CONCEPTUAL RECONSTRUCTION OF ENERGY CONCEPTS USING THE MODEL OF EDUCATIONAL RECONSTRUCTION IN THE GERMAN *DIDAKTIK* TRADITION

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FACULTY OF PSYCHOLOGY AND EDUCATION
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2022

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DECLARATION

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Azlinah binti Ispal
25 January 2022

ABSTRACT

This thesis sheds new light on how to prepare a physics lesson on energy concepts for upper secondary school students. Energy concepts are among the most important ideas in all of science. Similarly, the presence of energy as both a core concept and a cross-cutting concept will undoubtedly confuse students. This misunderstanding is caused by a number of identified factors, including differences in the definition of the word "energy" in the scientific world and in everyday conversation. Most textbook authors use complex terms that are commonly used by scientists but are difficult for students to understand. This problem is worsened when teachers are primarily dependent on the concepts restricted in the textbook and what is framed by the curriculum developer. Many teachers and physics educators believe that concepts for instruction must be "simpler" than the physics content itself in order for students to understand them after the "reduction" process from the original content structure. Unfortunately, this is also the reason why students struggle to understand energy concepts, particularly in physics. Thus, the researcher, who acted as a physics teacher in this study, has been investigating how students' everyday-oriented energy conceptions can be reconstructed into physics-oriented conceptions. To achieve the study's goal, the Model of Educational Reconstruction (MER) from the German *Didaktik* tradition was used as the framework of the research method. The research is based on Heidegger's philosophical hermeneutics, in which physics is viewed as a "language of thought." This inquiry's data is derived from semi-structured interviews, written responses, teaching experiments, student written self-reflection, and researcher self-reflexivity. While qualitative content analysis and systematic metaphor analysis are used to triangulate and interpret the text, according to the findings of the study; students' informal communication, culture, social media, and personal experiences influenced their language of thought, which profoundly shaped their understanding of the meaning of energy, which may or may not be correct. The most interesting finding was that most participants thought of potential energy as the "ability to do work," but scientists thought of it in a different way. Students' energy conceptions could be reconstructed and linked to scientific knowledge by interpreting their language of thought and meaning if they could only signify their conception as intelligible, plausible, and fruitful. This research on conceptual reconstruction of energy concepts contributes to the field of physics education knowledge, methodological issues, and has implications for the educational practises such as physics curriculum, instructional quality, assessment quality, and physics teacher quality. Thus, the MER from the German *Didaktik* tradition has the potential to be incorporated into our curriculum because this tradition emphasises the importance of conceptual clarification prior to beginning instruction, which has never been considered in our education.

ABSTRAK

PEMBENTUKAN SEMULA KONSEP TENAGA MENGUNAKAN MODEL PENDIDIKAN PEMBENTUKAN SEMULA DALAM TRADISI DIDAKTIK JERMAN

Tesis ini memberi penerangan baharu tentang cara persediaan pengajaran mata pelajaran fizik tentang konsep tenaga untuk pelajar sekolah menengah atas. Konsep tenaga adalah antara idea yang paling penting dalam semua bidang sains. Begitu juga, kehadiran tenaga sebagai konsep teras dan konsep merentas kurikulum sudah pasti akan mengelirukan pelajar. Salah faham ini disebabkan oleh beberapa faktor yang dikenal pasti, termasuk perbezaan definisi perkataan "tenaga" dalam dunia saintifik dan dalam perbualan seharian. Kebanyakan pengarang buku teks menggunakan istilah kompleks yang biasa digunakan oleh saintis tetapi sukar difahami oleh pelajar. Masalah ini bertambah buruk apabila guru bergantung terutamanya kepada konsep yang dihadkan dalam buku teks dan apa yang dirangka oleh pembangun kurikulum. Ramai guru dan pendidik fizik percaya bahawa konsep untuk pengajaran mestilah "lebih ringkas" daripada kandungan fizik itu sendiri agar pelajar memahaminya selepas proses "pengurangan" daripada struktur kandungan asal. Malangnya, ini juga sebab pelajar bergelut untuk memahami konsep tenaga, terutamanya dalam fizik. Oleh itu, penyelidik, yang bertindak sebagai guru fizik dalam kajian ini, telah menyiasat bagaimana konsep tenaga berorientasikan harian pelajar boleh dibina semula menjadi konsep berorientasikan fizik. Untuk mencapai matlamat kajian, Model Pembinaan Semula Pendidikan (MER) daripada tradisi Didaktik Jerman digunakan sebagai kerangka kaedah penyelidikan. Penyelidikan ini berdasarkan hermeneutik falsafah Heidegger, di mana fizik dilihat sebagai "bahasa pemikiran." Data inkuiri ini diperoleh daripada temu bual separa berstruktur, respons bertulis, eksperimen pengajaran, refleksi kendiri bertulis pelajar, dan refleksi kendiri penyelidik. Manakala analisis kandungan kualitatif dan analisis metafora sistematik digunakan untuk melakukan triangulasi dan mentafsir teks, menurut dapatan kajian; komunikasi tidak formal, budaya, media sosial dan pengalaman peribadi pelajar mempengaruhi bahasa pemikiran mereka, yang membentuk pemahaman mereka tentang makna tenaga, yang mungkin betul atau tidak. Penemuan yang paling menarik ialah kebanyakan peserta menganggap tenaga keupayaan sebagai "keupayaan untuk melakukan kerja," tetapi saintis memikirkannya dengan cara yang berbeza. Konsepsi tenaga pelajar boleh dibina semula dan dikaitkan dengan pengetahuan saintifik dengan mentafsir bahasa pemikiran dan makna mereka jika mereka hanya boleh menandakan konsep mereka sebagai boleh difahami, munasabah dan bermanfaat. Penyelidikan mengenai pembinaan semula konsep konsep tenaga ini menyumbang kepada bidang pengetahuan pendidikan fizik, isu metodologi, dan mempunyai implikasi kepada amalan pendidikan seperti kurikulum fizik, kualiti pengajaran, kualiti penilaian dan kualiti guru fizik. Oleh itu, MER daripada tradisi Didaktik Jerman ini berpotensi untuk dimasukkan ke dalam kurikulum kerana tradisi ini menekankan kepentingan penjelasan konsep sebelum memulakan pengajaran, yang tidak pernah dipertimbangkan dalam pendidikan kita.

