International Journal of Instruction
e-ISSN: 1308-1470 ● www.e-iji.net

October 2024 ● Vol.17, No.4
p-ISSN: 1694-609X
pp. 135-148

Article submission code: 20231216140528

Received: 16/12/2023
Revision: 08/04/2024

Accepted: 20/04/2024
OnlineFirst: 01/07/2024

Heutagogy in Action: Empowering Mathematics Teachers Through Innovative Pedagogical Approaches

Mohamad Ikram Zakaria
Universiti Teknologi Malaysia, Malaysia, *mohamad.ikram@utm.my*

Nik Abdul Hadi Noor Nasran
Universiti Teknologi Malaysia, Malaysia, *nikabdulhadi@graduate.utm.my*

Abdul Halim Abdullah
Universiti Teknologi Malaysia, Malaysia, *p-halim@utm.my*

Najua Syuhada Ahmad Alhassora
Universiti Teknologi Malaysia, Malaysia, *najuasyuhada@utm.my*

Mohd Fadzil Abdul Hanid
Universiti Teknologi Malaysia, Malaysia, *mohdfadzilabdulhanid@utm.my*

As a result, mathematics teachers are prompted to focus on the heutagogical approach. However, challenges arise, like inadequate training and support among mathematics teachers. Thus, this study concentrated on formulating a series of teaching activities aligned with the heutagogical approach, specifically tailored to assist mathematics teachers in enhancing their teaching methods. This study was conducted using the Fuzzy Delphi Method (FDM) involving 15 experts with various fields of expertise such as mathematics education, educational technology, heutagogy, pedagogy and the curriculum as well as primary and secondary school mathematics teachers. The data was collected from October 2023 to November 2023 by using a questionnaire as the primary means of collecting data. Findings were analysed using triangular fuzzy number, threshold value, percentage for expert consensus and defuzzification process to determine the acceptance and ranking for each teaching activity. The results indicate that teachers assign projects that require students to explore real-world applications of mathematical concepts, were ranked first, followed by other activities, while teachers arrange virtual sessions with guest speakers from the mathematics field to provide insights to real-world applications were ranked last. In conclusion, this study offers valuable insights for mathematics teachers interested in enhancing student-centered learning within the framework of Education 4.0.

Keywords: mathematics education, heutagogy, teaching activities, fuzzy delphi method, mathematics teachers, teaching

Citation: Zakaria, M. I., Nasran, N. A. H. N., Abdullah, A. H., Alhassora, N. S. A., & Hanid, M. F. A. (2024). Heutagogy in action: Empowering mathematics teachers through innovative pedagogical approaches. *International Journal of Instruction*, *17*(4), 135-148. https://doi.org/10.29333/iji.2024.1748a

INTRODUCTION

In the era of Education 4.0, which is characterised by advancements in technology and changes in educational paradigms, the curriculum for mathematics education is also evolving. This evolution demands that teachers adapt and employ a diverse range of teaching skills to effectively address the needs of students and effectively deliver the curriculum content in line with the requirements of Education 4.0. Notably, the need for education 4.0 underscores student-centred teaching strategies by promoting self-directed learning aligned with students' capabilities and capacities (Moore, 2020). This method enables students to undergo the learning experience (Kamrozzaman et al., 2020) while comprehending the process of acquiring knowledge and learning resources independently (Kelly & Lynes, 2022). Consequently, mathematics teachers are urged to concentrate on appropriate teaching approaches, such as the heutagogical approach (Jones et al., 2019).

The heutagogical approach is a progressive and student-centric educational philosophy that profoundly emphasises student's empowerment and autonomy (Lynch et al., 2021). Unlike traditional teaching methods, heutagogy takes the concept of self-directed learning to a higher level by encouraging students to actively shape and navigate their educational experiences (Blaschke, 2021). In the heutagogical model, students are not passive recipients of information but rather active participants in their learning journey. They are entrusted with the responsibility of setting their own learning objectives, choosing the methods and resources that best suit their individual learning styles, and evaluating their own progress (Stoten, 2020).

In the context of mathematics education, the heutagogical approach empower students as active participants in their educational journey (Chamo et al., 2023). Heutagogy is the idea of granting students the authority to take charge, fostering a deep sense of responsibility and ownership over their learning process (Sholikhan et al., 2022). Furthermore, heutagogy underscores the importance of students actively participating in goal setting and planning, urging them to define objectives, break down aspirations, and create a personalised roadmap for their educational pursuits (Suhaimi et al., 2020). Acknowledging the diverse nature of individual learning preferences, heutagogy advocates for the exploration of flexible learning methods (Chamo et al., 2023).

