

Maximizing Plastic Surgery Education Impact: Lessons from Resident Learning Styles and Experiential Learning Theory

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Background: Residents in many surgical disciplines express a strong preference for hands-on learning, but no studies have focused on plastic surgery. This initial study aims to ascertain the learning styles of plastic surgery residents, and identify potential trends that may better guide curriculum development.

Methods: Kolb Learning Style Index v. 3.1 was administered to plastic surgery residents across all training levels at three residency programs. The Kolb Learning Style Index is a 12-item questionnaire that characterizes an individual's learning style into 1 of 4 major categories: converging; accommodating; assimilating; and diverging.

Results: The surveyed cohort of plastic surgery residents (n = 45) demonstrated a diverse mix of learning styles: converging (38%, n = 17); accommodating (24%, n = 11); diverging (20%, n = 9); and assimilating (16%, n = 7). One resident was balanced between converging and accommodating (2%, n = 1). Despite varied learning styles, the majority (64%, n = 29) demonstrated a preference for "active experimentation," for example, hands-on learning.

Conclusions: A preliminary assessment of learning styles among plastic surgery residents suggests that they have mixed learning styles. This contrasts with the existing literature from other surgical specialties where a single learning style dominates. However, like these other specialties, active experimentation is particularly valued. As such, it behooves the plastic surgery educator to continue to strive for balance between book learning and hands-on experience for residents at all levels of training, to engage residents with all learning styles. (*Plast Reconstr Surg Glob Open* 2019;7:e2252; doi: 10.1097/GOX.0000000000002252; Published online 24 July 2019.)

INTRODUCTION

The challenge of surgical training has long been to teach complex anatomy and pathophysiology, develop technical competence, and nurture prudent decision-making in a limited number of years. In modern surgical residency, this

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challenge is compounded by work-hour restrictions and an increasing burden of documentation and "noneducational work" that detracts from clinical experience.¹⁻⁴ As a result, residents have even more limited time to master an expanding knowledge base that incorporates ever-evolving medical and technological advancements. Thus, educators must make a conscious effort to understand how residents best learn to maximize effectiveness and efficiency of learning.

One strategy to enhance educational impact is to incorporate theories of adult learning into surgical curricula. A well-known paradigm, Kolb's Experiential Learning Theory,⁵ has been widely applied to medical education across various specialties, including internal medicine,⁶ pediatrics,⁷ surgery,^{8,9} and anesthesiology.¹⁰ Kolb's Experiential Learning Theory emphasizes that experience plays a central role in the process of learning, defined as, "a process whereby knowledge is created through the transformation of experience."⁵ Two continua necessary for learning to occur: the *perceiving* continuum (how an individual grasps new information) and the *processing* continuum (how an individual transforms that experience into new learning) (Fig. 1). The learner perceives either through experiencing an event (concrete experience

