The Effect of Uncertainty Training on the Improvement of Diagnostic Ability in Chinese Medical Students

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Abstract

Background: To evaluate the effect of the uncertainty training on improvement of students' diagnostic ability.

Methods: Data were collected on 70 fifth year medical students enrolled in the Case Discussion courses on Obstetrics and Gynecology in the spring of 2020. Of these students, 36 were in the uncertainty training group and 34 in the control group. The effect of training was evaluated by cognitively diagnostic assessment which mapped exam questions to 4 attributes assessing clinical reasoning and basic science knowledge.

Results: Uncertainty training was able to improve students' ability to use basic science concepts for inference and problem solving, and the ability to integrate complex clinical information to arrive at a diagnosis. But it could not improve students' ability on the basic recall of foundational concepts and the ability to use basic science concepts in clinical reasoning. Medical students could do well in integrating complex clinical information although they didn't recall basic science knowledge well.

Conclusions: Uncertainty training could be used as an effective teaching method in Case Discussion course on Obstetrics and Gynecology. However, students still need to improve their basic knowledge besides the training.

Background

Medicine is a science of uncertainty and an art of probability[1]. Diagnosis is process of arriving at the true disease by coping with uncertainty. Data used for diagnosis may be conflicting, ambiguous, or scarce. Understanding the uncertain and unaware quadrant of "unknown unknowns" can have drastic implications for diagnosis[2]. Recognizing uncertainty could initiate information gathering or as an impetus to select a specific decision approach[3]. While failure to recognize uncertainty could lead to failure to identify the correct problem and asking the wrong question[4]. Managing uncertainty requires balancing clinicians' expertise and the available evidence. Medical students didn't have much expertise, so it would be more difficult for them to cope with uncertainty. The difficulty could lead to thinking disorders and psychological distress, and finally misdiagnosis. Thus, it is necessary to teach managing uncertainty and tolerance for ambiguity in medical education.

Facing the uncertainty of clinical thinking, doctors' responsibility is to use scientific methods to reduce the impact of uncertainty on clinical practice and avoid damage to patients, and strive for better clinical effect[5]. Helou et al.[6] reviewed articles related to uncertainty, and developed a framework to guide medical decisions in various uncertain situations. Their framework depicted the interplay between 6 main themes: recognition of uncertainty, classification of uncertainty, stakeholder perspectives, knowledge acquisition, decision-making approach, and evaluation of the decision-making process. This process originated in a clinician's ability to recognize uncertainty. It asked the decision maker to continually increase her or his understanding of the uncertainty before ultimately arriving at that decision through a

purposefully chosen approach or by effectively reducing the uncertainty in the situation. However, the framework hasn't been validated in teaching diagnosis yet, especially in Chinese students. In China, managing uncertainty is often taught indirectly through observation or informal clinical experiences. While these informal experiences may be beneficial, the medical education community now recognizes the need to formally address uncertainty as part of training[7]. Therefore, we chose the framework developed by Helou et al. as a formal way of training in Chinese medical students to see whether it could improve their ability of diagnosis under uncertain conditions.

To glean relevant diagnostic information about teaching effectiveness, we chose cognitively diagnostic assessment reported by Bangeranye et. al[8]. This assessment measured instructional quality that didn't rely on students' ratings of the ability of the instructor, the content of a course, or other measures. The exam questions were mapped to 4 attributes and analyzed the students' overall mastery of the content tested and the percentage of students mastering each attribute. It could determine the degree to which the teaching goals have been achieved by the students. We implemented this cognitively diagnostic assessment in an undergraduate Obstetrics and Gynecology course to evaluate students' learning progress of the concrete application of uncertainty knowledge within the context of clinical practice.

Methods

Participants

The participants were 70 fifth year medical students enrolled in the Case Discussion courses on Obstetrics and Gynecology in the spring of 2020 at The Second Xiangya Hospital of Central South University. Of these students, 36 were in the uncertainty training group and 34 in the control group. The institutional review board of Central South University exempted this study from review.

Online schooling procedure

Because of the national spread of Corona Virus Disease 2019 (COVID-19),online schooling was applied to provide education during isolation. Lessons were taught online by Tecent Class or Tecent Meeting (Special teaching or conference software supplied by TecentCorp, Shenzhen, China). We chose the Case Discussion course for study. Case Discussion is a course taught during the fifth year of medical school. It presented cases from clinical practice to train students to diagnose. The course were taught in small groups using a hybrid case-based/problem-based curriculum. Students were randomly assigned to uncertainty training group or control group. The uncertainty training group were trained to diagnose by the procedure of "uncertainty training" below. The control group were taught by the classic way: teachers analyzed the clues from the case and guided students to arrive at diagnosis.