Nevertheless, applying the heutagogical approach to mathematics education poses challenges. Multiple studies indicate that teachers encounter obstacles when incorporating heutagogy into their teaching methods (Arayathamsophon et al., 2020; Hidayat et al., 2020; Nasution et al., 2022; Alias & Matore, 2023). The lack of adequate training and support (Amiruddin et al., 2023) and limited resources such as suggested teaching activities (Abraham & Komattil, 2017; Mohamad et al., 2023) hamper mathematics teachers in effectively conveying mathematical concepts, linking lesson content to everyday life, providing systematic guidance, and achieving set objectives during the implementation of the heutagogical approach (Engelbrecht et al., 2020).

Hence, providing teachers with opportunities for professional development and sustained support is essential to equipping them with the skills necessary for the effective integration of heutagogy into their teaching methods (Blaschke, 2019; Chan et al., 2019; Blaschke & Marin, 2020). To this end, this study concentrated on formulating a series of teaching activities aligned with the heutagogical approach that mathematics teachers can use to improve their teaching practices. These activities were developed based on expert perspectives and grounded in the six heutagogic design elements, namely explore, create, collaborate, connect, reflect and share. The integration of these activities into teaching practices may assist teachers in refining their instructional methods and enriching the learning experiences of their students. To identify relevant teaching activities, the researcher has identified the following research questions: 1) What teaching activities aligned with the heutagogical approach can mathematics teachers utilise to enhance their teaching practices based on experts's consensus?

Review of Heutagogy in Education

The ongoing pragmatic revolution in education is a response to the imperative of staying competitive within the evolving landscape of globalisation. In the present interconnected world, where economies, industries, and societies are becoming increasingly interwoven, there is an escalating demand for individuals, organisations, and nations to adjust to swift changes and uphold competitiveness. This transformative shift necessitates a fundamental change in both technical and educational practices, calling for a reconsideration of the roles played by both teachers and students (Stoten, 2020). Contemporary students are increasingly seeking autonomy in their pursuit of knowledge, driven by their innate desires to shape learning patterns that align with their individual identities and preferences (Agonács & Matos, 2019). The success of modern education hinges on empowering students to become the principal agents in their learning journeys (Blaschke & Marin, 2020) and capacity for self-directed learning.

In this context, the heutagogical approach, introduced by Kenyon and Hase (2000), emerges as a modern and comprehensive educational model. This method places a strong emphasis on providing students with the skills to independently learn and enhance their self-improvement through techniques of self-directed learning (Blaschke & Hase, 2019). By integrating these innovative approach, education can effectively address the changing needs of students in an era characterised by rapid transformations and increasing complexity. Ultimately, this shift towards student empowerment and self-directed learning is pivotal for fostering a more resilient and successful modern education system (Chan et al., 2019).

According to Hase and Kenyon (2013), the establishment of a heutagogical teaching and learning environment becomes feasible when several key elements are in place. Firstly, students should be collectively engaged in shaping both content and learning processes (Rusli et al., 2020). Secondly, a system of flexible learning assessments should be implemented (Samin et al., 2020). Thirdly, an atmosphere that encourages active and collaborative learning should be fostered (Lock et al., 2021). Fourthly, students should be prompted to explore diverse learning resources (Adriani et al., 2022). Finally, there should be a deliberate reduction of control during learning sessions (Hainsworth et al., 2020).

Conceptual Framework

To facilitate the implementation of this study, the researcher conducted literature reviews centred on the fundamental principles of heutagogy to strengthen the conceptual aspects of the study. This process helped ensure that the study was well-informed and grounded in established knowledge before proceeding with its implementation. The construction of the study's conceptual framework includes six components that align with the six heutagogic design elements, namely explore, create, collaborate, connect, reflect, share (Blaschke & Hase, 2019). The ensuing section outlines these six elements that underpin heutagogy and were employed in shaping the framework for this study.

