It's Worth the Wait: Optimizing Questioning Methods for Effective Intraoperative Teaching

Meredith Barrett; MD[1*]

Christopher P. Magas; BS[1]

Larry D. Gruppen; PhD[2]

Priya H. Dedhia; MD, PhD[1]

Gurjit Sandhu, PhD[1, 2]

1. University of Michigan; Department of Surgery, Section of General Surgery; Ann Arbor, MI
2. University of Michigan; Department of Learning Health Sciences, Section of General Surgery; Ann Arbor, MI

*Corresponding Author:

Meredith Barrett

Address:

1650 West Medical Center Drive

MSRB II, B560B

Ann Arbor, MI 48109

Phone: 614-917-7037

Email: mebarret@med.umich.edu

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ans.14046

ABSTRACT:

Background: The use of questioning to engage learners is critical to furthering resident education intraoperatively. Previous studies have demonstrated that higher-level questioning and optimal wait times (>3 seconds) result in learner responses reflective of higher cognition and retention. Given the importance of intraoperative learning we investigated question delivery in the OR.

Methods: 12 laparoscopic cholecystectomies were observed and recorded. All questions were transcribed and classified using Bloom's Taxonomy, a framework associated with hierarchical levels of learning outcomes. Wait time between question end and response was recorded.

Results: 6 faculty attendings and 7 house officers at our institution were observed. A total of 133 questions were recorded with an average number of questions per case of 11.2. The majority of questions 112/133 (84%) were classified as Bloom's levels 1-3, with only 6% of questions of the highest level. The wait time before the resident answered the question averaged 1.75 seconds, with attendings interceding after 2.50 seconds. Question complexity and wait time did not vary based on resident PGY level suggesting limited tailoring of question to learner.

Conclusions: Intraoperative questioning is not aligned with higher level thinking. The majority of questions were Bloom's level 3 or below, limiting the complexity of answer formulation. Most responses were given within two seconds, hindering opportunity to pursue higher-order thinking. This suggests including higher-level questions and tailoring questions to learner level may improve retention and maximize gains. Additionally, with attendings answering 20% of their own questions, increasing their wait time offers another area for teaching development.

INTRODUCTION:

The structure of surgical residency education has seen a significant shift in the last two decades. Heightened regulations for resident duty hours in the setting of increased surgical complexity – in part from rising patient acuity, comorbidities, and technological innovations – requires residents learn more knowledge and skills in less time(1, 2). Serendipitous learning, a tenant of the past, is no longer sufficient and strategic efforts at improving resident education have been undertaken nationally(3, 4). Despite efforts aimed at improving residency education, many surgery graduates do not feel confident in their ability to perform operations independently(5). In a 2009 nationwide study, 27.5% of residents did not feel confident in their ability to operate autonomously and we contend that this number is likely an underestimation as increased work hour restrictions have been implemented in the interim(6). Furthermore, attending surgeons deem 21% of surgery graduates unprepared for fellowship(7). Concerns for

educational outcomes are a call to action for optimizing teaching and learning during residency training(7).

The operative suite is a learning environment unique to surgery residency; a signature pedagogy of the profession that is ripe for focused educational enhancements by both faculty and trainee(8, 9). Though consisting of only 6-12% of duty hours, intraoperative learning time is a crucial period for education and endowing residents with the tools necessary for autonomous practice(10). Given the high stakes environment in which trainee error can result in significant patient harm, developing the optimal teaching environment and interactions has become the focus of many surgical educators across the nation(1, 5, 11, 12). In particular, injecting pedagogical best practices, methodologies and theories into intraoperative teaching has the potential to improve resident learning, confidence and achievement of the overarching goal of effective, autonomous, attending surgeons(5, 8).

An aspect of education that has been extensively studied is that of questioning(13). Famously utilized by the philosopher Socrates, the power of questioning to induce learning and development has provided a scaffolding for teaching for centuries(14). More recently, education specialists have further investigated the art of questioning to better understand how to strategically utilize different types of questions to increase learner involvement and retention (15). Two components of interest with regard to question investigation are that of question complexity and learner wait time(16-18). We sought to investigate both these outcomes in the intraoperative environment.

