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Acquisition of Medical Immunology Knowledge: A Preliminary Study of the Knowledge Structures of Medical Students

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Introduction

Medical students from both Duke-NUS and NUS participated in a study that attempted to assess their knowledge structure in the medical immunology domain. Students had to perform a sorting task with a list of concepts derived from immunology experts. We collected demographic information as well as sorting data and the diversity of the sorts are presented in this article.

Structuring Knowledge

The multi-store model developed in the 1970s suggests that information gained by a learner flows in through a defined set of states (Atkinson & Shiffrin, 1968). First, sensory stores capture visual and auditory information. A small amount of that information is then transferred to the short-term memory compartment. Here, a great deal of work has been performed to suggest we can retain anywhere between five to seven discrete chunks of information at any given time (Simon, 1979). The information that is transferred from the sensory stores to short-term memory stores is often dependent on repetition. However, a fraction of that information can then be transferred to long-term memory stores and is dependent on encoding, visualising and experiencing that occur during the learning process. Finally, working memory is the result of accessing information from the short-term and long-term memory stores and is thought to rely heavily on visual-spatial patterning, etc. This is controlled by the central executive that integrates written and spoken material as well as visual and spatial information, and is at the core of problem solving. This multi-store model as originally defined by Atkinson and Shiffrin has now been replaced by an alternative model which has the same components but organises them in different ways and suggests that each component has limited capacity for storage and is independent of one another (Baddeley & Hitch, 1974).

Using Concept Mapping to Assess Higher-order Learning

Yet, amid this understanding of how learners capture and process information, the difficulty then when it comes to effective teaching in cognitive education is devising methods to assess working memory and higher mental processing that we hope most of our students will achieve. Courses like immunology are particularly difficult to teach and assess for a few reasons: the terminology is complex, there are many core concepts that are important, and the mechanisms and interactions of the concepts are highly complex. Thus, we usually rely on assessment that emphasises what a student has memorised

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and is able to derive primarily from their short-term memory or long-term memory. However, such assessment methods are rarely associative and may not test 'real' working memory. In order for us to start asking how well our students are achieving higher mental processes and lifelong learning in any one field, we first need to know how knowledge is structured and the tools that are needed to investigate these structures. Field-specific concept lists and their interrelatedness provide an informative platform for this kind of measurement. A concept or 'unit of thought' can be thought of as an element of thought that helps the learner organise and categorise his or her experience. A course is likely to have many conceptual terms but should be relatively restricted to core concepts that occupy a centre of density of meaning (Deese, 1965). Concept maps and concept mapping assessment (CMA) are not widely used in medical school classrooms formally as their validity and reliability are often called into question. However, a recent study has suggested that CMA may be useful in medical domain-specific areas and in evaluating a conceptual knowledge framework before and after instruction (West *et al.*, 2000). However, a limitation of this and other studies using concept mapping is that students need proper training in the use of concept mapping and faculty also need to be trained on how to score these concept maps.

However, defining a set of core concepts for each course that students take during medical school would likely still yield useful information. Linking or organising these concepts into relationship trees would provide educators with useful information in designing the teaching strategy, such as recognising important areas in the syllabus to place more emphasis, and even to assess how difficult a course is likely to be (e.g. courses with fewer core concepts may require less time to teach than those with more). Finally, an additional utility of having a set of defined core concepts in a particular course is that it allows the educator to assess the students' own knowledge structures without asking additional multiple choice and short answer questions. This can be done by asking students to come up with their own list of core concepts and compare those to a list derived from experts or asking them to sort core concepts based on similarity profiles.

In this brief report, we present a defined approach for measuring the knowledge structures of students via the use of immunology core concepts. We asked medical immunology students who had completed their immunology instruction at Duke-NUS and the Yong Loo Lin School of Medicine at NUS to look at a predetermined list of 25 terms that correspond to important core immunology concepts and to sort them into user-defined clusters. A brief explanation of how these concepts were derived will be presented in the "Results" section below. These terms represent concepts that faculty feel all medical students should thoroughly understand after taking any comprehensive medical immunology course and are not designed to map directly to the curriculum.

