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Bug-in-Ear Technology as a Clinical Teaching Tool for Au.D. Education: A Pilot Study

Abstract

Traditional forms of clinical pedagogy include post-observation feedback and side-by-side coaching. The purpose of this pilot study was to evaluate a newer strategy, bug-in-ear technology (BIET), in which clinical supervisors provide live feedback through a discrete earpiece. BIET has the potential to overcome limitations associated with traditional clinical pedagogy. This pilot study compared side-by-side coaching to BIET coaching, using standardized patients in an on-campus audiology clinic. In this study, first-year Au.D. students conducted a case history assessment for two standardized patients. Likert-response ratings and qualitative data from open-set questions indicated BIET coaching was well received by supervisors because it provided a discrete way to deliver quick, live feedback to students. Although supervisor ratings of BIET were slightly more positive than student ratings, comments from both students and supervisors indicated they could see BIET coaching working well in the future, with modifications. Likert-response items indicated student preference for BIET was associated with feelings of confidence and desire to use BIET. More research is needed to examine ways in which BIET coaching can be operationalized to support audiology clinical education.

Keywords

Audiology, Clinical education, Bug-in-Ear Technology

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The purpose of an educator is to teach and inspire students, to provide positive learning experiences, and to achieve specific learning objectives following a logical sequence of steps (Gooden et al., 2009). Clinical training begins with courses and labs that provide foundational knowledge and transitions to hands-on learning via simulated and real-world clinical experience. Students begin within a relatively safe environment and evolve from *learning to know* through *learning to perform* (CAPCSD, 2018; Dudding et al., 2019). Clinical learning requires practice, feedback, and behavior modification for students to develop skills needed to practice independently. Performance feedback in a pre-professional setting is a well-established, evidence-based practice to improve behavior, set expectations, and judge level of student understanding for future practice (Harrison, 2005; Kulhavy & Stock, 1989; Mory, 1992; Nottingham & Henning, 2014a, 2014b). One common technique used to facilitate learning in the clinic is post-observation feedback (Posner, 2005). Post-observation feedback involves verbal or written commentary by a supervisor after a clinic session, although research indicates verbal feedback is preferred by students and results in higher student self-ratings of performance and of clinical supervision (Ho & Whitehill, 2009). Unfortunately, the time between clinic session and post-observation feedback is problematic regardless of feedback mode (written or verbal) because feedback requires that students recall actions, store feedback, and make changes during subsequent sessions (Hattie & Timperley, 2007). The concern is students may forget feedback and revert to original behaviors. Compared to real-time feedback, post-observation feedback may increase the tendency of student clinicians to repeat behaviors supervisors have previously attempted to change (Schaefer & Ottley, 2018).

Real-time feedback provides an opportunity for immediate practice of a new behavior (Hattie & Timperley, 2007; Scheeler et al., 2004). A common technique used to provide real-time feedback is side-by-side coaching, in which student and supervisor are in proximity during a clinical session and feedback is provided while a patient is present (Kretlow & Bartholomew, 2010). When feedback is given in the moment, there is a direct connection between feedback and behavior to be corrected, which can aid in skill acquisition (Hattie & Timperley, 2007). The supervisor can model a refined technique with an immediate opportunity for the student to modify behavior (Scheeler et al., 2004). Research indicates side-by-side coaching improves knowledge and skill retention compared to post-observation feedback due to the immediacy of feedback delivery (Kohler et al., 1997; Kretlow & Bartholomew, 2010; Scheeler et al., 2004); however, the physical presence of a supervisor may interfere with the natural dynamic between student and patient and may cause anxiety for the student because both student and patient may perceive the student clinician made a mistake (Cohen & McConnell, 2019; Jaremka et al., 2020). The impostor phenomenon (i.e., impostor syndrome) is a concern because professionals-in-training fear failure and perceive lack of authenticity and competence as they enter real-world clinical settings (Cohen & McConnell, 2019). Side-by-side coaching could exacerbate student feelings in this regard because the supervisor is correcting clinical behavior in public.