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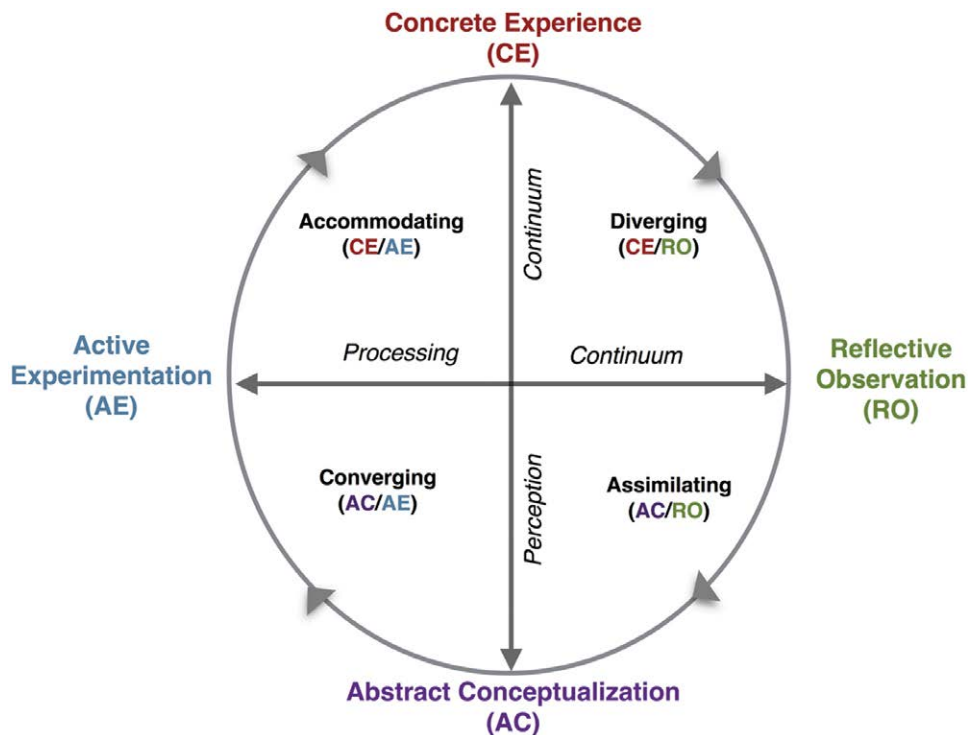


FIG. 1. The 4 learning styles: accommodating, diverging, converging, and assimilating, each formed by 2 of the 4 learning quadrants. (Adapted with permission from Kolb DA, Kolb A. *The Kolb Learning Style Inventory—Version 3.1 2005 Technical Specifications*. Boston, Mass.: Haygroup; 2005.)

[CE]) or by thinking about an idea or theory (abstract conceptualization [AC]). The learner makes a new experience meaningful either by reflecting on it (reflective observation [RO]) or applying it (active experimentation [AE]). Different components of surgical education activate different phases of learning: assisting/observing in the operating room involves CE, reading and self-study of theory RO, listening/watching lectures and digital animation AC, and hands-on operating or high-fidelity simulation AE.

Kolb's theory advocates that ideal learning involves all of these 4 processes. However, the influences of one's personality, culture, education, and profession cause individuals to prefer certain learning phases over others, creating distinct learning styles: *converging*, *diverging*, *accommodating*, and *assimilating* (Table 1). In Plastic Surgery, the importance of adult learning concepts and experiential learning theory has been acknowledged in the literature,¹¹ but little research has been done to create a foundation for driving educational improvements.¹² The purpose of this project is to appraise the learning styles of plastic surgery residents to provide preliminary insight into how knowing their preferred learning styles, in conjunction with an understanding of experiential learning theory, can be used to generate high-impact educational experiences.

METHODS

The Kolb Learning Style Inventory

The Kolb Learning Style Inventory (KLSI) was developed to increase an individual's awareness and understanding of his or her preferred learning styles in the

context of Kolb Experiential Learning Theory. The KLSI v 3.1 was for this study so results would be comparable to previous studies in other surgical disciplines. The questionnaire is comprised of 12 questions, each of which has 4 options corresponding to the phases of learning (AE, AC, CE, and RO) ranked on a 1–4 Likert scale. A total score for each phase of learning is determined and learning style derived from where the (AC-CE) score and the (AE-RO) score intersect. This tool characterizes learning style into 4 groups: converging, accommodating, assimilating, and diverging (Table 1).

Subject Selection and Recruitment

This study was conducted prospectively under Institutional Review Board exemption status at 3 plastic surgery residency programs, including residents from integrated and independent training pathways. Two programs were in New England (one with 6-year integrated and 3-year independent residencies and the other with a 3-year independent program only at the time of the study) and one in the mid-Atlantic region (6-year integrated residency only). Basic demographic information was collected including postgraduate year and independent versus integrated training track. All residents were invited to participate voluntarily, and responses were kept confidential. Results were returned to participants, if desired, for their own informational purposes.