Upon completing the learning activity, the sorting tasks were collated and analysed. The complexity of the sorts was surprising and informative. The nature of the data and its usefulness as a tool to study knowledge structures of medical immunology and guide curriculum will be discussed. However, this study was not without its limitations. For one thing, due to the preliminary nature of this study, only a small amount of data will be provided in this brief report. We did not ask students to comment on their experience and have collected no qualitative data. However, based on the results collected, we do feel strongly that students who participated in this study actually benefited from the activity that required them to think about and organise these 25 immunologic terms. In addition to the sorting of concepts into user-defined categories, we collected a limited set of demographic information such as gender, prior exposure to immunology and how students rated their understanding of the subject after the course. The complete methods are not described here and the following results focus exclusively on the sorting task.

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Table 1. Core concepts in medical immunology.

1. Anergy	6. Memory	11. Adaptive	16. Immunization	21. Humoral/Cellular
2. Processing/ Presentation	7. Synapse	12. Innate	17. Regulation	22. Differentiation
3. Antibody	8. Immunosuppression	13. Development	18. Response	23. Activation
4. Immunodeficiency	9. Inflammation	14. Diversity	19. Signaling	24. Transplant
5. Class Switching	10. Tolerance	15. Hypersensitivities	20. Complement	25. Immunotherapy

Methodology

In order to create a core concept list to assist in the assessing of the knowledge structures of medical students, we first asked faculty within the immunology discipline to come up with a list of core concepts that they expected medical students who were taking a medical immunology course to know. We derived a final list of concepts by removing those that did not conform to the criteria laid out in the instructions given to faculty (e.g. concepts that included nouns such as "T-cells" or those that were generic and not specific for the field of immunology).

This finalised list is shown in Table 1. Medical students are expected to recognise all of these terms after they have completed a course in medical immunology.

In order to gain a better understanding of how students acquire a deeper knowledge of medical immunology, we asked them to sort the various immunology-based concept lists into 'user-defined' categories or groupings. The students were asked to avoid putting all 25 terms into one group and to make sure that each group they defined had at least two of the 25 terms. When it came to evaluating the user-defined groups students produced, we first looked at the diversity of these groups in their totality and found an overall range of two to eleven terms for all 58 students participating in this study. There were a total of 23 unique groups defined by the students; this means that although they sorted the 25 terms into 2 to 11 groups, the user-defined nature of the sorting gave us 23 unique groups.

Results

As students who managed to sort the terms into more defined groups suggested evidence of displaying higher-order thinking and those who sorted the terms into less groups could assumed to be displaying lower-order thinking, we first broke up the data into "low", "medium" and "high" groups of students by the number of groups that were identified. The "low" group was designated as students who sorted the terms into 0 to 3 terms per user-defined group, "middle" group as 4 to 7, and the "high" group had between 8 to 11 (Figure 1). It is important to note that this type of study has not been performed before so there is no data to validate this conclusion at the moment, but we reasoned that the more categories that are used by students to sort the 25 terms, the greater the amount of cognitive effort used to manage these terms. We certainly do expect that organisation of these 25 terms into too many distinct categories (e.g. greater than 12) may be counter-productive and would suggest weak knowledge structures. The cut-offs point are therefore arbitrary and will need to be validated in other studies before they become reliable.

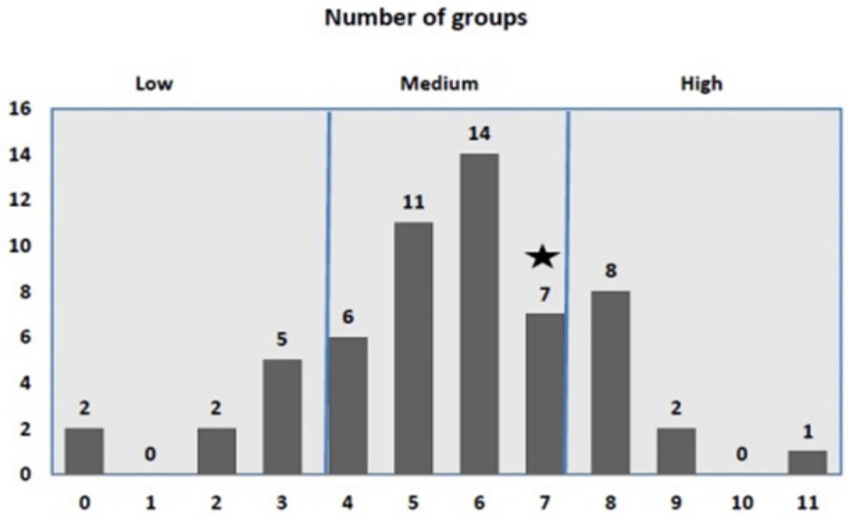

Figure 1. Students are clustered according to the number of defined groups that they have sorted the 25 terms into.

