

Supplementary Information

Supplementary Note A: Instruction to GPT-4 for Generating Topic Titles

The instruction prompt was given to GPT-4 to suggest a short topic name. The *[DOCUMENT]* slot is replaced by 10 most representative example feedback instances under the topics. The *[KEYWORDS]* slot is filled with 10 most representative keywords for the topic, following KeyBERTInspired representation¹.

I have a topic in the context of a trainer giving trainees feedback on surgical tasks that contains the following instances: [DOCUMENTS]

The topic is described by the following keywords: [KEYWORDS]

Based on the above information, can you give a short label for the topic?

Supplementary Note B: Trainee Behavioral Adjustment Prediction - Variables of Importance

Outcome: Behavioral Response			
Rank	GiniOOB	Predictor	Source
1	0.0291	Error of omission	Human
2	0.0135	1. Pulling, Retraction	AI
3	0.0066	Praise	Human
4	0.0059	Good trainee action	Human
5	0.0034	8. Trainer's Queries	AI
6	0.0014	11. Sweeping Techniques	AI
7	0.0013	Visual Aid	Human
8	0.0012	Technical	Human
9	0.0010	3. Prostate & Urethra Positioning	AI
10	0.0009	5. Instrument Positioning	AI
11	0.0005	10. Trainer's Intervention	AI
12	0.0003	7. Handling Bleeding	AI

Supplementary Table 1. Ordered variables of importance in the Random Forest-based prediction of Trainee Behavioral Response. The AI-discovered topics coded as binary predictors are highlighted.

Supplementary Note C: Trainee Verbal Acknowledgment Prediction - Variables of Importance

Outcome: Verbal Response			
Rank	OOBGini	Predictor	Source
1	0.0313	Good trainee action	Human
2	0.0070	2. Encouraging Continuation	AI
3	0.0050	11. Sweeping Techniques	AI
4	0.0029	Technical	Human
5	0.0018	Procedural	Human
6	0.0011	Error of omission	Human
7	0.0006	7. Handling Bleeding	AI
8	0.0003	8. Trainer's Queries	AI

Supplementary Table 2. Ranked variables of importance in the Random Forest Trainee Verbal Response prediction. The AI-discovered topics coded as binary predictors are highlighted.

Supplementary Note D: Analyzing the Impact of Human Refinement on Downstream Tasks

Category	Behavior Outcome	Difference		AI + Human Refinement		AI Initial	
		Δ AUC	95% CI	AUC	95% CI	AUC	95% CI
Trainee Behavior	Verbal Acknowledgment	0.01	(0.00, 0.02)	0.69	(0.67, 0.71)	0.68	(0.67, 0.70)
	Behavioral Adjustment	-0.01	(-0.02, 0.00)	0.73	(0.72, 0.75)	0.74	(0.73, 0.76)
	Ask for Clarification	-0.02	(-0.05, 0.02)	0.57	(0.52, 0.62)	0.59	(0.53, 0.64)
Trainer Reaction	Approval	0.00	(-0.01, 0.01)	0.65	(0.63, 0.68)	0.65	(0.63, 0.68)
	Disapproval	0.00	(-0.03, 0.03)	0.55	(0.49, 0.61)	0.55	(0.48, 0.61)
	Taking Control (safety)	-0.01	(-0.05, 0.03)	0.83	(0.73, 0.94)	0.84	(0.74, 0.94)
	Taking Control (non-safety)	-0.01	(-0.04, 0.01)	0.79	(0.73, 0.85)	0.80	(0.75, 0.86)

Supplementary Table 3. Comparison of AI-Discovered Topics before and after Human Refinement for predicting behavioral outcomes following surgical feedback. The analysis was performed using 5-fold cross-validation. Statistically significant differences are underscored.

Supplementary Note E: Analysis of Different Supervised Methods

Supplementary Table 4 presents the results of using different supervised models for the prediction of *Trainee Behavioral Adjustment* and *Trainer Reaction*. The main conclusion from this additional analysis is that the different supervised methods have little impact on the results, with all the AUCs from different models being within the estimated 95% confidence intervals of one another.

Category	Behavior Outcome	Random Forest		AdaBoost		Elastic Net	
		AUC	95% CI	AUC	95% CI	AUC	95% CI
Trainee Behavior	Verbal Acknowledgment	0.68	(0.67, 0.70)	0.68	(0.67, 0.70)	0.68	(0.66, 0.70)
	Behavioral Adjustment	<u>0.73</u>	(0.72, 0.75)	0.73	(0.71, 0.75)	0.71	(0.69, 0.73)
	Ask for Clarification	0.51	(0.45, 0.57)	0.52	(0.46, 0.58)	<u>0.55</u>	(0.49, 0.61)
Trainer Reaction	Approval	0.66	(0.63, 0.68)	0.66	(0.64, 0.68)	0.66	(0.64, 0.69)
	Disapproval	<u>0.59</u>	(0.53, 0.66)	0.52	(0.46, 0.59)	0.58	(0.51, 0.65)
	Taking Control (safety)	0.85	(0.75, 0.96)	<u>0.88</u>	(0.80, 0.96)	0.87	(0.78, 0.97)
	Taking Control (non-safety)	0.78	(0.72, 0.84)	<u>0.79</u>	(0.74, 0.85)	0.76	(0.70, 0.82)

Supplementary Table 4. Results of 5-fold Cross Validation for Feedback Outcomes Prediction using AI topics after Human Refinement (but no Human categories) with Different Supervised Methods. Best performance is underscored.