Uncertainty training

Managing uncertainty was trained by using the framework presented by Helou et al.(Fig. 1)[6]. Students would first be trained to recognize uncertainty in situation. Next, students would attempt to understand

what outcome the uncertainty would lead to. Once the uncertainty was identified and classified, students needed to seek more knowledge to reduce uncertainty and further clarify the diagnosis.

Cognitively diagnostic assessments

The effect of training was evaluated by cognitively diagnostic assessments[8]. Both the uncertainty training group and control group received the same tests after course. The tests consisted of 6 new clinical cases. Each case included 4 questions assessing clinical reasoning or basic science knowledge. Each question was graded as “correct” or “incorrect.” The content of the questions was mapped into 4 attributes:

- attribute α1 concerned the basic recall of foundational concepts;
- attribute α2 concerned the ability to use basic science concepts for inference and problem solving;
- attribute α3 concerned the ability to use basic science concepts in clinical reasoning;
- attribute α4 concerned the ability to integrate complex clinical information to arrive at a diagnosis.

Each of the attribute was recorded as “1” if students answered it correctly, or “0” if answered wrong. The 4 binary attributes could be used to construct 16 different attribute profiles ($2^4 = 16$). For example, an attribute profile consisting entirely of zeros, (0000), showed failure to master all 4 attributes. An attribute profile of all ones, (1111), indicated mastery of all 4 attributes. The profile (0101) showed that attributes α2 and α4 were mastered by the student but not attributes α1 and α3.

Data collection

Before lessons began, students were invited to investigation of study basis. After lessons finished, students were invited to investigation of study effect. The investigation was put on a special software for investigation named “Investigation Star”. Quantitative data included items on a Likert-type scale from 1 to 5 (1 = not at all satisfied, 5 = extremely satisfied).

Data analysis

Statistical analyses were performed with STATA10.0 (StataCorp, College Station, TX, USA). Descriptive statistics included means and standard deviation for continuous variables and frequency distributions for categorical variables. Comparisons between categorical variables were tested by chi-square test. Comparisons between normally distributed continuous variables were performed using Student t test or analysis of variance. P value < 0.05 was considered statistical significant.

Results

Table 1 presented the means and standard deviations of students’ study basis. Scores for interest on Obstetrics and Gynecology, preparation for lessons, study motivation, interest on questioning, reaction, self-study ability, comprehension ability, analysis ability and applied ability were not significant different between the two groups.

Table 1
Students' study basis as assessed by a 5-point Likert-type scale (1 = not at all, 5 = extremely)

	Uncertainty training		Control	
N	36		34	
	Mean	SD	Mean	SD
Interest on Obstetrics and Gynecology	4.02	0.61	3.85	0.7
Study motivation	3.42	0.69	3.35	0.65
Preparation for lessons	2.75	0.84	2.53	0.19
Interest on questioning	2.39	0.9	2.56	1.08
Reaction	3.17	0.7	3.09	0.83
Self-study ability	3.47	0.65	3.18	0.8
Comprehension ability	3.58	0.6	3.35	0.81
Analysis ability	3.44	0.73	3.26	0.75
Applied ability	3.14	0.59	3.26	0.71
Note: SD: standard deviation				

Figure 2 summarized the percentage of mastery for each individual attribute. In this study, the students that have mastered attribute α2 or α4 were significantly higher in uncertainty training group comparing to control. The students that have mastered attribute α1 or α3 were not significantly different between the two groups. At a glance, fewer students seemed to have mastered α1 or α2 both in the uncertainty training and control group.

The observed frequencies of the 16 different attribute profiles were reported in Fig. 3. Attribute profiles of 1101, 0111, 0101,0001 were significantly higher in uncertainty group comparing to control. Attribute profiles of 0000, 0010 were significantly lower in uncertainty training group comparing to control. Attribute profiles of 1111 were not significantly different between the two groups.

Table 2 showed the means and standard deviations of the students' study effect. The students in uncertainty training group scored higher on satisfaction with teaching, saving time on preparation or review, study efficiency, easy to understand the online lessons. There was no difference between the two groups on the scores of mastery on lesson, following others' questioning and involvement on discussion.