Statistical Analysis

Descriptive statistics were used to characterize frequency and distribution of learning styles. Fisher's exact test was used to compare distribution of learning styles

Table 1. Preferred Learning Activities and Role of Faculty for Each Learning Style

Learning Style	Preferred Method of Taking in New Information	Preferred Method of Transforming Information into New Learning	Description	Learner Values and Skills	Ideal Learning Environment/Activities	Role of Faculty
Diverging	CE	RO	Open-minded, imaginative learners; observers; idea generators	Values imagination and flexibility. Skilled at brainstorming and offering diverse alternatives.	Ideation/innovation of divergent approaches, multidisciplinary simulation, problem-based learning, whole-team debriefing	As a motivator
Assimilating	AC	RO	Logician learners; thinking, synthesizing and concept-building	Values theory. Skilled at analysing and integrating many facts and concepts.	Dynamic lectures, innovative concept-sharing, problem-based experiential learning, critical observation	As an expert/communicator of information
Converging	AC	AE	Creators of applied solutions. Appliers of knowledge	Values clarity and application. Skilled at problem solving and finding practical uses for ideas	Simulation testing of protocol or process, problem/solution-based experiential learning, learning for mastery, boot camps or workshops	As a role model and coach
Accommodator	CE	AE	Practical-minded tacticians	Values intuition experience and action. Skilled at drawing on experience to get work done	Simulation for practice or rehearsal, skill-building instruction, experiential workshops	As an evaluator/feedback-provider and guide

between resident PGY levels and subgroup analyses between binary cohorts (ie, integrated versus independent, male versus female, and junior versus senior residents). The Clopper–Pearson test was used to compare proportion of AE versus RO-preferring residents and CE versus AC-preferring residents to a null hypothesis of an even split (ie, 50–50 distribution). Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, version 24, IBM, Armonk, N.Y.) and Stata (version 15.0, StataCorp, College Station, Tex.). A two-sided alpha threshold of 0.05 was used to determine statistical significance.

RESULTS

Demographics

Forty-five residents (Table 2) completed the KLSI, with a response rate of 91%. Nonrespondents (n = 4) were residents on off-site rotations at the time of the survey. There were more integrated residents (71%, n = 32) compared with independent residents (29%, n = 13). There were also more male residents (62%, n = 28) compared with female residents (38%, n = 17). Nonrespondents had similar demographics compared with respondents.

Learning Styles in Plastic Surgery Residents

Plastic surgery residents demonstrated varied learning styles: converging (38%, n = 17); accommodating (24%, n = 11); diverging (20%, n = 9); assimilating (16%, n = 7); and balanced between the converging and accommodating (2%, n = 1) (Fig. 2). Taken together, AE-preferring learning styles (converging and accommodating)

Table 2. Demographic Breakdown of Resident Respondents

	Integrated	Independent
Total	32	13
Male	17	8
Female	15	5
Postgraduate level	1 2 3 4 5 6	6 4 3 0 0 0

were more common (64%, n = 29) than RO-based learning styles (36%, n = 16). Compared with our null hypothesis (even split between AE versus RO), there were significantly more AE-preferring residents ($P = 0.05$). There was no difference between AC- and CE-preferring learning styles. This indicates that when grasping a new experience, plastic surgery residents valued thinking about (AC) and experiencing (CE) new information about the same (24 versus 20 residents, with one balanced between the two). However, to transform that experience into learning, more residents preferred AE to RO (29 versus 16 residents) (Fig. 2). Subgroup analyses were performed between junior residents (Integrated PGY 1–3) versus senior residents (integrated PGY 4–6 and independent PGY 6–8, male versus female residents, and integrated versus Independent residents to evaluate differences in learning style distribution, as well as preference for AE (Table 3). No statistically significant differences were found in learning styles distribution for any of the subgroups, although there was a trend toward AE-based learning styles among junior residents and independent residents.