With improvements in technology over time, and research findings demonstrating the power of feedback to improve skill development, clinical education delivery has evolved (Fallon et al., 2015) and the benefits of side-by-side coaching may be realized using distance supervision strategies. Bug-in-ear (BIE) coaching was introduced by psychotherapists 70 years ago (Korner & Brown, 1952) and subsequently described in the literature using various terms including in-ear feedback, eCoaching, whisper-in-my-ear, mechanical third ear, and wireless technology feedback

(Farrell & Chandler, 2008; Rock et al., 2012). More recently, bug-in-ear technology (BIET) has been described as an effective tool for skill development in teacher education and athletic training (Nottingham, 2018; Schaefer & Ottley, 2018). BIET allows supervisors to provide live feedback via a small earpiece while students are actively engaged in student teaching or clinical practicum. Supervisors can speak discretely into a microphone from a distance (e.g., tele-supervision) or through supervision mirror windows, as they model clinical behavior, identify errors, and provide praise that is audible only to the student. Schaefer and Ottley (2018) reviewed 17 studies in which BIET was used to provide feedback to pre-professional teachers in various settings, subjects, and grades, and 89% concluded BIET was effective for student teacher education. Similar conclusions were made by Nottingham (2018) who examined athletic training student performance and found increased distance between supervisor and student facilitated confidence building and autonomy. Additionally, BIET increased feedback frequency because patients could not hear supervisors; in contrast, supervisor feedback was interjected only if necessary, using side-by-side coaching (Nottingham, 2018).

Although BIET has been used effectively in several disciplines, it has not been examined as a pedagogical tool for audiology clinical education. While the use of real-time feedback shares many similarities across disciplines, audiology education is unique compared with disciplines such as athletic training and education. To become audiologists, students must complete a clinical doctorate, which is a 3- to 4-year, post-baccalaureate, degree program in which students provide supervised clinical services to patients experiencing hearing and balance problems. Students earn approximately 2,000 clinical hours during the doctoral program, via a combination of on-campus and off-campus rotations and a final clinical externship year that, collectively, leads to clinician independence in audiological diagnostics and treatment. Unique to audiology training is that most of the clinical work occurs within a small sound-treated booth containing equipment, patient, and clinician, at a minimum. The proximity of a clinical supervisor within this restricted physical space presents an additional challenge to audiology students in training, which could exacerbate the natural dynamic between the student and patient and increase the likelihood of the imposter phenomenon. Thus, BIET offers a distinct benefit for audiology education, by limiting the number of people physically located within restricted spaces.

The purpose of this pilot study was to explore BIET in an on-campus audiology clinic. This pilot study provided preliminary proof of concept data for audiology clinical learning. The study examined these research questions: (a) which feedback method, BIET or side-by-side coaching, is preferred by students and supervisors? and (b) what is the nature of student and supervisor perspective on BIET?

Method

This study was approved by the Towson University Institutional Review Board. This study also met supplemental COVID-19 requirements for participant safety that were in place at the time of this study. All participants provided signed informed consent and were financially compensated.

Participants. Participants included 10 Au.D. students and 2 supervisors. Students were first-year, second-semester students who had completed a semester of courses and some clinic observation. Half of the students had no direct patient clinical experience; the other half had minimal experience (1 to 4 case histories with in-person patients). This population was deemed most likely to need

real-time supervisor guidance and least likely to have bias towards a specific coaching technique, compared with more advanced students. Supervisors were practicing audiologists with the following credentials: clinical doctorate, state license, CCC-A, and experience in on- and off-campus clinical supervision. Two standardized patients served as audiology patients. Both were third year, second semester Au.D. students with on- and off-campus clinical experience. Unfortunately, external paid actors could not be hired to serve as standardized patients, as we originally planned, because campus access was restricted to faculty, staff, and students enrolled in the COVID-19 monitoring program. Demographic information on student participants was not formally collected as part of the research. Both supervisors and both simulated patients were White women.