Table 2
Students' study effect as assessed by a 5-point Likert-type scale (1 = not at all, 5 = extremely)

	Uncertainty training		Control		p
N	36		34		
	Mean	SD	Mean	SD	
Mastery on lesson	3.63	0.61	3.61	0.5	
Satisfaction on teaching	4.15	0.63	3.63	0.9	< 0.05
Saving time on preparation or review	3.13	1.02	2.76	0.5	< 0.05
Following others to ask questions	3.67	0.79	3.42	0.83	
Study efficiency	4.04	0.63	3.48	0.71	< 0.05
Lessons are easy to understand	4.36	0.61	3.84	0.71	< 0.05
Involvement on discussion	3.67	0.67	3.63	0.65	
Note: SD: standard deviation					

Discussion

In this study, we found uncertainty training was able to improve students' diagnostic ability. The improvement was mainly on using basic science concepts for problem solving and integrate complex clinical information to arrive at a diagnosis.

Diagnosis is a complex processing of knowledge and experience using both critical thinking skills and intuition while recognizing uncertainty. Sources of uncertainty include the complexity of clinical information; the probability of particular outcomes; and individual clinician characteristics, such as tolerance for ambiguity[9] or an individual's ability to cope with complexity, risk, and uncertainty[10]. Uncertainty is more of an issue today because of the development of new technologies and the consequent physicians' insecure attitude towards adopting these new technologies, as well as patients' involvement in clinical practice[11]. There have been some articles about decision making under ambiguous or uncertain conditions. Politi et al.[12] presented research on shared mind and cognitive and communicative skills to facilitate management of uncertainty, and demonstrated patient-centered, collaborative communication could enhance decision-making process. Mumford et al.[13]developed an ethics training course based on a proposed sensemaking model. They showed this training led to sizable gains in ethical decision making and these gains were maintained over time. Cristancho et al.[14] explored a "Reconciliation Cycle" as core element of an intraoperative decision-making model. The result suggested that transforming information requires a higher degree of awareness, not yet accounted by current conceptualizations of situation awareness. Helou et al.[6] combined components in previous

articles into an all-encompassing process map for managing uncertainty in decision making. We applied Helou's framework in our study, and found it mainly worked on students' ability to apply the knowledge they had learned, but not how much the students remembered of the basic knowledge, or their reasoning ability. It accorded with the nature of the framework as guidance of reasoning. It taught students a method to deduce, but would not change their knowledge base. Rather than expecting medical students to memorize a long list of concepts and "facts," educators should spend more time emphasizing the importance of critical inquiry and discussing strategies for weighing the risks, benefits, and alternatives to various diagnostic[15]. As attribute α4-the ability to arrive at a correct diagnosis is the target of the course of Case Discussion, uncertainty training turned out to be effective and could be used as a teaching method of the course.

Cognitively diagnostic assessment was aimed to provide specific diagnostic information on students' knowledge and processing skills. It evaluated the extent to which the initially set teaching goals for a course were actually achieved. It can also be used to provide students with direct feedback on their learning progress—specifically which skills they have mastered and which require more work on their part[8]. Teaching medical trainees to examine their cognitive biases can contribute to reducing diagnostic errors [16] .According to the 4 attributes in our study, students could do well in integrating complex clinical information although they didn't recall basic science knowledge well. The results is similar to that from Bangeranye et. al[8]. It might be explained that students on clinical medicine tended to diagnose by clinical symptoms and signs. Although uncertainty training could not change much on students' knowledge basis, it increased the diagnostic accuracy from 67.9–85.7%. The distribution of student profiles across attribute mastery levels also showed students did better in integrating complex clinical information than recalling basic science knowledge. Uncertainty training increased the accuracy of attribute α2, making 0111 the most frequent in the uncertainty training group. The training also reduced the percentage of 0000, increasing the percentage of students that at least diagnosed right (0001). In addition, investigation of study effect showed uncertainty training increased students' efficiency and understanding. Seen from all above, uncertainty training could improve students' diagnostic ability, but not basic knowledge.

Limitation

A limitation of this study was that participants were recruited from a single institution on Obstetrics and Gynecology course. It limits the generalizability of the findings. The result might differ from other schools or courses. An additional limitation is the self-reporting survey methods to collect data from students on study basis and effect. Another comparison limitation is that the effectiveness of training was examined only in the fifth year medical students. It is not sure whether the training would be effective for people who have greater professional expertise, such as residents.