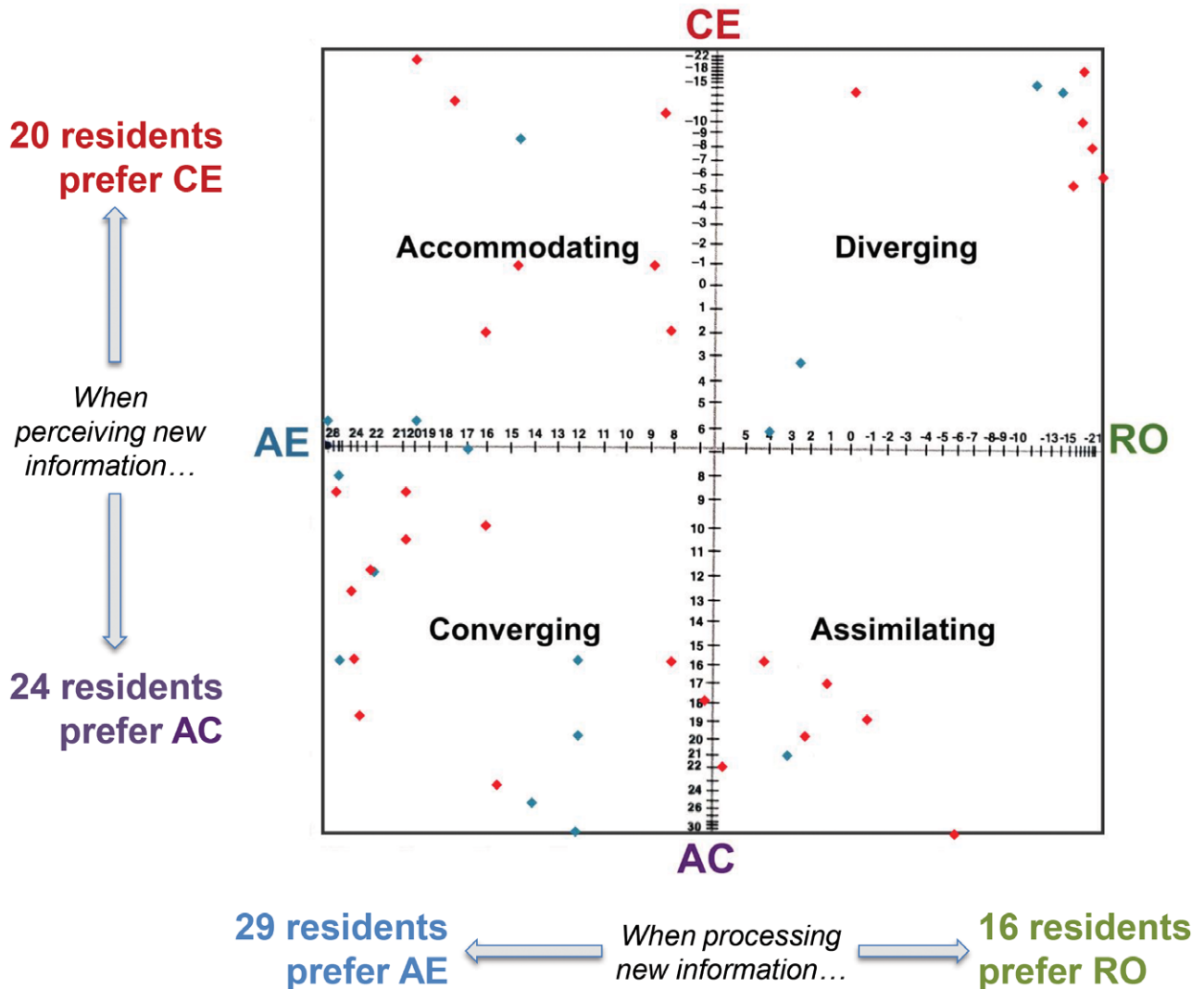


FIG. 2. Overall learning style distribution of plastic surgery residents; red dots denote PGY1-3 (integrated program) and blue dots PGY 4–6 (integrated program) and PGY 6–8 (independent program) with schematic representation of how residents prefer to grasp experience and transform it into new learning. Annotations along the x-axis of the figure denote the number of residents out of 45 that preferred AE vs RO. Note one resident was balanced between AC and CE, so annotation along the y-axis denotes the number of residents out of 44 that prefer AC vs CE.

