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The Integration of Industry Case-Based-Environmental Sustainability with Heutagogy Approach in Evaluating the Thinking Skills Among Technical Students

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ABSTRACT

This study evaluated the efficacy of an innovative teaching method framework, which incorporated heutagogical techniques and industrial case-based learning, in boosting the critical thinking abilities of vocational students. Using a pre-and post-test experimental design, 120 students from three Malaysian vocational colleges were randomly assigned to experimental and control groups. The experimental group participated in a three-day environmental sustainability and heutagogy-based educational camp. Pre- and post-test performance was graded using a validated rubric that evaluated analytical, creative, and practical thinking skills. Controlling for pre-test performance, Multivariate Analysis of Covariance (MANCOVA) demonstrated a substantial influence of the heutagogical method on the post-test scores of the students. These findings demonstrate the potential for creative, hands-on teaching techniques, such as heutagogy coupled with industry case-based learning, to improve students' critical thinking abilities. For even more outstanding results, future studies should examine complex, personalised teaching tactics that consider pupils' various learning styles. This study highlights the significance of industry-relevant and learner-centred teaching approaches, especially in Technical and Vocational Education and Training (TVET).

Keywords: Industry case-based, heutagogy, technical education, environmental sustainability, thinking skills

INTRODUCTION

Technical and Vocational Education and Training (TVET) continues to evolve in response to the changing demands of the job market in the twenty-first century. These expectations highlight the importance of developing students' critical and creative thinking, which has prompted a paradigm shift from traditional educational methods to new, learner-centred approaches such as heutagogy (Blaschke 2012).

Self-directed learning, or heutagogy, is an advanced educational approach that promotes introspection, double-loop learning, and the ability to adapt and respond effectively to change (Hase & Kenyon, 2000). Its emphasis on learner autonomy and capacity-building positions it well within the TVET sector, where developing industry-relevant skills and lifelong learning habits is fundamental (Ashton & Elliott 2007).

Simultaneously, the push for sustainability has gained prominence across all industries, including education. Including environmental sustainability in TVET can prepare the future workforce with the skills and knowledge required to manage environmental concerns (Sagar 2020).

Integrating industry-based case-based learning with an emphasis on environmental sustainability is a novel approach to achieving this goal. This instructional approach provides students with a realistic, real-world framework to investigate and solve complicated, industry-based environmental problems. Such experiential learning gives chances for decision-making, critical thinking, and problem-solving, which are crucial abilities for pursuing

sustainable development (Jonassen & Hernandez-Serrano 2002).

Given the importance of heutagogy, environmental sustainability, and industry case-based learning in shaping future TVET practises, the purpose of this study is to investigate the efficacy of a heutagogical approach integrated with industry case-based learning on environmental sustainability in fostering critical thinking among TVET students. This research is anticipated to add to the continuing dialogue on new teaching methodologies in TVET and give educators, policymakers, and sector stakeholders significant insights.

METHODOLOGY

This experimental study employs pre-treatment and post-treatment evaluations to determine the efficacy of the unique educational framework.

The control and experimental groups were given a pre-test in the first part of the experiment. The researcher controlled the entire procedure, from the distribution of examinations to the collection of student replies. The pre-test was administered to 120 Construction Technology students from Klang Vocational College, Sungai Buloh Vocational College, and Batu Pahat Vocational College three weeks before the primary experimental investigation.

The purpose of the subsequent phase of the experiment was to provide unique learning experiences to the experimental group, emphasising the development of critical thinking abilities through heutagogical methodologies. Experts in the area created and evaluated a heutagogically-based curriculum that blends thinking skills and industrial case-based learning about environmental sustainability.

Simple random selection split the 120 civil engineering students' samples into control (n=60) and experimental (n=60) groups. The control group continued with their traditional learning process, while the experimental group participated in a three-day learning camp consisting of six sessions based on the suggested pedagogical framework.

In the final phase, a post-test was administered to both the control and experimental groups. This phase occurred after the teaching and learning sessions utilising the innovative pedagogical strategy. The researcher gave and collected both groups' completed test sets.