Conclusion

In this study, we validated Helou's framework in teaching diagnosis in Chinese students, and evaluated teaching effectiveness by cognitively diagnostic assessment. The result showed uncertainty training could be used as an effective teaching method in Case Discussion course on Obstetrics and Gynecology. However, students still need to improve their basic knowledge besides the training. Further studies are needed to validate our result in other courses and schools and people with greater professional expertise.

Abbreviations

COVID-19: Corona Virus Disease 2019

SD: standard deviation

Declarations

Ethics approval and consent to participate

Approval for the present study was obtained from the ethics commission of the Second Xiangya Hospital of Central South University. All methods were performed in accordance with the relevant guidelines and regulations. The purpose of the study was fully explained to all participants, all data were collected and kept completely anonymously and written consent had been obtained from all participants by a research team member prior to completing the questionnaire. Participants were informed that their participation was entirely voluntary and their decision to participate or not had no influence on their academic performance.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Competing interests

The authors declare that they have no competing interests

Authors' contributions

Y(Yan)Z contributed to design of the study, data collection, data analysis, data interpretation and writing of the manuscript. XX contributed to data interpretation and writing of the manuscript. PX contributed to design of the study and data collection of the manuscript. XW and XF contributed to data collection and data interpretation. Y(Yi)Z and JC contributed to design of the study and revision of the manuscript. The authors have seen and approved the final version of the manuscript.

