CITATION
Chow AK, Sharmin N. The impacts of augmented reality teaching tools in health professional education. *Can J Dent Hyg*. 2025;59(2):125–32.

Supplementary Table S1. Details of the studies included in the review

	Author, year, country	AR-based tool used	Research method	Data collection tool	Content area	Study participants	Study design (Evaluation of the AR tool)	Measured outcome	Major findings (Impact of the AR tool)
1	Henssen et al. (2020)[3] The Netherlands	GreyMapp-AR	Mixed methods	Survey Focus group	Neuro-anatomy	First-year medical, biomedical students	Participants were randomly divided into 2 groups: control and AR app	Knowledge acquisition Cognitive load Motivation Mental rotation	Students who worked with cross-sections in the control group (n = 16) showed significantly more improvement on test scores than students who worked with GreyMapp-AR (p = 0.035) (n = 15). No differences in cognitive loads, mental rotation test (MRT) scores or motivation.
2	Kugelmann et al. (2018)[8] Germany	AR Magic Mirror	Quantitative	Survey	Anatomy	880 first-year medical students	Measured the effectiveness of an AR tool on student perception of learning	Engagement Spatial understanding	82% of participants agreed that AR facilitated engagement and active learning. 93% of participants agreed that AR improved their 3D understanding of human anatomy.
3	Ferrer-Torregrosa et al. (2015)[15] Spain	ARBOOK	Quantitative	Survey Test score	Anatomy	211 students from 7 public universities	Participants were randomly distributed into 2 groups: The control group received standard sessions. The experimental group received an AR book as well as	Knowledge acquisition Metacognitive: Attention Motivation Autonomous learning	AR group had higher scores for: • attention and motivation task • autonomous work • spatial comprehension • written tests The score (mean ±SD) for the control group was 7.21 ±1.73 points and 8.34 ±1.64 points for the AR BOOK group (p = 0.0001).

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							the standard sessions.	Spatial understanding	
4	Bogomolova et al. (2020)[18] The Netherlands	Anatomical stereoscopic 3D AR model	Quantitative	Survey	Anatomy	First- and second-year undergraduate students in medicine and biomedical sciences	Compared stereoscopic 3D AR model, monoscopic 3D desktop model, and 2D anatomical atlas Randomized controlled trial	Knowledge acquisition Mental rotation	AR group performed as well on the knowledge test as the 2 other groups. The overall post-test scores in the stereoscopic 3D AR group (47.8%) were similar to those in the monoscopic 3D desktop group (38.5%; $p = 0.240$) and the 2D anatomical atlas group (50.9%; $p = 1.00$). Students in the AR group with lower MRT scores achieved higher post-test scores than those in the other 2 groups. Students with lower MRT scores achieved higher post-test scores in the stereoscopic 3D AR group (49.2%) as compared to the monoscopic 3D desktop group (33.4%; $p = 0.015$) and similar to the scores in the 2D group (46.4%; $p = 0.99$).
5	Bork et al. (2019)[19] Germany	AR Magic Mirror	Quantitative	Survey Test score	Anatomy	749 first-year medical students	Students used the Magic Mirror, anatomy table or traditional radiology atlases. Pre- and post-test scores were compared.	Knowledge acquisition Mental rotation	Significant improvements from pre- to post-test scores (from 29.60 ±18.37% to 64.89 ±19.69% ($p < 0.001$) for the AR and anatomy table group. Students with low MRT scores benefited from the Magic Mirror. They achieved significantly higher post-test scores than students with low MRT scores in the control group. For the MRT–High subgroup, the following average MRT scores resulted: Magic Mirror (91.54 ±7.38%), Anatomage (87.07

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									±10.28%), and Theory (87.21 ±9.66%). In the MRT–Low subgroup, the average MRT scores were 50.42 ±10.48% for Magic Mirror, 52.55 ±10.19% for Anatomage, and 51.92 ±11.84% for the Atlas-based theory group.
6	Küçük et al. (2016)[20] Turkey	ARMagicBook	Mixed methods	Survey Interview	Neuro-anatomy	70 second-year undergraduate students	Students were randomly distributed into experimental and control groups	Knowledge acquisition Cognitive load	Students using AR tools scored higher on exams. The experimental group students who studied with ARMagicBook were significantly ($p < 0.05$) more successful than the control group students. The experimental group was found to have significantly ($p < 0.05$) lower cognitive loads in comparison to the control group.
7	Khan et al. (2019)[21] South Africa	Anatomy 4D	Quantitative	Survey	Anatomy	Undergraduate health science students studying medicine	Learning motivation was compared before and after the use of AR tool A questionnaire based on Keller's IMMS model for motivation was used to measure motivation	Motivation Attention Confidence Satisfaction	After using AR, the mean value significantly increased for attention ($p < 0.00001$), confidence ($p = 0.015$), and satisfaction ($p = 0.0073$), while decreased for relevance factor ($p = 0.223$).

