *vs* The clinical dental hygiene instructors incorporate basic sciences into their clinical teaching on a regular basis.	0.016	Students feel that the basic science educators do a better job of integrating clinical examples than the clinical instructors do of integrating foundational knowledge.science in clinic.

Integration of foundational science concepts with clinical knowledge

Twenty-nine students completed the exam to test foundational science integration with clinical knowledge. Y3 (n = 10) students scored 63.67% on the exam while Y4 (n = 19) students scored 61.07%. When the years are combined (n = 29), the overall score on the integration exam was 61.97%. Two-tailed heteroscedastic t-tests revealed there were no significant differences between Y3 and Y4 students on the overall integration test. There was only one test item that showed differences between Y3 and Y4 (Why do acidic substances cause caries? p = 0.034), with Y4 demonstrating superior performance.

Item statistical analysis showed that Y3 and Y4 students also demonstrated similar levels of "partial integration" (Y3 26.00%; Y4 25.26%), as illustrated by the number of answers that were deemed partially correct with a score of 1 on the test (Table 2).

DISCUSSION

In recent years, there has been increasing emphasis on incorporating basic science education into clinical programs,[12] recognizing that, in the ideal situation, students should be able to supply the basic science reasoning behind their clinical decisions. Explicit connections between foundational science concepts and clinical examples have not only been demonstrated to enhance long-term retention and deeper understanding of content[13] but have also led to improved diagnostic accuracy.[1]

Learners in clinically focused programs do not always appreciate the significance of the foundational sciences in their curriculum, and educators in various health professional programs have struggled for years to effectively integrate basic science curriculum with clinical content[14,15] and help learners see the importance of this foundational knowledge.

In the present study, the Wilcoxon signed-rank tests that compared pairs of questions indicated that students think having clinical examples in foundational classes is more important than having basic science in clinic, which is unsurprising in clinically focused learners. Encouragingly, the other question pair comparison showed that students feel that basic science educators do better at integrating clinical examples than the clinical instructors do at integrating foundational knowledge.

Table 1. Content analysis of students' comments from the survey

Content	Subthemes	Representative quotations
Benefits of integrating clinical examples in basic science teaching	Makes teaching more relevant to students	*"With integrating clinical examples/relevance, it makes the teaching more relevant to us as well as helps us understand the concepts."* *"This helps to make it feel that what you are learning and doing actually has relevance."* *"I believe that the relevance of the subject matter would be more influential if there were clinical scenarios related to our learning material."*
	Helps with remembering facts learned in class	*"I found it helps to remember things when we have done hands on work in the clinic and can relate it back!"* *"I find concrete examples or stories to be easier to remember details from over rote memorization."*
Benefits of integrating basic sciences in the clinical curriculum	Helps in making sense of the material	*"Without basic sciences, material we learn would not make much sense."* *"Basic sciences are the foundation of our clinical encounters, without understanding basic concepts we would not be able to make sense of complex situations."*
	Helps in understanding the reason behind the diagnosis	*"Helps understand the reason behind diagnosis"* *"I believe having the background knowledge has helped me to be able to diagnose and tx plan in clinic, but I do not believe I would be able to recite concepts from my memory and directly apply the knowledge on a regular basis."* *"Having the science knowledge provides greater understanding for the reason behind the diagnosing [sic] a patient."*
	Helps set the foundation	*"Without basic science, I would not have the fundamental knowledge to diagnose and treatment plan."* *"The diagnoses we have learnt are founded on basic science knowledge, it is an important foundation as a health care provider."*

In the test administered for the integration of foundational science concepts, it was initially disheartening to see that more senior students placed less importance on foundational science knowledge. Interestingly, though, this group did not perform any worse on the integration tests, which is surprising given that they are one year further removed from most of their foundational science courses. One possible explanation may be that the Y4 students have started the process of encapsulating knowledge as they progress into the domain of expertise. Encapsulated knowledge is proposed to be a component of expertise development, where learners who are working towards becoming experts will "package" foundational concepts into higher-level ones that have a similar explanatory ability to those with similar levels of expertise.[16] For example, a novice oral health professional trainee, when approaching a clinical case that involves increased probing depths, red and bleeding gingiva, and halitosis, may use explanatory concepts that include the foundational sciences (e.g., colonization with red-complex bacteria stimulates an inflammatory response that leads to vasodilation and edema of the gingiva. Persistent host inflammatory response leads to release of matrix metalloproteinases by neutrophils, which would then cause non-specific breakdown of the connective tissue supporting the tooth.). As trainees progress towards expertise, this foundational knowledge becomes encapsulated or "packaged" as a clinical concept that implicitly includes this foundational knowledge (i.e., periodontitis), without explicit articulation of this knowledge. As the more senior students gain expertise, they may be unconsciously encapsulating this knowledge into their clinical practice. This hypothesis is supported by work that shows there is an inverted U relationship between expertise and knowledge encapsulation,[17] similar to what was observed in the present study.