Materials and Procedure. This pilot study collected data via survey. Students and supervisors provided 5-point Likert-response ratings (1/strongly disagree to 5/strongly agree) to eight statements and qualitative data in response to two open-set questions. Students completed two back-to-back sessions, including two coaching types and two clinical cases, counterbalanced to minimize order effects (see Table 1). Standardized patients followed a semi-structured script (see Table 2) designed via collaboration between research and clinical faculty. Case #1 (Basic) was a relatively straight-forward case history for a patient with hearing loss. Case #2 (Advanced) was a more difficult case history for a patient with tinnitus. Both cases were designed to include "red flag" reports that should trigger a request for additional information that might be missed by a student clinician, providing an opportunity for supervisor feedback. In the side-by-side condition the supervisor was physically in the room sitting next to the student. The supervisor position during the BIET condition was behind the testing room door close enough to hear; however, the supervisor could not see the student and the student could not see the supervisor. The distance between supervisor and student was sufficient that neither the student nor the simulated patient could hear the supervisor voicing via direct transmission. For the BIET condition, nine of the students wore two (bilateral) Phonak Audeo-P Receiver in the Canal (RIC) hearing aids with no prescribed gain, connected via Bluetooth to a Phonak Roger Pen, used as a supervisor microphone. Because of a technology failure immediately prior to the arrival of participant #10, the BIET condition used a different system with similar appearance and functionality, ReSound ONE RIC. Two parallel surveys (student, supervisor) included similar items with different perspectives (see Table 3). Student participants completed the survey after completing both case histories. Supervisors completed Likert-response items after each student and open-ended questions once, after their final student observation.

Qualitative (open-set question) data were analyzed using an inductive and immersive process (Pitney et al., 2020) to find similarities among responses. Responses were coded through open then axial methods to collapse data into consistent themes (Merriam, 2009). Through the coding process, reoccurring patterns in data support the achievement of saturation (Merriam, 2009) which increases the trustworthiness and credibility of the findings. Qualitative analysis was conducted collaboratively by the first, second, and third authors; the first author was an Au.D. student with course work in research design and analysis. The second and third authors were faculty with expertise in qualitative analysis. The second author provided resources (e.g., Saldaña [2013], and examples of qualitative research papers) and individual mentoring to the first author prior to and throughout the analysis process. Initial codes (words and short phrases) were used to label participant responses, usually at the sentence level; however, single sentences could be associated

with multiple codes, for longer, more complex sentences in which multiple ideas were expressed. After initial codes were assigned to the text, focused coding involved considering how initial codes could be related within larger categories, which resulted in draft themes, which were independently and critically reviewed by the third author. Final themes, as presented here, were agreed upon by all authors through peer debriefing (Merriam, 2009) to establish trustworthiness and credibility of the data.

Table 1

Study Design Including Session, Technique, and Clinical Cases Associated with Four Conditions (A-D) and Assignment of Conditions to Student and Supervisor Participants

Condition	Session	Technique	Clinical Case
A	1	Side-by-side	Case #1
	2	BIET	Case #2
B	1	BIET	Case #1
	2	Side-by-side	Case #2
C	1	Side-by-side	Case #2
	2	BIET	Case #1
D	1	BIET	Case #2
	2	Side-by-side	Case #1

Assignment of Participants to Conditions A-D

Student	Supervisor	Condition
1	1	A
2	1	B
3	1	C
4	1	D
5	1	A
6	2	B
7	2	C
8	2	D
9	2	A
10	2	B

Table 2

Description of Standardized Patient Cases

Case	Difficulty	Semi-structured Script
Case #1: Hearing Loss	Basic	• Patient reports coming in because son believes there is a hearing loss • Medical history unremarkable • Noise exposure going to concerts when younger • Expresses slight difficulty communicating at restaurants • Patient asks, "If you find a hearing loss what happens next?" • Patient asks, "How much do hearing aids cost? Will insurance cover hearing aids?" • Patient asks, "Is there surgery to fix hearing loss?"
Case #2: Tinnitus	Advanced	• Patient reports coming in due to referral from primary doctor regarding tinnitus • No issues with hearing • Various mental health struggles with suffering from tinnitus • Significant medical history and medications • Onset of tinnitus was after car crash one year ago • Patient spends a lot of time describing low quality of life and lack of support at home • Patient asks, "Is there a cure for my tinnitus?" • Patient asks, "I don't have any hearing trouble, why do you need to test my hearing?"