Supplementary Note F: Discovered AI-topics with Representative Feedback Instances

#	Topic	Size	Feedback Instances
0	Affirmative Feedback and Inquiry	755	yeah that's reasonable okay, that's pretty good alright, nice job good I think you're good, I think you're doing well here
1	Pulling, Retraction and Positioning Techniques	908	grab yep grab higher pull this up, stop, don't cinch that since this one. look up, you need to grab this regrab, don't pull like that cinch it, cinch it down
2	Encouraging Continuation and Progress	652	alright keep going so advance your... yeah, advance... good yeah and just keep going uh-huh, keep going ok, right direction, mmhm
3	Guidance on Prostate and Urethra Positioning	482	you can even come 1 mm closer to the prostate so again, the key is to find the posterior plane, extend it to the urethra okay, don't take the urethra, just take the DVC look, if this shoulder is the prostate, put your scissors on it and snip i would come closer to the prostate
4	Visual Guidance and Recognition	708	so where do you want to go? so you want to be here, does that make sense? you are going to be in his way, so you're going to have to... go in right there do you see it pulsating behind the nerve?
5	Managing Instrument Positioning and the Fourth Arm	666	I would just grab that with the fourth arm make sure you travel here Pull through, grab that with your 4th arm. take control of your fourth arm that was decent travel, probably no more than that though
6	Tissue and Vein Handling Precautions	589	I'm glad you're cautious, but you're like... barely touching the tissue be careful don't avulse that vein that's probably the vein that you just cut mhm, better grab of the tissue, good and you just ripped the tissue off, that's not exactly what I want to see
7	Controlling and Addressing Bleeding	241	solve that bleeding problem, it's going to keep bleeding until you fix it... there are a few open vessels... yeah, just burn those stop whatever is bleeding here when you're done buzz that, buzz that there's something bleeding at about 10 or 11 o'clock position underneath it
8	Trainer's Queries and Clarifications	309	what did you do? inv stuff that we talked about, prob gonna be here what are you doing? so what does that tell you? what's that there? you think that's anything?

Supplementary Table 5. Discovered AI-topics with representative feedback instances under each topic (first 9 topics)

#	Topic	Size	Feedback Instances
9	Adjustment of Surgical Precision	408	come in a little bit more and retract down, does that make sense? take one more... yeah, one more bite of that just a little bit, just a little bit more uhh.. the thing that's a little bit closer.. this thing open out a little bit more
10	Trainer's Intervention and Visual Verification	251	let me see okay, can I show you? okay, so can I show you one thing here, okay let me help you okay hold on let me see
11	Sweeping Techniques in Surgical Procedures	219	it's good, yeah... sweep all that off, since you're here okay, don't rip it off, gentle okay, so I don't like that long sweeping motion sweep down, there sweep, sweep, sweep, that should be a very blunt dissection
12	Opening and Positioning Surgical Planes	331	open and spread so you can open up... you're going to have to open up the thing if you have flow...don't want it to open you want to open here maybe? forget about extending, just open that space up
13	Guidance on Cutting and Clipping Techniques	268	I usually cold cut so your cuts should be down, directly down why are we cutting all of this just cut it just take it, divide it about
14	Adjusting Surgical Positioning and Height Guidance	227	<i>you have a little ways to go</i> too low, too low... I think... there a little further back a little higher, higher, higher okay, so I usually don't look for it here. you usually look for it up higher
15	Maintaining and Identifying Correct Surgical Planes	106	stay in one plane, you're kind of... zig-zaggy keep your planes stable, can't move the plane again and again see the two difference in planes here okay there's your plane now right? like it should be one fat plane that comes together
16	Stitching Techniques and Knot-Tying	177	okay fine, yeah, it's your last stitch so one, 2, 4, 5 stitch we are using stop there. can we get a new stitch? I don't want the suture lines tied right over each other, okay? what are we doing, why are we using acute stitches? one more stitch here and then we will go to the other side
17	Handling and Positioning of the Vas and SV	94	the medial side, yeah yeah, you could probably get rid of the vas now if you do it correctly, there should be a nice little septum here between right and left SV as long as you don't separate the VAS from the SV... they retract both thats the cava?
18	Fat Dissection and Exposure	112	you can but you're just going to have to take all this fat off dont cut into yellow fat leave that endopelvic fat at the floor, this way if you are in a lot of fat, you should probably go here cinch that down cinch the yellow down
19	Layer Depth Assessment and Correction	45	work layer by layer starting from here and progressing this way no, open the superficial layer first I think you're a layer too deep but... exactly, but it's all stuck, so you need to be careful, layer by layer yeah I think we are okay, second layer

Supplementary Table 6. Discovered AI-topics with representative feedback instances under each topic (last 11 topics) ^{4/4}