White and Ghobadi[18] have reviewed different models that can facilitate basic science and clinical integration. However, one challenge may be the profile of educators themselves. There are few educators who are cross-trained and comfortable in teaching both the clinical and foundational sciences, particularly in the oral health professions. The majority of foundational science instructors do not have medical or dental training and have limited exposure to clinical training programs. To facilitate effective foundational science-clinical integration, these educators have to develop an understanding of what content is most relevant to clinical situations and clinically focused audiences.[19,20]

Similarly, clinician preceptor/instructor discomfort with basic science knowledge decreases student opportunities to apply foundational knowledge in the clinic.[21,22] Expert clinician instructors may have encapsulated basic science knowledge and do not necessarily consciously access this knowledge during their teaching. Expert clinicians,

Table 2. Student scoring on the test measuring integration of foundational science concepts with clinical knowledge. The percentage of scores with no integration (0), partial integration (1), and complete integration (2) of foundational knowledge with clinical concepts is shown.

SCORE	Y3	Y4	Y3 and Y4 Combined
0	25.33%	24.56%	24.83%
1	26.00%	25.26%	25.51%
2	48.67%	49.47%	49.20%

when asked to think aloud, rarely verbalize basic science concepts, unlike novice learners, who tend to incorporate more foundational science details.[22,23] Experts also preferentially favour this type of encapsulated knowledge, sometimes referred to as clinical knowledge. While conveying encapsulated knowledge may streamline communication and diagnosis for experts, this type of knowledge conveyance fails to explicitly link foundational concepts to learners who have not yet matured in their expertise. Moreover, students may become discouraged in their efforts to integrate foundational knowledge when told by instructors to stick to "practical clinical knowledge."[24]

Clinical instructors may benefit from scaffolding and support to help students recognize the relevance of foundational knowledge, and foundational science faculty can develop insight into clinical scenarios through case presentations and clinic visits. Dominguez and Zumwalt[25] have proposed that peer shadowing and collaborations between clinical and foundational science instructors may be effective strategies for facilitating curricular integrations at the faculty level.

CONCLUSIONS

The findings of this study showed that students placed moderately high importance on foundational science integration with their clinical practice and demonstrated that they do incorporate some basic science knowledge when thinking about clinical situations. While these results have been interpreted through the lens of foundational science instructors, it is important to consider that clinically focused instructors may view results differently.

The integration of concepts can be difficult to test and assess. One avenue for future investigation may be to examine clinician attitudes and integration of the basic sciences in their teaching, which may shed further light on the challenges encountered by many educational programs.

CONFLICTS OF INTEREST

The authors of this study declare no conflict of interest.

APPENDIX: Sample questions used in the Integration of Foundational Science Concepts with Clinical Knowledge test

Scoring of each choice is shown in red.

Q1. Why do acidic substances cause caries?

2 Protons sequester calcium ions from hydroxyapatite
1 Acidic substances will etch the enamel, making it rough
0 The pellicle can not form in low pH environments
0 At low pH, phosphate stimulates biofilm formation
0 An acidic environment changes the shape of enamel rods

Q2. Why does attrition increase the risk of caries?

2 Dentin demineralization can occur at a higher pH than enamel demineralization
1 There is more collagen in dentin than in enamel, making it softer
0 Attrition increases the number of cariogenic bacteria found in the mouth
0 Streptococcus mutans preferentially adheres to dentin
0 Exposure of dentin to saliva prevents odontoblasts from forming hydroxyapatite

Q3. The cells of the oral epithelium have high turnover rates. Why do amalgam tattoos persist in the oral mucosa?

2 Amalgam particles penetrate past the epithelium into the submucosa
1 Amalgam particles containing silver are a dark blue or grey colour
0 Amalgam particles are released by the epithelial cells before the cells turnover
0 Amalgam particles stimulate melanocytes in the area to release pigment
0 Amalgam particles cause the epithelial cells to mutate into darkly stained cells

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