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8	Ferrer-Torregrosa et al. (2016)[22] Spain	ARBOOK	Quantitative	Survey Test score	Anatomy	170 health science students	Participants were divided into 3 groups: Didactic aid 1 group used supplied notes and traditional images. Didactic aid 2 group used supplied notes and video. Didactic aid 3 group used supplied notes and AR tool.	Knowledge acquisition Attention Motivation Autonomous learning Spatial understanding	Compared to images and videos, students who used the AR tool had: 1) Significantly higher test scores. The average mark obtained with AR (7.20 points) was significantly higher than that obtained with video (6.54 points), which in turn was significantly higher than that obtained with the notes (5.61 points). 2) Higher scores in all aspects of metacognitive perceptions, including attention and motivation (p = 0.001), autonomous learning (p = 0.039), and 3D comprehension (p = 0.004).
9	Norgaard et al. (2019)[23] Denmark	AR application for HoloLens	Mixed method	Survey Test score	Anatomy, CT-scan	110 university students	Participants were randomly distributed into 3 groups: Group 1 used traditional PowerPoint. Group 2 used AR without quiz. Group 3 used AR with a quiz.	Knowledge acquisition Self-efficacy Motivation Spatial understanding	Quizzes helped the AR group gain spatial understanding. There were no significant group differences in motivation test score. Self-efficacy was significantly higher for the group who used the AR tool along with quizzes (p = 0.033).
10	Gonzalez et al. (2020)[24] Chile	SPECTO	Quantitative	Survey Test score	Anatomy, physiology (of heart)	101 third-year undergraduate biomedical	Participants were randomly divided into 2 groups: the control group and	Knowledge acquisition Motivation	AR use enhanced the comprehension of anatomical and physiological concepts.

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						science students	the experimental group that used AR. Pre- and post-test results were compared. Students were asked to do detailed anatomical drawings.		Control and experimental groups showed no differences in baseline knowledge in their pre-test. The students who experienced the AR activities showed an increase in the complexity of representation levels in post-test results and also showed a significant difference in scores for the final exam. The use of AR increased motivation for learning.
11	Schneider et al. (2021)[25] Australia	ARMagic Book	Mixed methods	Survey Test score	Pharmacy	25 undergraduate pharmacy students	Pre- and post-test scores Survey on student experiences using the tool Thematic analysis of written comments	Knowledge acquisition Satisfaction	AR was effective in enhancing student learning, showing 42% improvement in quiz score ($p <$ 0.0001). High acceptance, engaging, and stimulating
12	Duncan-Vaidya & Stevenson (2021)[26] USA	AR head-mounted display	Quantitative	Survey	Anatomy	32 students from community college, studying introductory anatomy and physiology	Group 1: Traditional books and models Group 2: HoloLens as the AR tool The study compared pre- and post-quiz scores, and engagement.	Knowledge acquisition Satisfaction	Pre- and post-quiz scores were statistically the same between both groups. Anatomy group: pre-quiz = 32.7% (±25.2); mean (±SD), post-quiz = 61.8% (±19.5); n = 15; t(28) = 3.53; p = 0.001. Traditional group: pre-quiz = 44.9% (±18.6), post-quiz = 67.9% (±17.3); n = 17; t(32) = 3.73; p = 0.0007. The survey indicated that AR was “fun to use” and that AR was an