Table 3. Subgroup Comparisons of Learning Style

Subgroups	Comparing Differences in Overall Learning Style Distribution		Comparing Preference for AE	
	<i>P</i> *	Prevalence (% [n])	<i>P</i> *	
Junior vs senior†	0.51	73% (n = 11) vs 60%, (n = 18)	0.51	
Male vs female	0.29	64% (n = 18) vs 59%, (n = 10)	0.71	
Integrated vs independent	0.81	59% (n = 19) vs 77% (n = 10)	0.32	

Report of *P* values when comparing subgroups for differences in learning style (center column) and preference for AE (right column).

†Junior residents were defined as integrated PGY 1–3 and senior residents defined as either integrated 4–6 or independent PGY 6–8.

*Statistical significance was defined as *P* < 0.05.

Plastic Surgery Residents versus Other Surgical Residents

An additional impetus for this study was to see how the learning styles of plastic surgery residents compare to residents in other surgical specialties. Results from similar studies of other surgical specialties in the literature were examined, including otolaryngology,^{13,14} orthopedic surgery,^{15,16} neurosurgery,¹⁷ and general surgery.^{9,18} Our initial cohort study indicates that overall learning styles in plastic surgery may be more evenly distributed than other specialties, with all learning styles having some representation (Fig. 3). Neurosurgery residents were found to have a different distribution of learning styles compared to residents in plastic surgery (*P* = 0.03), and all other surgical specialties reported in the literature. Despite appearing more balanced, the distribution of plastic surgery learning styles was not significantly differ-

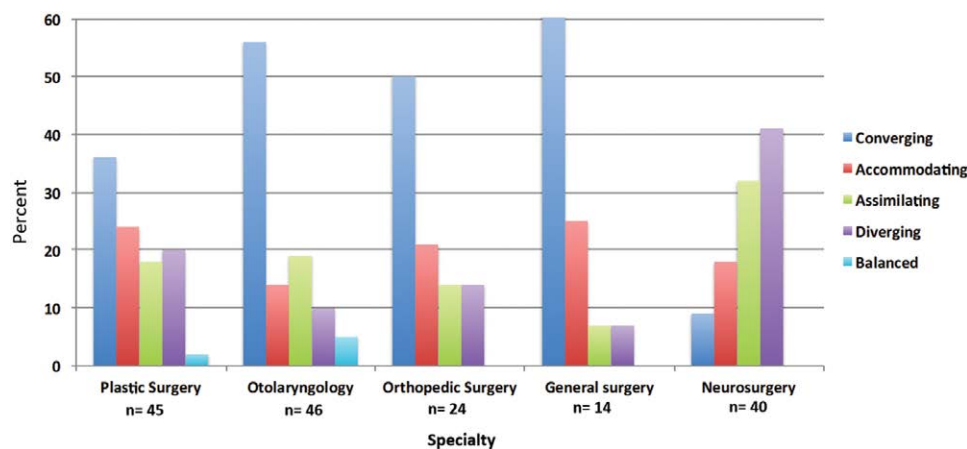


FIG. 3. Comparison of learning style distributions between various surgical specialties. Plastic surgery data from this study are shown alongside resident data from similar studies in otolaryngology,¹⁵ orthopedic surgery,¹⁸ neurosurgery,¹⁹ and general surgery²⁰ in the published literature.

ent from the distribution in otolaryngology ($P = 0.25$), orthopedic surgery ($P = 0.89$), and general surgery ($P = 0.09$) residents.

DISCUSSION

Given the time constraints placed on teaching in modern surgical residency training, there has been growing interest in identifying residents' learning styles, with the end goal of improving educational efficiency. Mounting evidence in several surgical specialties suggests predominance of the converging learning style, which is characterized by grasping new knowledge via thinking and processing that knowledge through doing. This is not surprising given that immediate application of new knowledge and skill has been recognized as an essential feature of adult learning for decades.^{19–21} In surgery, immediate application of new knowledge typically occurs by operating the essential function of the discipline.