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LIST OF ABBREVIATION

CC-BY	–	Creative Common Attribution
CDC	–	Curriculum Development Centre
DAAD	–	German Academic Exchange Service
DBR	–	Design-based Research
DfE	–	Department for Education
DPBA	–	Double-Pan Balance Approach
ESERA	–	European Science Education Research Association
GIREP	–	International Research Group of Physics Teaching
HOTS	–	Higher Order Thinking Skills
IAI	–	Interview-about-Instances
IAE	–	Interview-about-Event
IB	–	International Baccalaureate
IPN	–	Leibniz Institute for Science and Mathematics Education
KBSR	–	New Primary School Curriculum
KBSM	–	New Secondary School Curriculum
MBMMBI	–	Uphold Malay Language and Strengthen English Language
KMK	–	*Ständige Konferenz der Kultusminister der Länder*
KSSR	–	Primary School Standard Curriculum
KSSM	–	Secondary School Standard Curriculum
MA	–	Metaphor Analysis
MEB	–	Malaysia Education Blueprint
MER	–	Model of Educational Reconstruction
MES	–	Malaysian Examination Syndicates
MINT	–	Mathematics, Informatics, Natural Sciences and Technology
MoE	–	Ministry of Education
MRSM	–	MARA Junior Science College
NGSS	–	Next Generation Science Standards
NRC	–	National Research Council
OECD	–	Organisation for Economic Cooperation and Development
PADU	–	Education Performance and Delivery Unit

PPSMI	–	English for Teaching Mathematics and Science
PhD	–	Philosophy Doctorate
PISA	–	Programme for International Student Assessment
PMR	–	Lower Secondary Assessment
PT3	–	Form 3 Assessment
QCA	–	Qualitative Content Analysis
SBA	–	School-Based Assessment
SPM	–	Malaysian Certificate of Education
SRP	–	Lower Certificate of Education
STEM	–	Science, Technology, Engineering and Mathematics
TA	–	Thematic Analysis
TE	–	Teaching Experiment
TIMSS	–	Trends in Mathematics and Science Study
UNESCO	–	United Nations Educational, Scientific and Cultural Organisation
UK	–	United Kingdom
UMS	–	Universiti Malaysia Sabah
US	–	United State

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CHAPTER 1

INTRODUCTION

1.0 Chapter Overview

This chapter serves as an introduction to the thesis. It begins with the context of the study, followed by a summary of the study's background and extends through the problem statement, theoretical framework, and study's aim, which includes research objectives and research questions. The study's rationale and significance are discussed at length. Following that, the study's empirical limitations and the definition of terms are discussed before proceeding to the researcher's profile. The researcher's profile, which includes my self-reflective expressions, is essential in the context of the study presented in this thesis. This chapter also talks about the structure of the thesis and wraps up the introduction chapter with a summary.

1.1 The Context of the Study

The context of the study informs the reader about the what, why, how, who, where, and possibly when of the study, among other things. Following that, the reader will have a more in-depth understanding of the background of the study in the following section. This shows that the nature of the study, which is linked to my background as the person who did the study, the research objectives/questions, the research method, the results, and the contribution, which includes the study's implication, is very important.

This research focuses on specific information about students' ideas and ways of thinking. This is consistent with a new trend in the framework for developing, implementing, and evaluating teaching and learning environments in physics education, which explores teaching and learning at the micro-level (a single topic) rather than the macro-level (a year or more of teaching and learning) (Kariotoglou & Tselfes, 2000). Much of the literature indicates that physics education research is initially less concerned with producing content-specific instructional knowledge (Duit & Treagust, 1998), despite the fact that this method leads to the identification of the "missing level" and understanding of what happens in physics classrooms in terms of content-specific interactions between teaching and learning processes.

According to Fensham (2001), the complexity of physics content should be treated in the same way that it is treated in the content of instruction. In physics education research, the Model of Educational Reconstruction (MER) is the best way to bridge the gap between physics content issues and teaching-learning issues (Duit *et al.*, 2012). MER was discovered in Germany and is based on a constructivist epistemological foundation (Duit & Treagust, 1998, 2003; Kattmann *et al.*, 1996). This epistemological point of view is concerned with the interpretation of scientific knowledge as well as the conceptual understanding of students' points of view. Focusing on either the physics content or the students helps to avoid one-sidedness.

Fensham (2001) noted how the German education tradition of *Didaktik* can improve instruction by focusing on students' learning needs and abilities. This tradition views learning as students developing their own knowledge based on what they have already learned. Students' pre-knowledge and beliefs are not viewed as obstacles to learning, but rather as starting points for bringing them to the physics knowledge they must acquire (Driver & Easley, 1978). On the other hand, physics content is regarded as a physicist's creation (Abd-El-Khalick & Lederman, 1998), and usually physics knowledge in the scientific fields is not always in a form that qualifies it for presence in a school curriculum. Scientists, on the other hand, build their knowledge in a very different way from how young people build their knowledge in school.