Table 3

Survey Items

Q#	Respondent	Survey Item
Q1	Supervisor	I preferred giving feedback via earpiece over the side-by-side feedback
	Student	I preferred the earpiece feedback to the side-by-side feedback
Q2	Supervisor	I preferred to be physically present in the appointment with the student
	Student	I preferred my supervisor to be physically present in the appointment with me
Q3	Supervisor	I preferred giving feedback corrections live with the earpiece rather than after
	Student	I preferred receiving feedback corrections live with the earpiece rather than after
Q4	Supervisor	I found speaking to the student via earpiece to be frustrating/not helpful
	Student	I found the earpiece feedback to be frustrating/distracting
Q5	Supervisor	I felt I was able to give more guidance when the student was wearing the earpiece
	Student	I felt my supervisor gave me enough guidance when wearing the earpiece
Q6	Supervisor	I felt less anxious having to "step in" when the student was wearing the earpiece
	Student	I felt my supervisor spoke too much into the earpiece
Q7	Supervisor	I felt the student was more confident conducting case history with the earpiece
	Student	I felt more confident conducting case history with the earpiece
Q8	Supervisor	I would want my students to use the earpiece in future appointments
	Student	I would want to use the earpiece in future appointments
		Open-Set Questions
Q9	Supervisor	What is your perspective / take away from delivering feedback via the earpiece in clinic?
	Student	What is your perspective / take away from receiving feedback via the earpiece in clinic?
Q10	Supervisor	How would you improve delivering feedback and the use of the earpiece in the future?
	Student	How would you improve receiving feedback and the use of the earpiece in the future?

Results

To examine the first research question, we focused on Likert-type responses to Q1 (preference for earpiece) and Q2 (preference for side-by-side). A comparison between Q1 and Q2 yielded a strong, statistically significant, negative correlation (r = -.876, p = .001), which we expected because these items were reverse coded as validity indicators. Two single-sample t-tests were used to compare student responses for Q1 and Q2 to a neutral response value of 3 (which indicates neither agreement nor disagreement with statements about preference). Overall results indicated student responses were not significantly different from neutral for Q1, t (9) = -.452, p = .662, but there was a significant difference found between student responses and neutral rating for Q2, t (9) = 3.873, p = .004, in the direction of agreement with a preference for side-by-side coaching. There was a significant positive correlation between ratings for Q1 by students and ratings for Q1 by supervisors for each student (r = .637, p = .048), with each point illustrated on the scatterplot in Figure 1. Although these data are exploratory, they suggest an association between the way students rated their preferences and the way supervisors rated the preferences for each student. This could suggest preference for the use of BIET technology may depend on individual student performance, learning needs, receptiveness to the technology, or other individual factors.

The second research question was examined via exploration of the correlation among Likert-type response items (Table 4) and qualitative analysis of open-set response items. Q1 was significantly and positively correlated with Q7, indicating overall preference for BIET was associated with feelings of confidence while using the earpiece. A similar finding between Q1 and Q8 indicted preference for BIET was associated with desire to use the earpiece in the future. Significant, positive correlations were found between Q5 and Q7, indicating students' perception of receiving sufficient guidance via the earpiece was associated with feelings of confidence when using the earpiece. A significant positive correlation between Q7 and Q8 indicated perceptions of confidence when using the earpiece were related to student desire to use the earpiece in the future. Analysis of variance (2 x 2 x 2) indicated no significant main effects for supervisor, order of coaching strategy, or order of clinical case; in addition, there were no significant interactions ($p > .05$ for all contrasts).