The star over the seven represents the number of categories or groups the faculty used when sorting these 25 terms. To further analyse the diversity of the responses by students following the sorting task, we ranked the descriptors students used to name their groups in order of frequency, as shown in Figure 2.

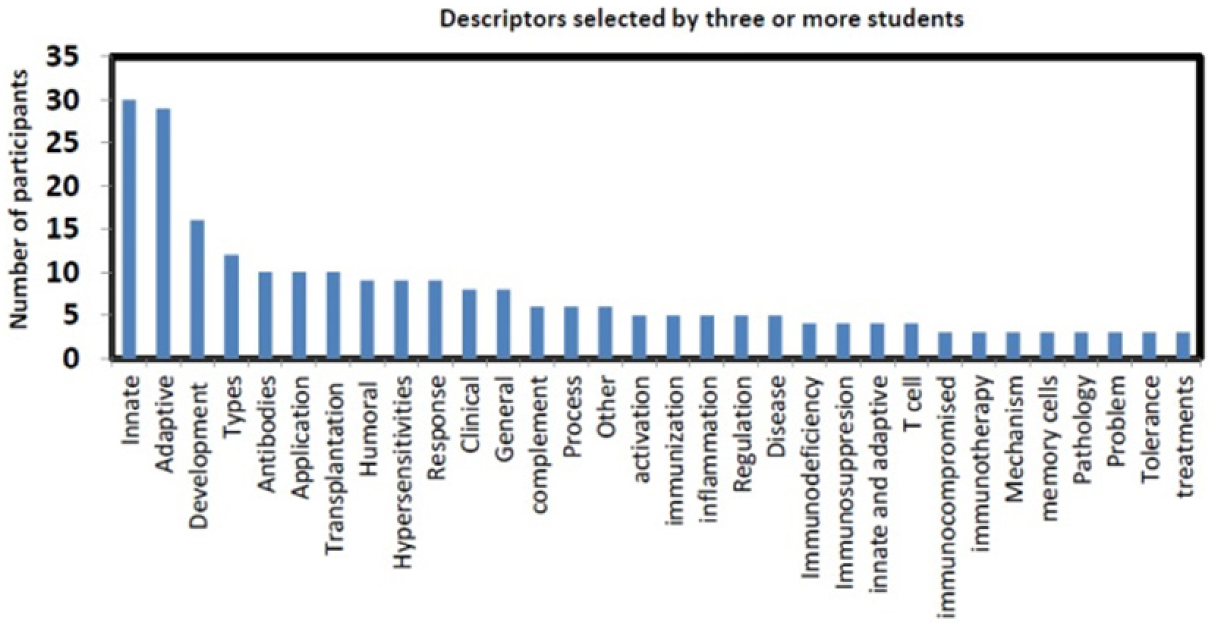

Figure 2. Frequency of descriptors selected by the students.

As is shown in Figure 2, the most commonly defined group was "innate" immunity. The chart in Figure 2 shows the descriptors for the sorts that were indicated by three or more student participants. The group defined as 'other' or 'unknown' by students was common as well but was the most uninformative as it cannot be well defined. Some of the most common terms included "innate" and "adaptive" immunity which corresponded to what was emphasised frequently during the instructional portion of the immunology course. Overall the user-defined terms and their frequency are only partially informative. The more interesting information is how the students sorted the various 25 terms into their respective groups as it addresses the more complex nature of integration of their knowledge. This data is still being analysed and will be published in the near future.

Concluding Remarks

The data suggest that by using concept-driven sorting tasks to assess whether effective learning has occurred, one may start to understand the knowledge structures of medical students in any given course. Ideally, this type of exercise would be more useful if performed with students before they start a course and after they have completed a given course. We hope that we can expand this work and encourage faculty to come up with a robust set of core concepts for all medical courses.

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About the Author

Dr Charles Gullo was the Deputy Director of the Body and Disease course and Assistant Professor at both Duke-NUS (MERE) and the Yong Loo Lin School of Medicine (Dept of Microbiology). He was also the Deputy Director for Phase I at the Lee Kong Chian School of Medicine. Charles was a member of the facilitation team at both organisations and was also actively involved in pursuing academic research in medical cognition and education as well as a trainer in various areas of team-based learning.