The KLSI has been applied toward the study of learning in surgery.^{18,22} For example, general surgery,^{8,9} otolaryngology,^{13,14} and orthopedic surgery¹⁵ residents have been found to prefer hands-on learning through AE, supporting the increase in simulation-based training in these disciplines (eg, the FLS® Technical Skills Proficiency-Based Training Curriculum in general surgery, copyright 2019 Society of American Gastrointestinal and Endoscopic Surgeons). Interestingly, this preferred learning phase has not been born out in all surgical disciplines. This suggests different personality types or educational styles unique to various surgical subspecialties and may also reflect how a learner responds to different subject matter given that learning styles are not static and at any time are influenced by both intrinsic and extrinsic factors.

Rather than assuming that all residents assimilate information in a similar fashion, information about prevailing learning styles could be helpful to surgical educators.

Our preliminary study highlights three key features of the plastic surgery resident population:

- (1) All learning styles were well represented within this cohort of plastic surgery residents from these three programs.
- (2) When grasping a new experience, surveyed plastic surgery residents equally valued thinking about and experiencing new information.
- (3) Significantly more plastic surgery residents from this cohort value actively doing something to process an experience over reflecting on it when transforming that experience into retained knowledge.

Plastic Surgery Residents Have Varied Learning Styles

In contrast studies of other surgical specialties,^{8,9,15,17} most of which have reported a strong preference for the converging learning style (thinking and applying), no one learning style is clearly dominant in the plastic surgery resident population studied here, suggesting more varied learning needs. The absence of a prevailing learning style is perhaps unsurprising given our experience that plastic surgery residents enter the specialty from disparate backgrounds, ranging from a distinctively artistic population to engineers and the mathematically inclined. Of all the surgical specialties studied in the literature thus far, Plastic Surgery is most congruent with Kolb's Experiential Learning Theory, which proposes increasing efficiency by honoring this variation in learning styles and structuring educational experiences as a learning cycle (Fig. 1). If this diversity is upheld across other plastic surgery residency programs, it would emphasize the need to maintain a variety of educational experiences at all levels of plastic surgery residency, to derive the most learning power and impact from training opportunities.

Plastic Surgery Residents Value Learning by Doing

This study revealed almost twice as many plastic surgery residents preferred to transform experience into

knowledge through the act of doing, ie, *AE*. This was true across both residency pathways, both genders, and all training levels, and particularly for junior residents who often appropriately have fewer hands-on opportunities than their more senior colleagues. Although this is largely intuitive, it drives home the importance of hands-on experience as a key step in processing and ultimately retaining new knowledge in plastic surgery at all stages of the resident training process, especially the junior years. For early trainees with a preference for watching/reflecting, our current surgical education model caters well to three-quarters of the learning cycle (CE, RO, and AC), through theory- and lecture-based introduction of new information and early experience observing in the operating room (Fig. 1). However, for the majority of our cohort with a preference for doing/experimenting, the tradition of graduated responsibility in the operating room as the primary method for hands-on learning, offers limited engagement with their preferred learning phase early in residency and by extension fewer opportunities for completion of the learning cycle and maximal learning. Although this limited operative autonomy with real patient is imperative from an ethical and safety standpoint, it emphasizes the need for educational innovation outside of the operating room to fulfill resident learning needs at all levels of training.

Ideas for Promoting *AE* Early in Plastic Surgery Training

To allow residents to traverse the entire learning cycle in the early years of training, some programs are already fostering hands-on experience through junior resident participation in cadaveric anatomic dissections, flap courses, microsurgical skills laboratories, and more. However the logistics and high cost of these opportunities typically prohibit their widespread adoption. This has prompted an interest in physical simulation²³ to give plastic surgical trainees the hands-on experience needed to process knowledge gained through books, lectures, and other modalities without the ethical dilemma of allowing novices to practice on real humans.