Descriptive statistics associated with Likert-response items are summarized in Table 5. Mean ratings at or close to 3 indicate a neutral response, ratings below 3 indicate disagreement, and ratings above 3 indicate agreement with survey statements. For all statements in which BIET technology was phrased in the positive (Q1, 3, 5, 7, 8), supervisor ratings were greater (more positive) than student ratings. For all statements in which side-by-side was phrased in the positive (Q2) or BIET was phrased in the negative (Q4, 6), student ratings were greater than supervisor ratings. The highest mean student ratings indicated students preferred having the supervisor physically present (M = 4; Q2), supervisors gave enough guidance with the earpiece (M = 3.8; Q5), and students preferred live over post-observation feedback (M = 3.3; Q3). The highest supervisor ratings indicated supervisors wanted students to use the earpiece in the future (M = 4.3; Q8), preferred giving feedback live rather than post-observation (M = 4.2; Q3), and felt they were able to give more guidance via the earpiece compared to side-by-side (M = 4.2; Q5). Overall, supervisor ratings of BIET were more positive than student ratings.

Figure 1

Student and Supervisor Ratings for Question 1 (Q1) Indicating Preference for BIET

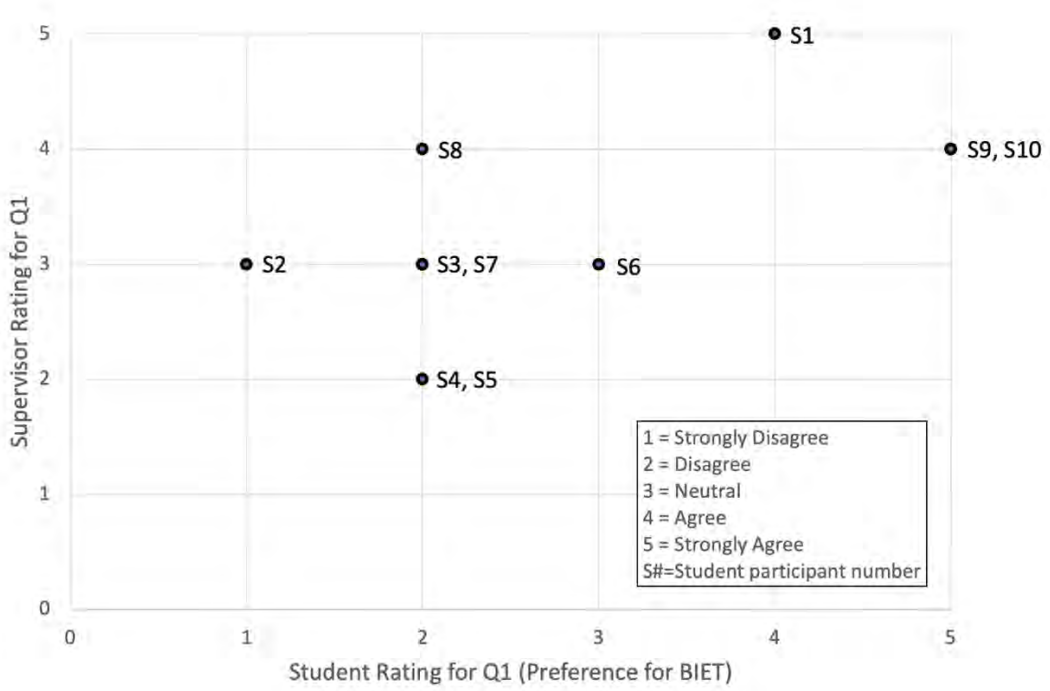

Table 4

Correlation Matrix for Likert-responses for Students

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Q2	-.876**						
	.001						
Q3	.670*	-.364					
	.034	.301					
Q4	-.245	.273	-.303				
	.496	.445	.394				
Q5	.585	-.791**	.187	-.115			
	.076	.006	.605	.751			
Q6	.201	-.215	-.165	-.188	.272		
	.578	.551	.650	.603	.447		
Q7	.892**	-.861**	.423	-.129	.697*	.167	
	.001	.001	.223	.722	.025	.645	
Q8	.800**	-.791**	.605	-.245	.562	-.272	.834**
	.005	.006	.064	.496	.091	.447	.003