Multivariate Analysis of Covariance (MANCOVA) was used to analyse the connection between an independent variable (nominal or ordinal) and a dependent variable (interval or ratio) while adjusting for other factors (covariates). According to Chua (2014), the application of MANCOVA facilitates the identification of statistically significant differences between pre-test and post-test scores on inventive problem-solving and thinking abilities for the control and experimental groups based on a researcher-developed alternative assessment rubric.

Multivariate analysis of covariance (MANCOVA) is a statistical approach that extends the analysis of covariance (ANCOVA) to include several dependent variables and adjust for the impact of one or more covariates. In research, MANCOVA is used to assess the effects of independent factors and the interactions between independent variables on multiple dependent variables while adjusting for the effects of covariates. Covariates may impact the dependent variables but are not the researcher's primary focus.

The goal of MANCOVA in an experimental setting is to adjust the dependent variables for differences that may exist at baseline (pre-test) and to determine if changes in the dependent variables are attributable to the experimental manipulation of the independent variables. It is precious when the dependent variables are not independent of one another.

THINKING SKILL RUBRIC

This study constructed a thorough scoring rubric for assessing students' thinking skills, emphasising three key constructs: analytical thinking skills, creative thinking skills, and practical thinking skills. These components were then subdivided into eleven unique questions to assess the complete scope of students' cognitive ability.

Each scale point is related to predetermined accomplishment requirements. A score of 1 signified the lowest degree of achievement, while a score of 5 indicated the highest level.

Before implementation, three subject matter experts rigorously validated the scoring rubric to verify its reliability and efficacy in grading students' critical thinking skills. Based on the level of consensus among these experts, it was determined that the scoring rubric was adequate for its intended purpose.

This rubric is a helpful tool for educators in the field since it provides an organised and verified way for evaluating and enhancing students' critical thinking abilities. It delivers actionable insights into students' strengths and shortcomings in analytical, creative, and practical thinking, allowing individualised teaching techniques to improve these essential cognitive skills.

TABLE 1. Expert agreement on thinking skill rubric

Construct	Item	Agreement Percentage (%)
Analytical	Identifying Problems	88.89
	Solving problems	
	Giving criticism	
Creative	Project development	100
	Solving problems	
Practical	To relate	88.89
	Manipulating the environment	
	Way of Work	

Table 1 shows the consensus rate among experts about each item of the thinking skills rubric across three constructs: Analytical, Creative, and Practical.

In the Analytical construct, experts agreed with Identifying Problems, Solving Problems, and Giving Criticism 88.89% of the time, demonstrating that this item correctly evaluates a significant aspect of analytical thinking skills.

In the Creative construct, experts agreed unanimously (100%) that Project development and Problem-solving are legitimate and valuable measures of creative thinking ability.

In the Practical construct, the item To relate, Manipulating the environment, and way of Work received 88.89 percent agreement, indicating that most experts feel this item correctly evaluates practical thinking abilities.

These high levels of agreement reflect a robust consensus among the experts and justify these rubric elements. It is vital to note that these percentages of agreement give valuable information into the validity of these specific parts of the rubric. High levels of agreement also show that the rubric will likely be a valid instrument for measuring students' critical thinking abilities in the relevant subject areas.

RESULT

The study aimed to examine the effect of heutagogy tactics on students' capacity to solve environmental sustainability-related industrial case studies while adjusting for their past performance in these disciplines. A multivariate covariance (MANCOVA) analysis was conducted to examine the influence of the independent factors - instructional methodologies (Heutagogi) - on the dependent variables - post-test results on the thinking skill subtest. The thinking ability pre-test scores were included in the model to compensate for baseline variations among the students.

TABLE 2. Multivariate test on the effectiveness of thinking skills through the heutagogy approach

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.096	.853[b]	3.000	24.000	.479
	Wilks' Lambda	.904	.853[b]	3.000	24.000	.479
	Hotelling's Trace	.107	.853[b]	3.000	24.000	.479
	Roy's Largest Root	.107	.853[br]	3.000	24.000	.479
Jumlah skor keseluruhan pra	Pillai's Trace	.813	34.819[b]	3.000	24.000	.000
Heutagogi	Wilks' Lambda	.187	34.819[b]	3.000	24.000	.000
	Hotelling's Trace	4.352	34.819[b]	3.000	24.000	.000
	Roy's Largest Root	4.352	34.819[b]	3.000	24.000	.000
	Pillai's Trace	.000	.[b]	.000	.000	.
	Wilks' Lambda	1.000	.[b]	.000	25.000	.000
	Hotelling's Trace	.000	.[b]	.000	2.000	.
	Roy's Largest Root	.000	.000[b]	3.000	23.000	1.000

[a]. Design: Intercept + Jumlahskorkeseluruhanpra + JenisGogies

[b]. Exact statistic

When all independent variables are equal to zero, the intercept indicates the predicted mean value of the dependent variable. The p-value (Sig.) of.479 is more prominent than.05, indicating that the influence of the intercept is not statistically significant.