Not all questions are of the same complexity; therefore, the thinking that is required for question response varies. Harnessing the variability in questions to engage the learner to think beyond basic facts has led to the development of questioning frameworks. Though many different taxonomies for cognitive learning exist, one of the most prominent is the revised Bloom's taxonomy(16, 19). This classification was first introduced by educational psychologist Benjamin Bloom in 1956 as a way to organize cognitive domain of learning and propel learners into higher and more complex thinking(16). Updated in 2000, the revised Bloom's Taxonomy divides learning objectives into six categories—each with successive complexity-*remembering, understanding, applying, analyzing, evaluating, and creating(19).* The first level, *remembering*, asks the learner to recall and remember basic knowledge facts. *Understanding* reaches further, requiring the learner to not just memorize the information but have a comprehension of its meaning. *Application* refers to understanding and knowledge in a certain scenario—the learner must understand the concepts at hand and be able to use them in concrete situations. Next, *analyzing*, asks of the learner to break down information and into pieces and relate those pieces to another for answer formulation. *Evaluating* is founded on defense of one's answers—the learner must have a thorough understanding of the concept at hand as well as recall and manipulation of known facts to supplement one's response with factual data. Finally, the highest level, *creating,* is the utilization of all lower levels to go beyond the known and potential to formulate novel ideas. (Table 1) (20, 21).

Given the higher-level thinking that must be utilized for responding to more sophisticated questions, another aspect of questioning of interest is that of wait time, or the time between question end to learner response or teacher interjection. Many researchers have investigated the optimal wait time to allow the learner time for question digestion and answer synthesis; nearly all agree that at least 3 seconds should be given to the learner to allow for a thoughtful response(17, 18, 22-24). The percentage of questions answered and the quality of answers given improve when wait times of 3 seconds are greater are attained. Additionally, teachers are more effective when longer wait times are achieved. Longer wait times allow for teacher pause and learner assessment—tailoring the questions to the learner at hand instead of relying on standard questions(13, 25).

The literature behind question complexity and wait time is robust in the field of postsecondary education in general but very little has been reported on utilizing such tools in medical education—particularly intraoperatively. We previously reported on the lack of higher order questioning in the operating room as an area for improvement and faculty development (15). Yet, given the complexity of questioning in the OR we recognize that question taxonomy is only one aspect of question-induced learning. To further this work, we investigated how wait time is, or is not, utilized in the operating room. Given the lack of diversity in questioning in our previous work we hypothesized that wait time would likely be less than the recommended three seconds for response as more complex questions promote complex answers; answers which necessitate learner assessment, judgment, and synthesis as opposed to simple rote recall.

Secondary outcomes of interest included analysis of wait times by trainee level and question complexity to assess if longer wait times were allotted for lower level of training or greater question complexity.

METHODS:

Setting and Participants:

This study took place from December 2014 –February 2015, at the University of Michigan; an allopathic, US-based institution. Prior to intraoperative case recording, ethics approval was obtained (IRB No. HUM00084551). A total of 12 operative cases were recorded with sample selection based on convenience sampling. Residents of all levels of training as well as faculty of various tenure were included. Both resident and attending provided verbal consent to videography, with a written consent obtained from patients. To our knowledge no faculty members had prior training on questioning techniques. The study participants were not provided any special educational training or instruction from study members prior to video recording. Attempts were made to make the videography as unobtrusive as possible and participants were encouraged to operate and interact as routinely as possible for the case at hand. The participants knew they were being recorded in an attempt to assess and optimize the educational environment but no instruction on the wait time or question taxonomy was provided. To limit the variation in questioning secondary to procedural type we elected to limit our review to one procedure.

Laparoscopic cholecystectomy was utilized for its frequency, relevance to all learner levels, and laparoscopic nature, which allowed for both intraabdominal and operative room camera views.

Video Recording:

For optimal sound and video quality, faculty surgeons agreed to wear a portable microphone and an iPAD mini™ (Apple, Cuppertino, CA) was placed on a mobile stand to allow for the best videography without being obtrusive. Recording began at the end of the preoperative time-out and was completed when the faculty surgeon left the case. A member of the study team (CM) was present for the entirety of all recorded procedures to insure functionality of equipment and monitor sound quality.

Data recording and synthesis:

At the completion of each case, videos were uploaded to a secured server for further analysis. Audio from videos was transcribed verbatim and de-identified. Transcripts were reviewed for accuracy by two study team members (CM, GS). Utilizing the transcription, all questions asked during the case were noted. Dialogue of both question and answer were recorded. Time of question end, time of answer initiation, and question respondent (resident vs. attending) were all recorded for analysis. Wait time was defined as the length of time from end of question to either resident response or attending interjection. Data were managed using Microsoft Excel (Microsoft, Redmond, WA).