Note. Each cell contains correlation statistic followed by *p* value. Significance is indicated as follows: * Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

The last two survey questions were open-set response items (qualitative data). All participants provided perspectives on using the earpiece and how they would improve use of the earpiece. Data yielded three themes: potential benefit, challenges faced during BIET use, and need to refine protocols to operationalize BIET use. The frequency of comments within each theme and example quotes are provided in Table 6. Student and supervisor perspectives were often similar; specifically, both perceived BIET had the potential to benefit clinical teaching, both acknowledged that they faced challenges trying to use BIET for the first time, and both provided examples of items that needed to be considered for BIET to be operationalized as part of audiology clinical teaching.

Common benefits included increased confidence in working directly with the patient, rather than deferring to a supervisor. Common challenges included figuring out the best way to communicate to avoid disrupting the flow of student clinician to patient conversation. Common suggestions for future protocols included the need for training on how best to use this technology. One unique supervisor perspective was that the benefits of BIET may vary based on student experience level. For example, students with more clinical experience (i.e., third-year Au.D. students) could benefit or feel more comfortable using BIET, compared with first-year students, due to needing less guidance and desiring greater autonomy. Through triangulation of open-set and Likert-response items, both students and supervisors perceived the use of BIET led to confidence when interacting with patients.

Discussion

This pilot study provided initial proof of concept data to indicate BIET is a promising technology for use in audiology clinical training. The first research question asked which feedback method was preferred, BIET or side-by-side coaching. Overall, mean ratings for BIET preference were higher for supervisors, suggesting supervisors may appreciate BIET more than students; however, neither student nor supervisor ratings (agree or disagree) of preference for BIET technology were significantly different from a neutral response (neither agree nor disagree). Student mean ratings indicated a preference for supervisors to be physically present, with ratings significantly higher than neutral; however, this finding may be dependent on student level. We purposefully selected students with minimal to no direct patient contact experience for this pilot study, as a starting point. We wanted to minimize bias by studying students who were least likely to have experience with specific clinical coaching methods. However, even with minimal clinical experience, the students likely had a lifetime of side-by-side coaching experience associated with other activities such as sports. As a result, students may have felt greater comfort with the physical presence of a supervisor because of their inexperience. It is possible, with more experience, that student desire for autonomy will outweigh desire for comfort. The second research question asked about the nature of perspectives on BIET coaching. Significant correlations among Likert-type response items indicated student preference for BIET coaching was associated with a feeling of confidence while using the earpiece, and a feeling of confidence using the earpiece was associated with the perception of receiving sufficient guidance and the desire to use the earpiece in the future. Thus, it appears student confidence, perceptions of guidance, and desire to use the technology may be linked. Thematic analysis of student and supervisor commentary indicated both students and supervisors perceived the inherent potential of BIET technology by describing the potential benefits of BIET; in fact, the most common theme from the commentary was the potential of BIET

to enhance clinical learning. However, students and supervisors also described the challenges associated with BIET and the need for more refined protocols to be developed.

Table 5

Summary of Survey Responses for Supervisors and Students

					Number (*n*) of Ratings by Category		
		M	*SD*	*Mdn*	SD + D Rating 1 or 2	Neutral (N) Rating 3	A + SA Rating 4 or 5
Q1	Students	2.80	1.40	2	6	1	3
	Supervisors	3.30	.95	3	2	4	4
Q2	Students	4.00	.81	4	0	3	7
	Supervisors	3.50	.71	3	0	6	4
Q3	Students	3.30	1.49	3.5	4	1	5
	Supervisors	4.20	.42	4	0	0	10
Q4	Students	2.70	1.49	2	6	1	3
	Supervisors	1.80	1.03	1.5	8	1	1
Q5	Students	3.80	1.03	4	2	0	8
	Supervisors	4.20	.79	4	0	2	8
Q6	Students	1.80	.63	2	9	1	0
	Supervisors	2.60	1.51	2	6	0	4
Q7	Students	2.60	1.26	2.5	5	3	2
	Supervisors	4.10	.74	4	0	2	8
Q8	Students	3.20	1.03	3	3	3	4
	Supervisors	4.30	.48	4	10	0	0

Note. SD = strongly disagree, D = disagree, A = agree, SA = strongly agree. Students completed the survey once. Supervisors completed Likert-response survey items for each student observed.

