Use of Artificial Intelligence Technology for Otolaryngology Core Medical Knowledge Learning in the Covid-19 Pandemic

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BACKGROUND

A major obstacle to overcome during the pandemic is teaching clinical core medical knowledge (CCMK) pertaining to otolaryngology (CCMK-OTO).

Modern data-driven AI techniques (e.g., deep learning in artificial neural networks) can analyze large amounts of data to build knowledge models. Therefore, the present study proposes the multi-expert knowledge–aggregated adaptive assessment scheme (MEKAS), which is based on an AI- and knowledge-based method.

The MEKAS is designed to efficiently acquire and aggregate the CCMK-OTO provided by multiple senior physicians (experts), and it provide trainees with personalized test items on the basis of their competency levels by implementing the MEKAS on the basis of aggregated CCMK-OTO.

MATERIAL AND METHODS

- *CCMK-OTO*

CCMK-OTO was defined to include: ENT basic science, interpretation of ENT tests, management of ENT emergency and community diseases, identification of referable ENT conditions.

CCMK-OTO education was delivered virtually over a 4-week period. The effects of longitudinal training on the experimental (EG) and control (CG) groups were compared. The EG comprised 8 otolaryngology (ENT) residents and 15 non-ENT trainees (5 postgraduate [PGY] and 10 undergraduate [UGY] trainees); the control group comprised non-ENT trainees (5 PGY and 10 UGY trainees). A 5-point technology acceptance model was used to assess user experiences.

- *AI- and Knowledge-based Approach*

Multi-expert Knowledge Aggregation Scheme

The present study applied an AI- and knowledge-based approach, which included the repertory grid technique (RGT) and case-based reasoning (CBR), to systematically construct a representative CCMK base for clinical training.

Adaptive Assessment Scheme

On the basis of the representative CCMK base, an adaptive assessment scheme (AAS) was developed to automatically generate adaptive test items in accordance with the participants' current capabilities. The AAS defined selection strategies (test item generation rules, TIGRs) to generate adaptive test items with various difficulty levels.

Test item generation process for AAS

On the basis of the TIGRs of the AAS, various editable test item templates were defined to automatically generate adaptive test items with various difficulty levels.

- *User Experience Questionnaires for Assessing System Usability*

To obtain the participants' feedback on their experiences with using the MEKAS system, the EG participants were asked to complete a technology acceptance model (TAM) questionnaire with items rated on a 5-point Likert-type scale (1 = *strongly disagree*; 5 = *strongly agree*).

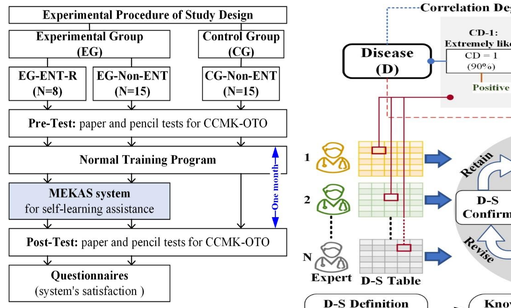

Figure 1. Study Design

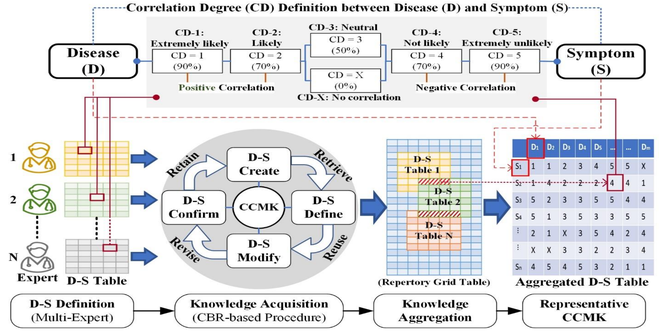

Figure 2. Multi-Expert Knowledge Aggregation Scheme (MEKAS)

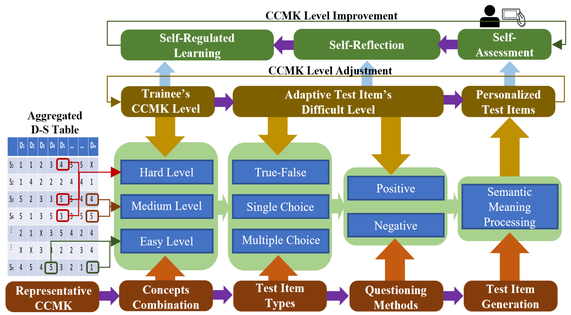

Figure 3. Adaptive Assessment Scheme (AAS) in MEKAS

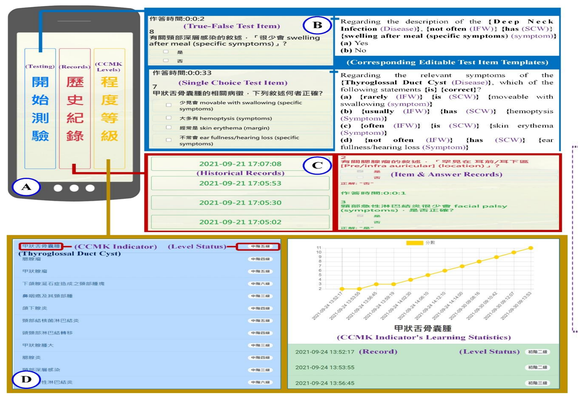

Figure. 4. Processes for generating test items using the TIGR of AAS in the MEKAS