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									effective and engaging tool for anatomy learning.
13	Reeves et al. (2021)[27] United Kingdom	ZapWorks	Quantitative	Survey Test score	Structural biology	20 university students	Participants were randomly assigned to 1 of the 2 groups. Group 1 completed the formative test before attending the AR session. Group 2 completed the AR session and then the formative test. Control group (Group 0): Did not attend any sessions (lecture or AR).	Knowledge acquisition Satisfaction	There was no statistically significant difference in test performance between groups 1 and 2 (those having completed the AR-session first versus the taking the quiz first). There was a significant difference in test performance between group 0 (no lectures and no AR session) and group 2 but not group 1. Students responded overwhelmingly positively to the engaging nature and interactivity of AR.
14	Noll et al. (2017)[28] Germany	mARble-Derma	Quantitative	Survey Test score	Dermatology	44 third-year medical students	Participants were randomly divided into 2 groups: a control group (B) and an experimental group (A) that used a mobile AR tool. Pre- and post-test scores were compared.	Knowledge acquisition	Pre- and post-test improvements were similar between groups: group A: 3.59 [SD 1.48]; group B: 3.86 [SD 1.51]. Differences between both groups were statistically insignificant ($p = 0.10$). However, students who used the AR tool made 8.1% fewer errors on the test.
15	ChanLin et al. (2019)[29] Taiwan	Mobile AR nutrition monitoring system	Mixed methods	Test score Interview	Nutrition	65 volunteer, non-nutrition major university students	Test scores were compared before and after the AR system use.	Knowledge acquisition	Improvement in the mean nutritional concepts ($p < 0.01$) and a decrease in their mean misconceptions ($p < 0.001$) after

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									learning with the Mobile AR nutrition monitoring system.
16	Albrecht et al. (2013)[30] Germany	Mobile AR-based prototype app	Quantitative	Survey Test score	Gunshot wound	10 third-year medical students	Students were divided into control and AR-exposed groups. Pre- and post-test scores about gunshot wound were compared.	Knowledge acquisition	The AR group (6/10) showed greater knowledge gain than the control group (4/10) ($p = 0.03$).
17	Herbert et al. (2021)[31] USA	Smartphone app on heart failure	Quantitative	Survey Test score (on heart failure assessment)	Anatomy, physiology	33 nursing students	A quasi-experimental, randomized pre-test post-test study was conducted. The experimental group used the self-paced app; the control group viewed the same content using prerecorded video lecture.	Knowledge acquisition Satisfaction	No significant differences were found between the 2 groups for assessment completion time ($t[30] = 1.626$, $p = 0.114$) and overall % test accuracy ($t[30] = 1.846$, $p = 0.075$). No significant differences were found in "understanding" ($t[30] = 1.058$, $p = 0.299$). Significant difference was reported between the students' accuracy on questions that required "remembering" ($t[30] = 2.760$, $p = 0.010$). In the survey, 33.4% of students responded that they would prefer reviewing material via video lecture; 38.9% preferred the AR app.
18	Mellos et al. (2022)[32] Australia	AR tool for the estimation of food portions	Quantitative	Survey Score (assessment of the	Nutrition	33 university students studying nutrition	A quasi-experimental, randomized pre-test post-test study was conducted.	Knowledge acquisition	The AR group showed higher improvement between pre- and post-test than the control group. The mean absolute error was lowest in the online group (53.0%),

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				accuracy of the estimation of food portions)			The experimental group used the AR tool, while the control group received an infographic instructing them how to estimate food portions with different hand shapes.		followed by AR (59.5%) and control (64.0%). Relative error scores revealed higher accuracy for the AR group (45.5%) followed by online (43.5%) and control group (29.0%). Overall improvement in estimation was highest in the AR group (+12.2%) followed by the online (+11.6%) tool, with a decrease seen for the infographic (−1.7%) tool.
19	Kim-Berman et al. (2019)[33] USA	The AR virtual tooth identification test	Quantitative	Survey Test score	Dentistry, tooth identification	93 first-year dental students	The AR virtual tooth identification test scores were compared with real tooth identification tests, scores on summative exams. A survey was also conducted.	Knowledge acquisition Validity of the AR tool	The AR virtual tooth identification test had a positive correlation with the real tooth identification test ($r = 0.410$, $p < 0.01$), a combined score of 2 real tooth identification tests ($r = 0.545$, $p < 0.01$), the final exam ($r = 0.489$, $p < 0.01$), and overall grade for the dental anatomy course ($r = 0.661$, $p < 0.01$). The students had some difficulty viewing images and experienced technical difficulties related to their smartphones. Their survey responses expressed little support for the AR tool.

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