Table 6

Themes Associated with Participant Comments (from Open-set Questions) and Example Quotes

Themes	Students	Supervisors
Potential benefit	*n* = 16 • Thought it was beneficial • Liked the idea • Helped get to cause quicker • Not having to look at supervisor when stuck • Felt more confident interacting with patient • Felt more comfortable not being watched	*n* = 5 • Freedom to provide reinforcement • Did not have to wait for a good time to provide corrections/input • They [students] seemed more confident / independent
Challenges faced during BIET use	*n* = 7 • Made feedback harder to get when patient was talking at the same time • Was not able to attend to patient as well • Not knowing which to listen to first • Long pauses between hearing feedback and talking to patient • Felt awkward staring while hearing feedback	*n* = 3 • Difficult figuring out when to interject • Started talking at same time as patient • Student needed to ask to repeat information
Need to refine protocols to operationalize BIET use	*n* = 11 • Code word for needing help • Training on how to avoid long pauses and how to manage listening to both • Getting feedback quicker • Reducing the volume • Experiment with earpiece in just one ear • Try earpiece with window so supervisor can see	*n* = 4 • Codes or gestures to indicate needing more/less help • Train how to use earpiece but appear natural • Go through questions in specific order • Might work better for more advanced students

Note. Qualitative data were provided by all students and both supervisors in response to two open-set questions. For this table, *n* = number of comments. In some cases, participants provided more than one comment in a theme.

Benefits of BIET. Clinical learning requires practice, feedback, and the opportunity to apply recommended changes. This pilot study allowed us to explore a novel approach to Au.D. clinical learning using a distance supervision technique within a restricted environment. This line of research may, ultimately, provide Au.D. educators with an effective tool for clinical education. In the traditional side-by-side coaching, when a student clinician needs guidance from a supervisor (e.g., when the student is unable to answer a patient's questions), the student may look over to the supervisor as a signal for them to assist. The signaling can cause disruption to the flow of the appointment and inspire feelings of impostor syndrome within the student, because they need supervisor guidance while the patient is present (Cohen & McConnell, 2019). Alternately, when using the earpiece, students have a discrete way to obtain feedback and corrections, which may improve the flow of the appointment and allow students to apply supervisor feedback immediately to improve clinical performance. One student stated, "It [the earpiece] was discrete and gave me confidence in interacting with the patient." Nottingham's (2018) research also found increased levels of student confidence and autonomy among athletic training students using BIET. Another student from the current study stated, "I enjoyed not feeling bad for looking over at the supervisor in terms of getting any missed information while I had the earpiece in." With this comment also, there were similarities with findings from athletic training students, where using BIET created an appropriate distance for the student to take control of the session and gain independence, while maintaining communication with the supervisor when needed (Nottingham, 2018). Supervisors in the current study noted a benefit in not having to wait for a "good time" to stop the student, which allowed them to interject corrections sooner using BIET compared with typical side-by-side coaching. The same observation was found with pre-service physical education teachers, where supervisors found BIET minimized interruptions and enhanced natural communication flow (Farrell & Chandler, 2008). An additional advantage for audiology, compared with other disciplines, is removing the physical presence of a supervisor from small spaces (e.g., sound booths) associated with audiology clinical education.