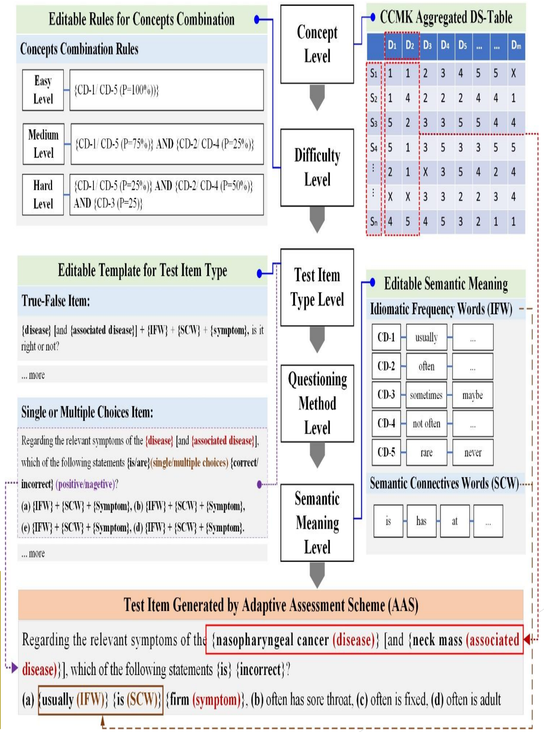

Figure 5. Screenshots of adaptive test items, test records, and CCMK level status in the MEKAS

RESULTS

- *Participants*

In total, 38 participants, comprising 20 UGY, 10 PGY, and 8 ENT-R participants, were recruited. The presented study assigned 23 trainees to the EG and 15 to the CG. The EG comprised the EG-ENT-R (8 otolaryngology residents) and EG-non-ENT (5 PGY and 10 UGY trainees) groups, and the CG comprised CG-non-ENT trainees (5 PGY and 10 UGY trainees).

- *Training Effectiveness*

After the MEKAS scheme was applied, the EG-ENT-R and EG-non-ENT groups both achieved significant improvements in their CCMK-OTO ($p < .05$), whereas the CG-non-ENT group did not ($p = 0.732$). Among the 3 groups, the EG-non-ENT group improved the most ($p < .001$ Table 1).

- *User Experiences*

The internal consistency (Cronbach's alpha = 0.990) of the TAM was high. Overall, the participants reported high satisfaction with the MEKAS. The satisfaction scores were more than 3.5 (out of 5) for most satisfaction dimensions, except for the "intention to use" dimension in relation to the EG-ENT-R group (Table 2).

Table 1. MEKAS CCMK-OTO Learning Outcomes.[a]

Group	Experimental Group (EG) (N = 23)	Control Group (CG) (N = 15)	EG vs. CG *p* value
ENT-R (n=8)			
Pre-test	73.7 (13.0)		
Post-test	86.3 (7.4)		
Change	12.5 (13.4)		
p value	.033*[b]		
Non-ENT (n=15)			
Pre-test	65.7 (13.9)	58.7 (17.4)	.233[c]
Post-test	85.3 (11.4)	60.7 (12.1)	.000***[c,d]
Change	19.7 (13.2)	86.3 (7.4)	.013*[c]
p value	.000***[b]	.732[b]	

[a] Values are presented as means (standard deviations).
[b] Paired samples t test. [c] Independent samples t test. [d] Analysis of covariance.
* $p < .05$, ** $p < .01$, *** $p < .001$.
Abbreviations: CCMK-OTO, otolaryngology clinical core medical knowledge; MEKAS, multi-expert knowledge–aggregated adaptive assessment scheme.

Table 2. TAM Survey of User Experiences.

Scales	Total (N = 23) Mean (SD)	EG-ENT-R (N = 8) Mean (SD)	EG-non-ENT (N = 15) Mean (SD)	EG-ENT-R vs. EG-non-ENT *p* value
SLA	3.8 (0.7)	3.8 (0.7)	3.9 (0.7)	.719
AT	3.8 (0.9)	3.7 (1.1)	3.9 (0.7)	.529
SATI	3.7 (0.7)	3.6 (0.7)	3.8 (0.7)	.529
ENJ	3.6 (0.8)	3.6 (0.9)	3.7 (0.7)	.770
ItU	3.5 (0.8)	3.3 (0.9)	3.7 (0.8)	.298
PU	3.6 (0.8)	3.5 (0.8)	3.8 (0.8)	.309
PEoU	3.9 (0.6)	4.1 (0.5)	3.9 (0.6)	.364

Abbreviations: TAM, technology acceptance model; SLA, self-learning assistance; AT, adaptive testing; SATI, perceived satisfaction; ENJ, perceived enjoyment; ItU, intention to use; PU, perceived usefulness; PEoU, perceived ease of use.

CONCLUSIONS AND SIGNIFICANCE

Through the application of a knowledge-based approach, the MEKAS was demonstrated to be a useful tool for facilitating CCMK-OTO learning in the context of otolaryngology. The MEKAS enables the application of low-contact, efficient knowledge aggregation and level-based self-assessment methods for conducting adaptive CCMK-OTO learning. Our study verified that AI technology can play a crucial role in supporting post-pandemic otolaryngology education.

ACKNOWLEDGEMENT

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