Data Analysis:

After transcription and identification of all questions, the questions were subject to coding based on Bloom's Taxonomy as previously described(15). The highest level, that of *creating,* was deemed not appropriate for this study as creating or innovating new surgical techniques is likely beyond the foundational educational experience of the resident surgeon. The remaining five (Table 2) domains were coded independently by authors (CM, MB, GS). The research team met to resolve any discrepancies prior to analysis.

Wait time and codes along with surgeon and resident demographic information was analyzed using STATA 13 (LP StataCorp, College Station, TX). Mixed modeling was used to analyze the effect of faculty experience, PGY year, and question complexity on wait time.

RESULTS:

Seven residents and six faculty were observed. Faculty experience level ranged from 1 year to 26 years and residents ranged from PGY 1 to PGY 5. The average case time was 68 minutes (47-90min). Average number of questions asked per case was 11.2, ranging from 0-29 questions or 9.5 questions/hr. As we previously reported, a majority of questions were classified in the lower three levels of Bloom's taxonomy with approximately 15% being higher level questions (Table 2) (15). Additionally, despite variation in resident training level from intern to chief the type of question asked did not vary by resident training level.

Results of wait time analysis are listed in Table 2. On review, 117 of 133 questions were answered; 96 by residents, 21 by attendings. The percent of questions answered by attending or

resident did not vary based on Bloom's level. The average wait time overall was 1.77 seconds, with residents answering in 1.57 seconds and attendings interceding in 2.67 seconds. Subgroup analysis did reveal that more complex questions, Blooms level 4 and 5, did allow for longer wait times (3.27 and 2.29 seconds respectively) but given the low number of questions in this category this was not found to be statistically significant.

DISCUSSION:

Surgical resident training of the 21st century has made great strides since the apprenticeship models of the early 20th century(4). Instead of "see one, do one, teach one" residency programs are transforming teaching models to be strategic and learner-centered (1, 2). In an age of increased patient comorbidities and acuity, accompanied by less time in the OR for learning, utilizing intraoperative experiences for the greatest educational gain is crucial in producing competent and autonomous residents(1).

The use of questioning to guide the intraoperative learning experience is a key facet of one-on-one teaching that can be utilized for the great gain(26). Often employed to assess resident knowledge and determine next steps for extending growth, strategic use of questioning and wait time can engage learners in an educational dialogue thereby guiding the trainee to further understanding of the concept at hand(15, 25, 27)). Not all questions provoke the same level of inquiry and reliance on lower level questions diminishes the learner's need to synthesize and

formulate higher level answers(27). Though helpful in creating confidence and providing a foundation for further knowledge expansion, lower level questions encourages rote memorization without a true understanding of the complex concepts behind surgical practice. Through the use of higher-level questions, the teacher reinforces existing learning and probes the learner to make connections and analyze deeper. Encouraging the resident to step out of the concrete through the answering of hypothetical, situational questions both establishes the resident's current knowledge base and encourages them to use it for problem solving(27). For example, if during removal of the gallbladder from the fossa instead of simply observing, the attending surgeon asked the resident learner "*What would you do if after transecting the cystic duct and artery you encountered another tubular structure?"* the potential gains would be multifold. Not only would the resident's answer inform the attending surgeon on their knowledge of the gravity of the situation (potential misidentification injury); such questioning would also encourage the resident to provide a diagnostic or therapeutic solution. Conceptualization and problem solving is required for competent surgical practice, asking questions which encourage such higher level thinking breeds confidence for eventual autonomy.

Building on our previous work in which we solely analyzed the type of question asked, this study includes an analysis of the wait time allotted to residents after question end. The average wait time of 1.77 is below the recommended 3-5 seconds with questions being answered in only 1.57 seconds by residents and after 2.67 seconds attendings answered their own

questions. On statistical analysis there was no difference in wait time based on question complexity or PGY year. Nor was there a difference in question type based on PGY year alone.

These findings on interesting on multiple levels. First, lack of question variation by PGY year suggests that interns and chief residents are being confronted by the same types of questions intraoperatively. Just as one would expect questions asked of elementary school students to be different from high school learners, the lack of strategic variation in question delivery presents an area for educator improvement(25). Tailoring the question to the resident helps trainees at all levels solidify their knowledge of the operation at hand. Focusing on lower level questions when working with interns helps to develop the basics needed for further conceptualization. Notably, the questions must advance beyond these lower levels to allow for continued growth. Progressively complex questions should be seen as the learner progresses(19, 25). This was not found in our cohort and is reflective of the majority of teaching settings (28).

