REPRESENTATIONAL COMPETENCE OF FORM FOUR SCIENCE STUDENTS ON BASIC CHEMICAL CONCEPTS

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Kecekapan Perwakilan (*Representational Competence)* Konsep Kimia Asas Pelajar Tingkatan Empat Sains

ABSTRAK

Tujuan am kajian ini adalah untuk menyiasat kecekapan perwakilan pelajar Tingkatan 4 sains tentang konsep kimia asas. Antara tujuan utama kajian ini ialah: (i) menyiasat pemahaman pelajar tentang konsep kimia asas, (ii) menilai pemahaman pelajar tentang perwakilan kimia (*chemical representations*), (iii) mentaksir kecekapan perwakilan pelajar, dan (iv) mengkaji pengaruh pembolehubah kognitif terpilih ke atas kecekapan perwakilan. Sampel kajian ini terdiri daripada 411 orang pelajar Tingkatan empat sains dari tujuh buah sekolah menengah bandar di Negeri Perak. Tujuh instrumen digunakan untuk mengutip data kajian. Pakej statistik (*The Statistical Package for the Social Sciences, SPSS*) digunakan untuk menganalisis data kuantitatif. Dapatan utama kajian ini ialah:

Skor min untuk *Test of Chemical Concepts* (TCC), *Test of Chemical Representations* (TCR) dan *Test of Representational Competence* (TRC) ialah 13.68 (45.60%), 18.63 (51.75%), dan 16.90 (42.25%) masing-masing.

Pelajar dengan aras pemahaman (a) konsep kimia, dan (b) perwakilan kimia yang tinggi menunjukkan aras kecekapan perwakilan lebih tinggi secara signifikan. Tidak ada perbezaan signifikan antara pelajar dengan aras pemahaman (a) konsep kimia, dan (b) perwakilan kimia yang sederhana dan rendah.

Peratus konsepsi alternatif untuk 18 item dalam TCC melebihi 50%; min atau peratus min konsepsi alternatif untuk lima kategori konsep kimia paling asas juga melebihi 50%. Peratus konsepsi alternatif untuk 13 item dalam TCR melebihi 50%; domain isi kandungan (*content domain*) dengan peratus min konsepsi alternatif paling

tinggi (71.93%) ialah `tiga aras perwakilan jirim' (*the three levels of representation of matter*).

Peratus kesukaran untuk 23 item dalam TRC melebihi 50%; kategori dengan peratus min kesukaran paling tinggi (78.83%) ialah `kebolehan bergerak antara pelbagai perwakilan merentasi aras' (*the ability to translate between different representations across levels*).

Kesemua sembilan peserta temuduga tidak biasa dengan istilah perwakilan kimia. Peserta dari [1]*High group* boleh memberi contoh perwakilan kimia sedangkan peserta dari [2]*Low group* tiada idea tentang perwakilan kimia. Peserta dari *Low group* mempunyai pandangan makroscopik tentang jirim, memberi focus terhadap ciri-ciri permukaan perwakilan (*surface features of representations*) dan menggunakan perwakilan sebagai *depictions*. Kebolehan mereka mentafsir atau menghasilkan perwakilan konsep kimia dan bergerak antara perwakilan adalah terhad; Peserta dari [3]*Medium group* mempunyai pandangan mikroscopik jirim tetapi istilah mikroscopik hanya digunakan apabila dirangsang dan penggunaan perwakilan kimia kadang-kadang tidak betul; Peserta dari *High group* mempunyai pandangan makroscopik serta mikroscopik tentang jirim, menggunakan istilah mikroscopik secara tepat dan spontan, boleh menghasilakan perwakilan submikroskopik dengan menggunakan perwakilan kimia yang betul, serta boleh bergerak antara perwakilan tanpa masalah. Kesemua sembilan peserta temuduga tidak boleh menggunakan perwakilan aras berganda (*multiple levels of representations*) dalam deskripsi mereka. Aras kecekapan perwakilan ialah: aras 1 (tiga orang), aras 2 (tiga orang), aras 3 (dua orang), dan aras 4 (seorang).