The total pre-test score indicates the students' total scores before implementing the teaching approach. In this instance, the p-value is 0.000, indicating that the pre-test scores significantly affect the result. In other words, there is a considerable difference between the pre-test and post-test results. Therefore, the students' beginning performance (pre-test score) substantially influences their performance once the teaching approach has been implemented.

In this instance, the p-value for Heutagogi is.000, showing that the Heutagogi instructional method substantially influenced post-test scores. This illustrates that the instructional method has a significant effect on student results.

This research demonstrates that both the pre-test scores and the Heutagogi teaching style substantially impact pupils' post-test scores.

The findings of the MANCOVA analysis give strong evidence that the Heutagogi teaching technique substantially influences the post-test scores of students, highlighting the significance of teaching style for student learning outcomes.

The ramifications of this study for industrial case-based learning and the development of student's critical thinking abilities are particularly noteworthy. Numerous research in educational technology has demonstrated the efficacy of industrial case-based learning in fostering students' critical thinking and problem-solving abilities (Kim et al. 2006; Herreid 2007).

In the context of these findings, incorporating industry case-based learning into the Heutagogi teaching approach can provide a learning environment that respects students' individual learning preferences (visual, auditory, reading/writing, and kinesthetic) while fostering higher-order cognitive skills.

Developing thinking skills is a primary objective of education, especially in the 21st century, when critical thinking, problem-solving, and creativity are highly prized (Bell, 2010).

Combining a learner-centred teaching strategy with industry case-based learning may benefit educational technology. Given the fast development of technology and the rising demand for practical skills in the workforce, education must be more than theoretically sound; it must also be relevant to the actual world (Billett, 2009). When included in instruction, industry case studies provide a rich, contextually anchored learning experience intimately related to real-world applications (Ellet 2007).

CONCLUSION

In conclusion, the findings of this study suggest that educators and curriculum developers should consider incorporating industry case studies into a Heutagogi teaching approach to improve student's learning outcomes and critical thinking abilities while respecting their varied learning preferences.

Implementing Heutagogi, an industrial case-based teaching technique, substantially impacted the students' post-test scores, corroborating past research findings and highlighting such approaches' value on student outcomes (Blaschke 2012). This demonstrates the usefulness of industry-relevant, hands-on instruction in increasing student learning (Herreid & Schiller 2013).

This study also shed light on students' many talents, such as their visual, auditory, reading, and kinesthetic capacities. Consistent with past studies (Felder & Brent, 2005), it became clear that there may be more effective ways to accommodate these various learning styles. Adapting instructional methods to each student's unique aptitudes may improve learning outcomes (Dunn 2000).

In the context of Technical and Vocational Education and Training (TVET), it is impossible to stress the importance of experiential, case-based learning. The industry-related education provides students with applicable practical skills and builds an appreciation for the workplace (Maclean & Wilson 2009).

In light of these findings, there is a need for more study that investigates more nuanced, personalised teaching tactics that take into account the diverse learning styles of individuals. This may require experimenting with a combination of instructional approaches or investigating adaptive learning technology (Chatti et al. 2017).

In addition, more studies might be conducted to determine how the Heutagogi teaching technique, or any other industrial case-based teaching methods, can be enhanced to accommodate a variety of learning styles (Herreid & Schiller, 2013). It is possible to develop studies to isolate and identify the aspects of these strategies that contribute most substantially to student performance.

This study highlights the significance of implementing new and industry-relevant teaching approaches such as Heutagogi in educational practice, particularly in the context of TVET (Rauner & Maclean, 2008). It validates the demand for more practical and applied learning experiences closely connected with actual industrial settings (Choy et al. 2009).