Various types of simulation including procedural task trainers, mannequin-based simulation, and virtual reality simulation have gained traction in general surgery.^{24–26} These may ameliorate lack of early operative independence and create an efficient educational environment that respects duty hours and patient safety. In Plastic Surgery, an additional level of creativity is warranted to develop similar opportunities that simulate anatomically complex or delicate open procedures in a cost-effective way that foster more than just technical skills acquisition, but problem solving capability and more. Examples of this are currently being used range from low tech “sawbones” workshops for acquisition of maxillofacial plating skills to intermediate-fidelity microsurgery trainers²⁴ that allow the resident to not just learn to suture an anastomosis, but also to ergonomically position a microscope and appropriately set up the field, to high-fidelity procedural trainers for cleft lip and palate repair^{25,26} that allow a resident to think through steps of an operation, trouble shoot, and see their mistakes

through to their natural conclusion. The future of plastic surgery training will likely demand the creation of more of these types of original models. When thoughtfully combined with current didactics and adult learning concepts, these simulation opportunities can touch all phases of the learning cycle and appeal to all learning styles. Thus, residents can move from introduction of theory to the acquisition of new knowledge through observed experience, followed by practical application and then opportunities for self-reflection, completing the learning cycle and deriving maximal learning from a single educational experience.

Limitations and Future Directions

Although studies attest to the KLSIs construct validity and reliability^{27,28} and its improved psychometric properties over other instruments for learning styles assessment,²⁹ its lack of predictive value³⁰ (including in medical education³¹) and issues of test–retest reliability³² are drawbacks. Despite these limitations, the KLSI retains usefulness as a *descriptive* educational tool³³ because it is still well regarded as appreciating diversity and acknowledging differences in learning.³⁴ This has prompted its widespread use in medical education for descriptive studies, particularly because its experiential basis is relevant to current models of surgical training. Moreover, for our purposes, we consider the fact that learning styles assessed by the Kolb method are not static to be an advantage. Our interest was not the learning needs of the student or practicing surgeon, our interest was what those in the thick of residency training need to learn best so we can better guide the future of surgical education.

A potential weakness of this study is the fact that only East-coast residency programs were included. Although this permits extrapolation of our findings to a certain extent, because residents at these programs originate from across the nation (and even internationally), a national cohort surveying all geographic regions would help determine if apparent diversity in preferred learning style of plastic surgery residents is reflective of all plastic surgery residents or if geographic variation in personality and training styles impacts preferred learning style. It would also provide a basis for more in-depth analysis of changes in resident styles with increasing post-graduate year (PGY) level.

Due to the limited number of surgical resident learning styles studies using the KLSI, our study included data from international institutions, such as study of neurosurgery residents¹⁷ that was conducted in Asia. This may limit the value of our conclusions, due to potential differences in training structure and educational environment.

A final limitation is that only residents were surveyed. As alluded to earlier, this was intentional with the goal of better guiding residency curriculum development. However, it cannot be assumed that these results apply across all levels of plastic surgery learner. For example, preferred learning styles may be completely different for medical students just considering the field of plastic surgery or senior surgeons pursuing continuing medical education. Thus,

educational endeavors for these levels of learner may not necessitate the same amount of AE.

CONCLUSIONS

An understanding of experiential learning theory and recognition of the unique learning preferences of plastic surgery trainees can enhance curricular modifications, which will optimize resident training. The strong prevalence of AE-based learning styles in plastic surgery residents gives credence to the need for educational innovations that promote early autonomous trainee operative experience without risking patient safety, such as that afforded by simulation. The experiential learning model is most effectively supported when educational planning creates an environment in which all styles are fostered, and this is particularly relevant to plastic surgery residents, who have more diverse learning styles compared to peers in other surgical subspecialties. Future efforts in plastic surgery should use experiential learning theory to guide the development of more well-rounded, impactful curricula, recruiting advances in simulation and technology to cater to the unique needs of plastic surgery residents.

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