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Figures

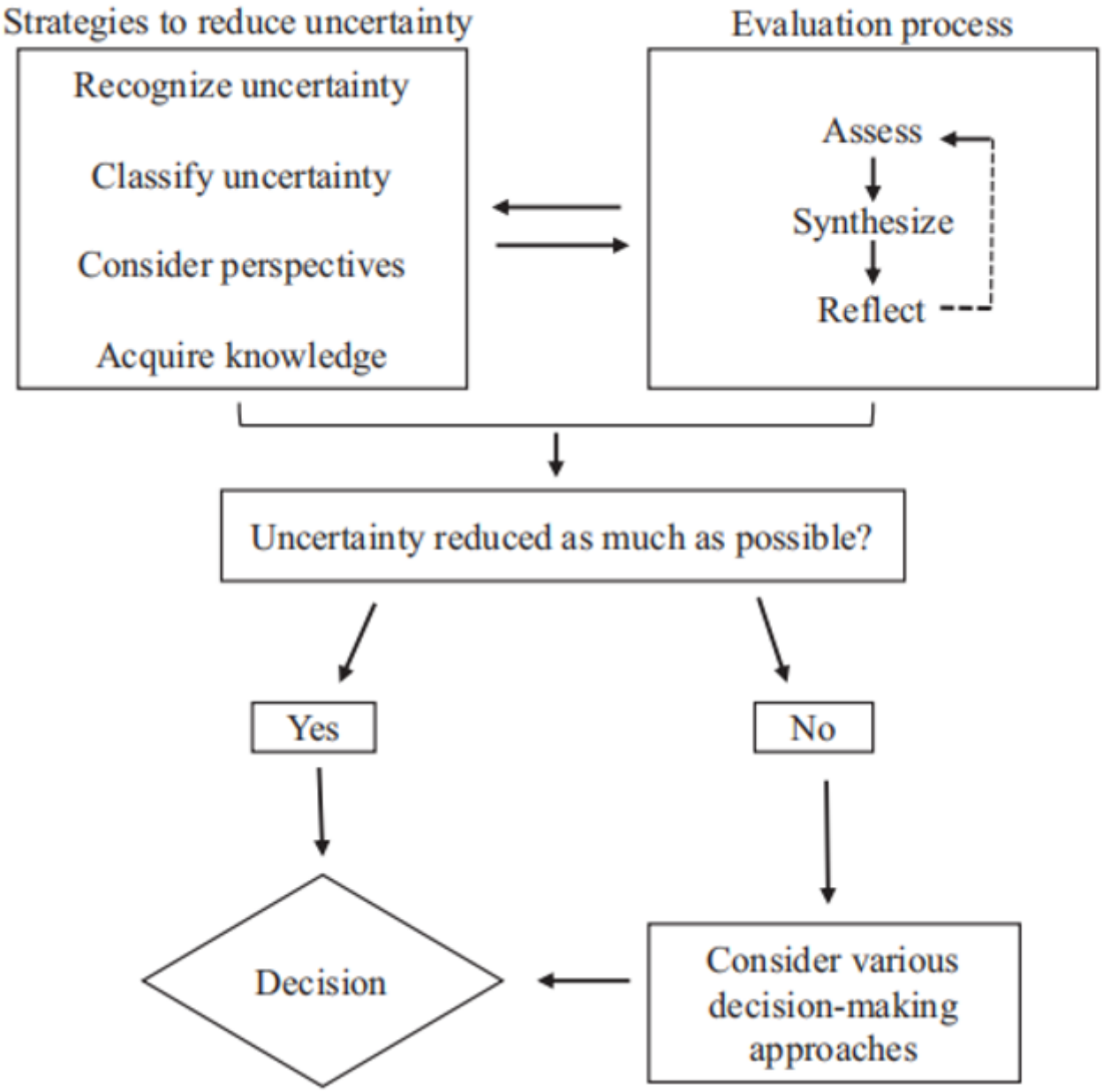

Figure 1

Framework for making decisions under uncertain conditions. Four themes are listed as strategies to reduce uncertainty. The decision maker uses these strategies along with an ongoing evaluation process of assessing, synthesizing, and reflecting on information obtained[6].

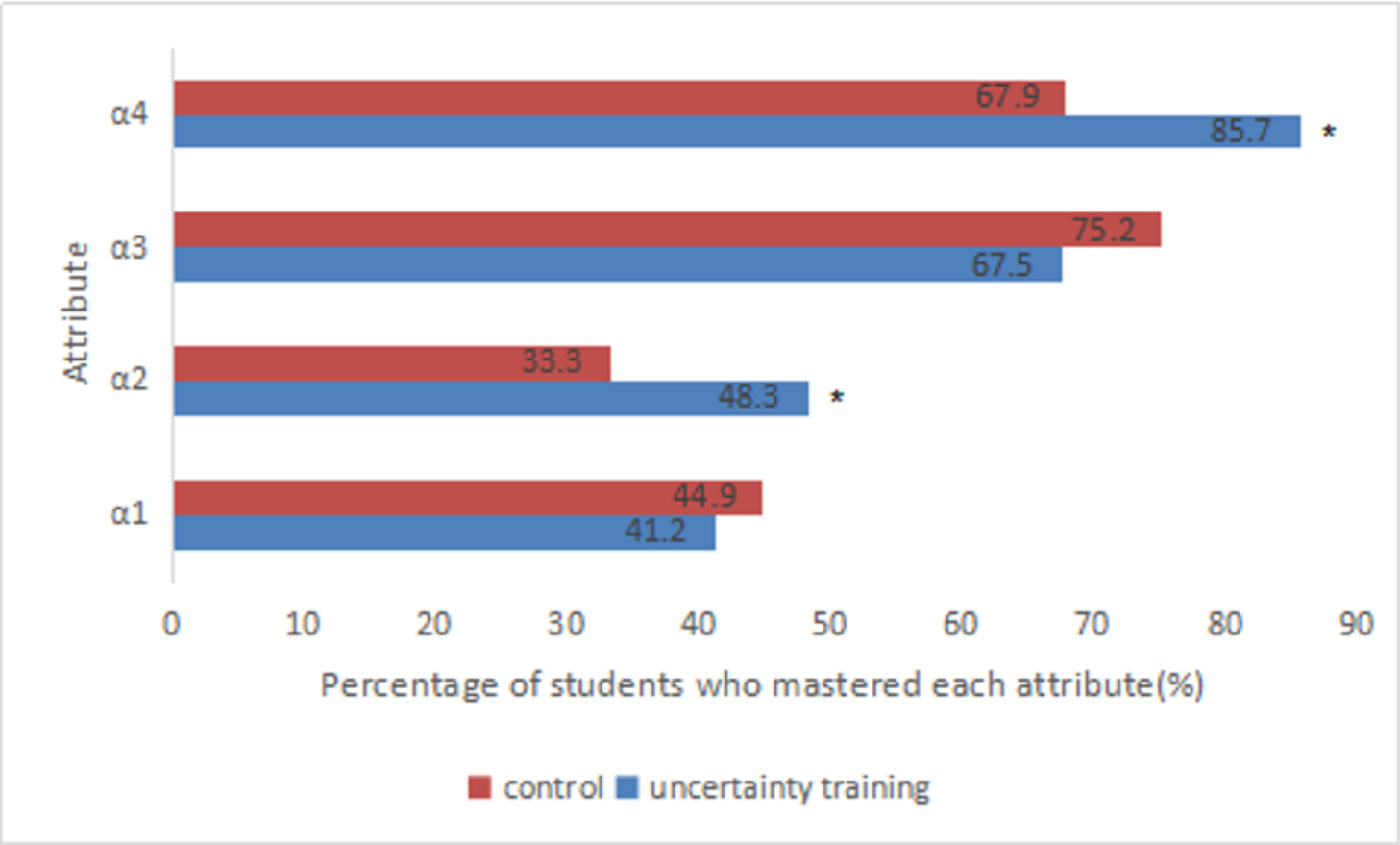

Figure 2

Group attribute mastery profiles. * $p<0.05$ when comparing the percentage between uncertainty training and control group.