[1] subjek dengan skor TRC dalam peratusan 25% yang atas
[2] subjek dengan skor TRC dalam peratusan 25% yang bawah
[3] subjek dengan skor TRC dalam peratusan 50% di tengah

Model regresi dengan tiga pembolehubah tidak bersandar menerangkan 71% varians kecekapan perwakilan (*Prior knowledge* ≈ 58%, *developmental level* ≈ 14%). *Predictor* terbaik untuk kecekapan perwakilan ialah pemahaman konsep kimia (*prior knowledge* I), yang menyumbang 55.5% terhadap varians. Model regresi merupakan *good fit*. Hubungan statistik secara menyeluruh adalah signifikan, $F(3,188) = 156.405$, $p < 0.001$).

Berdasarkan dapatan kajian, beberapa implikasi tertentu dibincangkan dan cadangan bagi kajian lanjut disyorkan.

Representational Competence of Form Four Science Students on Basic Chemical Concepts

ABSTRACT

The general purpose of this study was to investigate Form four science students' representational competence on basic chemical concepts. The main aims of the study were: (i) to investigate students' understanding of basic chemical concepts, (ii) to evaluate their understanding of chemical representations, (iii) to assess their representational competence in chemistry, and (iv) to examine the influence of selected cognitive variables on their representational competence. A total of 411 Form four science students from seven urban secondary schools in Perak participated in this study. Data was obtained from seven instruments consisting of five paper-and-pencil tests, one questionnaire and interviews. The Statistical Package for the Social Sciences (SPSS) was used to analyze quantitative data collected. The main findings of this study were:

Mean scores for the Test of Chemical Concepts (TCC), Test of Chemical Representations (TCR) and Test of Representational Competence (TRC) were respectively 13.68 (45.60%), 18.63 (51.75%), and 16.90 (42.25%).

Students with a high level of understanding of (a) chemical concepts, and (b) chemical representations, had significantly higher overall level of representational competence compared to both the medium and the low groups, at $p<0.001$. However, students with medium and low levels of understanding of (a) chemical concepts, and (b) chemical representations, showed no significant difference in their overall levels of representational competence.

Percent alternative conceptions for 18 of the 30 items in the TCC exceeded 50%; mean or percent mean alternative conceptions for all five categories of the most

basic chemical concepts exceeded 50%. Percent alternative conceptions for 13 of the 36 items in the TCR exceeded 50%; the content domain with the highest percent mean alternative conception were `the three levels of representation of matter' (71.93%),

Percent difficulty for 23 of the 40 items in the TRC exceeded 50%; the category with the highest percent mean difficulty was the ability to translate between different representations across levels (78.83%).

All the nine participants in the interviews were unfamiliar with the term `chemical representations'. However, participants from the [1]High group gave correct examples of chemical representations while participants from the [2]Low group totally had no idea about chemical representations. Participants from the Low group held a macroscopic view of matter, focused on the surface features of representations and used representations as depictions. Their ability to interpret or generate representations of chemical concepts, and to translate between representations, is limited; Participants from the [3]Medium group had a microscopic view of matter. Microscopic terms were used only when prompted, and chemical representations were sometimes incorrectly used; Participants from the High group had both a macroscopic view and a microscopic view of matter, able to use microscopic terms appropriately and spontaneously, could generate submicroscopic representations using correct chemical representations, and able to translate fluently between representations. None of the nine participants in the semi-structured interviews could use multiple levels of representations in their description. The representational competence levels of the nine participants were: three at level 1, three at level 2, two at level 3, and one at Level 4.

[1] subjects whose TRC scores were in the top 25%
[2] subjects whose TRC scores were in the bottom 25%
[3] subjects whose TRC scores were in the middle 50%

The regression model with three independent variables explains almost 71% of the variance of representational competence (prior knowledge ≈58%, developmental level ≈14%). The best predictor of representational competence is `understanding of chemical concepts' or prior knowledge I, which alone accounts for 55.5% of the variance. The regression model was a good fit. The overall relationship was significant, [F (3, 188) = 156.405, $p < 0.001$].

Arising from the findings, some implications and recommendation were discussed, and further research suggested.

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LIST OF ACRONYMS

TCC	Test of Chemical Concepts
TCR	Test of Chemical representations
TRC	Test of Representational Competence
CTSR	Classroom Test of Scientific Reasoning
LAQ	Learning Approach Questionnaire
DSBT	Digit Span Backwards Test
SSI	Semi-structured Interviews
TCCt score	Total TCC score
TCRt score	Total TCR score
TRCt score	Total TRC score
IPM	Information processing model
IPT	Information processing theory
SR	Sensory registry
SM	Sensory memory
WM	Working memory
LTM	Long-term memory
I	Interviewer
R	Interviewee
L	Low
M	Medium
H	High