Limitations of BIET. Although there were many benefits found with BIET, several participants discussed barriers they faced when receiving feedback with the earpiece. Common barriers included the need to focus on and interpret two stimuli simultaneously (patient and supervisor voices). Although students in the current study did not indicate supervisors spoke into the earpiece too often, other researchers have found delivering whole sentences or long messages through an earpiece can cause interpretation problems and cognitive overload (Coninx et al., 2013). In the current study, one student comment was, "the earpiece seems like a great alternative; however, the earpiece made feedback harder to get with the patient talking at the same time." Supervisors, without realizing, may have given lengthy feedback, which could explain some of the qualitative data in which students described long pauses in communication with the patient as awkward, because they had to be vigilant and listen to the supervisor's full message in the earpiece while maintaining face-to-face interaction with the patient. Some student and supervisor participants suggested a code word system might facilitate targeted feedback with minimal disruption. Previous research has indicated a code system can minimize distraction, with feedback designed to be intentionally short to allow students to focus on patient-care tasks (Scheeler et al., 2010). Structuring the amount of feedback, and having specific code words to convey concise messages, could optimize cognitive load and minimize pauses during each feedback segment (Coninx et al., 2013). With further research into protocols and strategies for BIET technology, it is likely many of the barriers to implementation could be minimized or eliminated.

Research Limitations and Future Research

This study was in the design phase at the start of the COVID-19 pandemic, which resulted in a university-wide shift to virtual operations. When the university re-opened for in-person activities, strict COVID-19 protocols were instituted across campus, including the clinical center, and the IRB imposed serious restrictions on in-person testing for research projects. As a result, we were unable to hire older, paid, actors to play the roles of the two standardized patients, who could best represent a typical on-campus clinic patient. Instead, two third-year, second semester Au.D. students were paid to serve as standardized patients. They fulfilled the requirements admirably, as they understood typical patient/student clinician interactions and were able to role play the clinical cases effectively; however, in future, simulated patients should include individuals across the lifespan and patients from diverse cultural backgrounds. Future research of BIET for audiology clinical training should also examine different audiologic appointments, extend beyond the case history, and involve students at various experience levels. In addition, the participant pool should be expanded to include student participants from multiple training programs with varying curriculum and approaches to pedagogy. In a typical Au.D. program, students begin clinical learning via lab and/or simulation work and university ("on-campus") clinic, then proceed to off-campus clinical rotations, and end with a final year externship; however, there is diversity across Au.D. programs which could be explored by including multiple university sites in future studies. We envision the use of BIET would be optimal during on-campus clinic and could be useful for off-campus clinical rotations, but this remains to be explored. Also remaining to be explored is the impact of participant, patient, and supervisor demographics on perceptions associated with BIET, as these data were not formally collected.

Given that we found BIET to be associated with more positive feedback from supervisors compared with students, future studies should focus on varying supervisor feedback and assessing the level and quality of feedback from the student perspective. Ultimately, we hope this research will result in protocols useful for Au.D. supervisors to provide discrete feedback that students can use immediately and effectively. It is possible BIET could even accelerate the rate of student clinical learning for some skills. It is also possible code systems could be created on an individual basis, to target specific areas of growth for individual students; this would allow supervisors to provide a quick, recognized code word when a student exhibits a specific behavior that needs to evolve. Additionally, the ways in which BIET could be used as part of tele-audiology and tele-supervision should be explored, to provide diverse pedagogical options for audiology programs, reflecting recent changes in healthcare delivery and clinical education. The employment of differentiated instructional and assessment strategies lends to the assumption that all students can recall and retain taught content and ultimately transfer knowledge to patient care. Although BIET is a useful live feedback tool, the impact on overall student learning remains to be explored; for example, will feedback provided via BIET transfer to the next session? Will feedback associated with rare clinical situations transfer to the next similar occurrence? And will BIET always enhance learning because of the immediacy of feedback and practice, or should it be used judiciously, because student clinicians must, ultimately, be able to analyze their performance and make behavioral changes based on self-reflection, which may not be facilitated with immediate feedback. Therefore, future research should also include long-term effects on student progress during the Au.D. program as well as clinical performance of new graduates as they enter the profession.

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