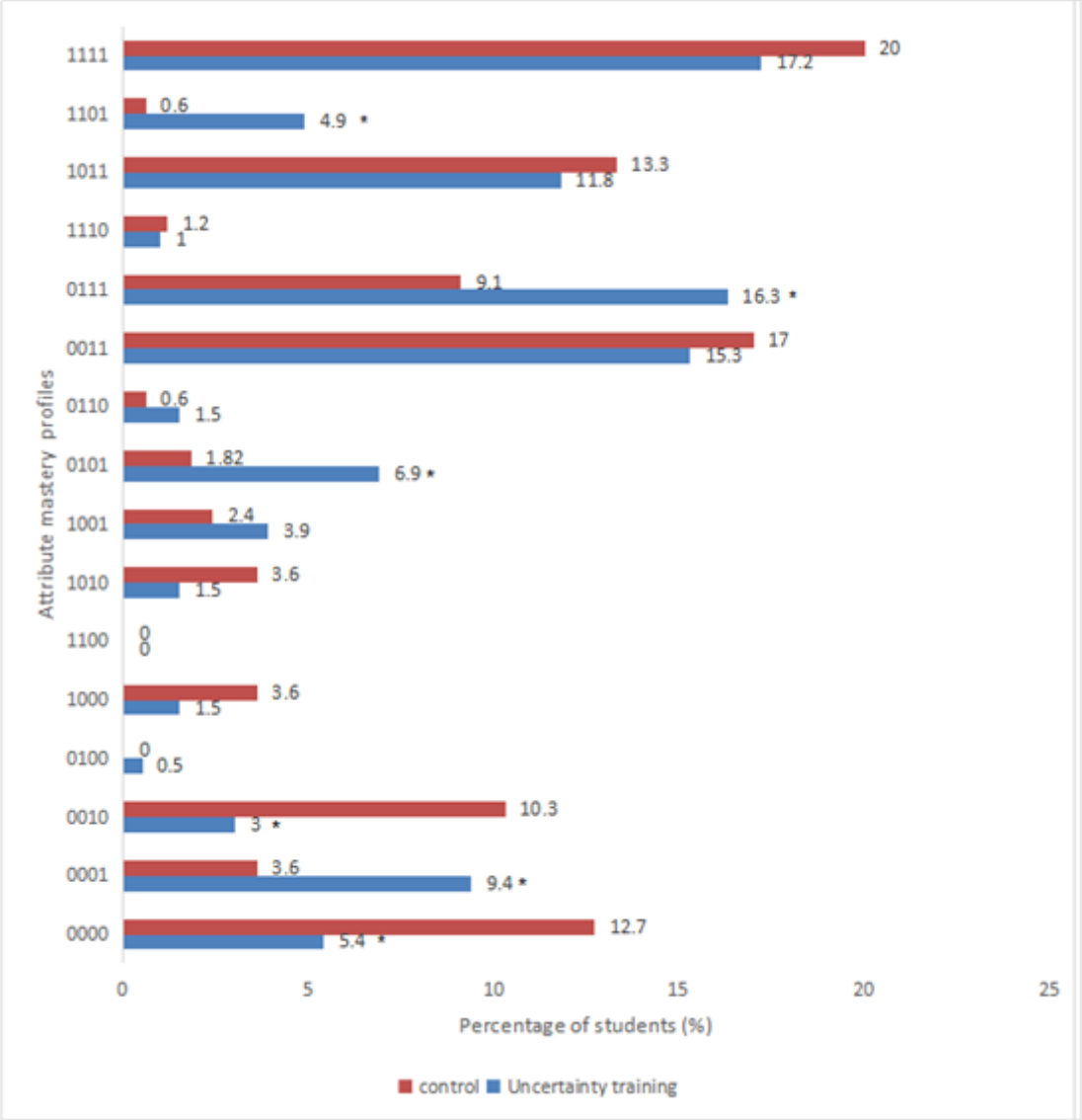

Figure 3

Distribution of student profiles across attribute mastery levels. * p<0.05 when comparing the percentage between uncertainty training and control group.