Subsequent wait time analysis also revealed a suboptimal teaching environment. The short wait time is reflective of both insufficient proctor pause and low question complexity(17). The lower wait times for the simpler questions are reflective of the lack of deep thinking necessary to formulate an answer. Expedient recall does not require or allow for complex reasoning and formulation of pertinent associations(21). Lower level questioning encourages simple knowledge retrieval as opposed to conceptualization—a significant opportunity lost for intelligent dialogue for both the attending and resident.

Additionally, the finding that attending surgeons only allowed for 2.67 seconds prior to usurping the question from the resident is detrimental on multiple levels. By answering the question before the 3 second wait time, the faculty surgeon eliminates the resident's opportunity to synthesize and develop an answer to the question. Supporting conditions for trainees to conceptualize results enhances learning and retention, an opportunity lost by rapid question answer. Second, by answering the question so quickly, the faculty surgeon creates an environment in which the resident is primed to attempt rapid response or else have their opportunity for answering be taken away. Again, this is detrimental to the learning environment encouraging the habit of rapid-fire answer without deep factual assimilation for question answer. (17). Limited wait time also allows the resident to avoid answering questions, knowing that in waiting only 3 seconds the answer will be provided by the attending faculty. This behavior eliminates the faculty's ability to assess the learner's knowledge base. Finally, beyond being beneficial to the resident learner, increased wait time results in better teaching(24). Despite the fact that teachers attest to anxiety when encountering wait time beyond a few seconds, pressing through the silence allows for increased dialogue between teacher and learner(29). By allowing for increased wait time, the teacher is set to listen for more thoughtful answers. In allowing for silence and response, a dialogue builds that scaffolds the abilities of the faculty and resident – deepening the resident's understanding of the concepts at play as well as the attending's understanding of the learners knowledge base(18, 24).

Limitations

This study has many limitations. First, as all data were collected at a single institution the results may not be widely generalizable. Additionally, the limited number of cases, attendings, and residents participating could introduce bias. The use of only one procedure type was strategic to decrease variability within the study cohort but it could limit the variety and complexity of questions asked of residents. The commonality of the procedure allows for study across resident training levels but may limit complex questions being asked to more senior residents. Additionally, as cholecystectomy is a fairly simple procedure technically, the opportunity for higher level questioning may be more limited compared to a more complex procedure or pathology. Also, in the operative suite, questioning may not be utilized solely for learning purposes but to determine the knowledge level of the learner and develop a framework for graduated entrustment from the faculty member. If questioning is utilized for this purpose, it may limit the conclusions to be drawn from complex questioning, answer development, and longer wait time. We recognize this is a limitation that we are unable to account for in the current analysis as instruction on questioning for learning was not provided to the faculty member or resident respondent. Finally, in using the definition of wait time as the duration of time between asking the question to resident response or attending interjection, the teacher is not in complete control of the wait time. This is an obvious limitation but given attending interjection without resident response was analyzed on its own and was still less than three

seconds, we feel conclusions on limited wait time are still valid. Further analysis with a larger cohort for just these non resident-answered questions is warranted.

This study has generated many hypotheses which require further analysis prior to reaching conclusiveness. To better define the effect of question optimization on learner experience, future work in which the faculty member is trained on the importance of questioning and wait time, followed by a similar analysis and resident assessment of learning experience could further support the conclusions of our current work. To implement this, a training course for faculty including simulation and a repository of questions of multiple taxonomy levels are all considerations for future research.

CONCLUSIONS:

Use of higher level questioning with sufficient wait time within the OR is a common, suboptimal pattern in our study of laparoscopic cholecystectomies. Given the increased complexity of surgical training and increased limitation on time spent in the OR, intraoperative experiences must be better aligned for educational gain. Improving question delivery and response wait time is an area of surgical education in which there is substantial room for improvement. Faculty and resident education on hierarchical questioning practices may allow for more growth within the operating room with the eventual goal of graduating confident and autonomous surgeons.

ACKNOWLEDGMENTS: The authors would like to thank Niki Matusko for her statistical support.

The authors have no financial disclosures.