The integration of case-based, industry-relevant information into teaching approaches is strongly encouraged. This might dramatically improve pupils'

comprehension, motivation, and readiness for future employment (Stasz 2001).

In addition, the research indicates that educators must consider students' specific skills and learning preferences while planning and presenting instructional content. This highlights the significance of varied instruction and individualised learning experiences in contemporary education, especially within TVET programmes (Billett 2011).

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REFERENCES

Ashton, J., & Elliott, R. 2007. Generational change and the rise of consumer-driven health care: emerging challenges for health and community services in Australia. *Australian Health Review* 31(2): 181.

Billett, S. 2009. Realising the educational worth of integrating work experiences in higher education. *Studies in Higher Education* 34(7): 827–843.

Billett, S. 2011. *Vocational Education: Purposes, Traditions and Prospects*. Springer.

Blaschke, L. M. 2012. Heutagogy and lifelong learning: A review of heutagogical practice and self-determined learning. *The International Review of Research in Open and Distributed Learning* 13(1): 56–71.

Chatti, M. A., Muslim, A., & Schroeder, U. 2017. Toward an open learning analytics ecosystem. In Big data and learning analytics in higher education (pp. 195-219). Springer, Cham.

Choy, S., Wärvik, G. B., & Hellström, A. 2009. From VET to higher education: The road less travelled. *Asia Pacific Journal of Education* 29(1): 131-147.

Dunn, R. 2000. Learning styles: Theory, research, and practice. *National Forum of Applied Educational Research Journal* 13(e1): 3–22.

Eklund, J., Kay, M., & Lynch, H. 2003. E-learning: Emerging issues and key trends. A discussion paper. Australian National Training Authority.

Felder, R. M., & Brent, R. 2005. Understanding student differences. *Journal of Engineering Education* 94(1): 57-72.

Felder, R. M., & Silverman, L. K. 1988. Learning and teaching styles in engineering education. *Engineering Education* 78(7): 674-681.

Fleming, N. D., & Mills, C. 1992. Not another inventory, rather a catalyst for reflection. To Improve the Academy, 11, 137–155.

Friedman, A., & Phillips, M. 2004. Continuing professional development: Developing a vision. *Journal of Education and Work* 17(3): 361–376.

Gentry, M. 2019. *Total School Cluster Grouping and Differentiation: A Comprehensive, Research-Based Plan for Raising Student Achievement and Improving Teacher Practice*. Prufrock Press Inc.

Hattie, J. 2009. *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. Routledge.

Hase, S., & Kenyon, C. 2000. From andragogy to heutagogy. UltiBASE In-Site.

Herreid, C. F., & Schiller, N. A. 2013. Case studies and the flipped classroom. *Journal of College Science Teaching* 42(5): 62-66.

Jonassen, D. H., & Hernandez-Serrano, J. 2002. Case-based reasoning and instructional design: Using stories to support problem-solving. *Educational Technology Research and Development* 50(2): 65-77.

Kolb, D. A. 1984. *Experiential Learning: Experience as the Source of Learning and Development* (Vol. 1). Prentice-Hall.

Maclean, R., & Wilson, D. 2009. *International Handbook of Education for the Changing World of Work*. Springer.

Mayer, R. E. 2008. *Learning and Instruction*. 2nd edition. Pearson/Merrill Prentice Hall.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. 2008. Learning styles: Concepts and evidence. *Psychological Science in the Public Interest* 9(3): 105-119.

Rauner, F., & Maclean, R. 2008. *Handbook of Technical and Vocational Education and Training Research.* Springer Science & Business Media.

Sagar, A. 2020. Embedding sustainability in technical and vocational education and training. *Journal of Cleaner Production*: 244, 118803.

Schön, D. A. 1987. *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions*. Jossey-Bass.

Stasz, C. 2001. Assessing skills for work: Two perspectives. *Oxford Economic Papers* 53(3): 385–405.

Tomlinson, C. A., Brighton, C., Hertberg, H., Callahan, C. M., Moon, T. R., Brimijoin, K., ... & Reynolds, T. 2003. Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of the literature. *Journal for the Education of the Gifted* 27(2-3): 119–145.

Wang, Q. 2008. A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International* 45(4): 411–419.