REFERENCES:

1. Evans CH, Schenarts KD. Evolving Educational Techniques in Surgical Training. Surg Clin North Am. 2016;96(1):71-88.
2. Scally CP, Sandhu G, Magas C, Gauger PG, Minter RM. Investigating the Impact of the 2011 ACGME Resident Duty Hour Regulations on Surgical Residency Programs: The Program Director Perspective. J Am Coll Surg. 2015;221(4):883-9.e1.
3. Franzese CB, Stringer SP. The evolution of surgical training: perspectives on educational models from the past to the future. Otolaryngol Clin North Am. 2007;40(6):1227-35, vii.
4. Walter AJ. Surgical education for the twenty-first century: beyond the apprentice model. Obstet Gynecol Clin North Am. 2006;33(2):233-6, vii.
5. Sandhu G, Magas CP, Robinson AB, Scally CP, Minter RM. Progressive Entrustment to Achieve Resident Autonomy in the Operating Room: A National Qualitative Study With General Surgery Faculty and Residents. Ann Surg. 2016.
6. Yeo H, Viola K, Berg D, Lin Z, Nunez-Smith M, Cammann C, et al. Attitudes, training experiences, and professional expectations of US general surgery residents: a national survey. JAMA. 2009;302(12):1301-8.
7. Mattar SG, Alseidi AA, Jones DB, Jeyarajah DR, Swanstrom LL, Aye RW, et al. General surgery residency inadequately prepares trainees for fellowship: results of a survey of fellowship program directors. Ann Surg. 2013;258(3):440-9.
8. Kieu V, Stroud L, Huang P, Smith M, Spychal R, Hunter-Smith D, et al. The operating theatre as classroom: a qualitative study of learning and teaching surgical competencies. Educ Health (Abingdon). 2015;28(1):22-8.
9. Shulman LS. Signature Pedagogies in the Professions. Daedalus 2005; 134(3): 52-59.
10. Chung RS. How much time do surgical residents need to learn operative surgery? Am J Surg. 2005;190(3):351-3.
11. Roberts NK, Brenner MJ, Williams RG, Kim MJ, Dunnington GL. Capturing the teachable moment: a grounded theory study of verbal teaching interactions in the operating room. Surgery. 2012;151(5):643-50.

12. Chen XP, Williams RG, Smink DS. Do residents receive the same OR guidance as surgeons report? Difference between residents' and surgeons' perceptions of OR guidance. J Surg Educ. 2014;71(6):e79-82.
13. Rowe MB, Educational Resources Information Center (U.S.). Wait-Time and Rewards as Instructional Variables
Their Influence on Language, Logic, and Fate Control. [S.l.]: Distributed by ERIC Clearinghouse; 1972. Available from: http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED061103.
14. Rohrich RJ, Johns DF. The Socratic method in plastic surgery education: a lost art revisited. Plast Reconstr Surg. 2000;105(5):1803-5.
15. Magas C, Dedhia P, Barrett M, Gauger P, Gruppen L, Sandhu G. Strategic questioning in surgical education. Clin Teach. 2016.
16. Bloom B. Taxonomy of Educational Objectives, The Classification of Educational Goals. New York: D. McKay Co.; 1974.
17. Bilaloglu R, Arnas Y, Yasar M. Question types and wait-time during science related activities in Turkish preschools. Teachers and Teaching2016.
18. Tobin K. The Role of Wait Time in Higher Cognitive Level Learning.: *Review of Educational Research*; 1987. p. 69-95.
19. Krathwohl DR. A Revision of Bloom's Taxonomy: An Overview. Theory Into Practice2002. p. 212-8.
20. Adams NE. Bloom's taxonomy of cognitive learning objectives. J Med Libr Assoc. 2015;103(3):152-3.
21. Omar N, Haris S, Hassan R, Arshad H, Rahmat M. Automated analysis of exam questions according to Bloom's taxonomy. Procedia-Social and Behavioral Sciences. 2012;59:297-303.
22. Cho YH, Lee SY, Jeong DW, Im SJ, Choi EJ, Lee SH, et al. Analysis of questioning technique during classes in medical education. BMC Med Educ. 2012;12:39.
23. Yuen J, Cheung K, Fung K, Lai A, Leung C. A New Dimension in Student Learning: Measuring Wait Times. Hong Kong: Springer Berlin Heidelberg; 2013.
24. Rowe MB. Wait Time: Slowing Down May Be a Way of Speeding Up! Journal of Teacher Education1986. p. 43-50.
25. Long M, Blankenburg R, Butani L. Questioning as a teaching tool. Pediatrics. 2015;135(3):406-8.
26. Oh RC. The Socratic Method in medicine--the labor of delivering medical truths. Fam Med. 2005;37(8):537-9.
27. Tofade T, Elsner J, Haines ST. Best practice strategies for effective use of questions as a teaching tool. Am J Pharm Educ. 2013;77(7):155.
28. Phillips N, Duke M. The questioning skills of clinical teachers and preceptors: a comparative study. J Adv Nurs. 2001;33(4):523-9.

29. Jegede OJ, Olajide JO. Wait-time, classroom discourse, and the influence of socioeconomic factors in science education. Science Education. 1995;79(3):16.