1. **Explore:** students should have the opportunity and freedom to embark on their learning journey by exploring diverse paths and knowledge sources. It is essential for them to have the flexibility to formulate and test hypotheses, as well as to pose and address questions, all of which naturally emerge during the exploration process (Handayani et al., 2021)

2. **Create:** students are given a valuable opportunity to translate theoretical knowledge into practical application through the incorporation of the element of creation. This approach emphasises active engagement and hands-on learning, allowing students to move beyond the passive reception of information (Mohamad et al., 2021)

3. **Collaborate:** students should be given the opportunity to collaborate, allowing them to participate in mutual learning experiences. Collaborative endeavours support students in achieving common objectives and goals. Through working together, students can adeptly tackle challenges, solve problems, and enhance their knowledge by exchanging information and sharing experiences with one another (Engelbrecht et al., 2020)

4. **Connect:** students should have the chance to engage with their peers, establishing a shared learning environment and exchanging experiences, fostering a supportive community. As co-creators of their learning journey, students gain advantages from interacting with fellow learners. This shared setting promotes the exchange of ideas, collaborative problem-solving, and the collective creation of knowledge (Web et al., 2019)

5. **Reflect:** students should be provided with the opportunity for reflection, as it is essential for fostering intellectual growth. Reflection is a cognitive process that goes beyond the surface level of learning. It encourages students to think critically about their learning experiences, actions, and the knowledge they have gained (Yeh et al., 2019)

6. **Share:** students should have the chance to share their knowledge with peers who share similar interests through diverse online platforms, such as social media and video conferences. This approach not only encourages collaboration but also facilitates a dynamic exchange of ideas among students (Morris, 2019).

METHOD

The methodology section will cover the specific approach taken to conduct the study. This will include a description of the study design, the group of experts, research instrument, validity and reliability and analysis procedure.

Research Design

The research was carried out from October 2023 to November 2023 and involved a comprehensive review of existing literature, followed by the implementation of the Fuzzy Delphi Method (FDM). This method featured a consensus meeting that brought together experts from diverse fields, representing a spectrum of expertise (Yusoff et al., 2021). The primary objective of this consensus meeting was to collaboratively curate a comprehensive list of teaching activities. In the implementation of this method, Fuzzy set theory was intricately woven into the conventional Delphi method. This integration aimed to introduce a more flexible and nuanced dimension to the expert evaluation process. The initial Likert scale, which had been selected by the experts for their assessments, underwent a transformation into a Fuzzy scale (Rahman et al., 2021). This transformation involved employing Fuzzy scoring, utilising binary terms (0,1) to represent degrees of agreement. Through the application of Fuzzy scoring, the consensus achieved by the participating experts was distilled into three distinct values. These values encompassed the minimum, representing the most conservative viewpoint; the most reasonable, indicating the middle ground or the consensus point; and the maximum, reflecting the most optimistic or ambitious perspective (Yaakob et al., 2020).

Group Expert

The meticulous execution of the Fuzzy Delphi Method (FDM) involved a careful process of constituting expert groups through purposive sampling. Deliberately selecting purposive sampling aimed to choose individuals with specialised knowledge, ensuring their insights significantly contribute to the inherent consensus-building process of the FDM (Hasim et al., 2021). The process of expert selection in this study adheres to the criteria outlined by Effendi et al. (2017), defining an expert as an individual with professional and field expertise, possessing a minimum of five years of experience in their respective domain. Beyond establishing the criteria for expertise, the selection process for this study also considered the number of experts involved. In an expert selection, Lim et al. 2021 suggesting a panel of ten to fifty experts and Yusoff et al. (2021) have stated that seven is the minimum number of experts required. This finding is supported by Mustapha et al. (2023) which reported that seven samples are adequate in the FDM. In alignment with these recommendations, a total of 15 experts in mathematics education, educational technology, heutagogy, pedagogy and the curriculum as well as primary and secondary school mathematics teachers were chosen for this study.

Research Instrument

In this study, the researchers used a questionnaire as the primary means of collecting data. The researchers intricately designed this set of questions with the explicit aim of gathering specific and relevant information aligned with the research objectives.

Mustapha et al. (2023) suggest that researchers can effectively generate questionnaire items by thoroughly examining relevant literature and conducting pilot studies. As a result, the researchers developed the instrument based on six heutagogic design elements, namely explore, create, collaborate, connect, reflect, and share (Blaschke & Hase, 2019), comprising 30 items (Part A=5 items; Part B=25). To achieve consensus on the items, researchers implemented a seven-point Likert Scale (1=strongly disagree; 7=strongly agree). The seven-point Likert Scale is well-suited for transformation of fuzzy set theory into the Delphi method, offering a structured yet fuzzy framework for experts to convey their opinions with varying levels of certainty (Wiles et al., 2017; Paris et al., 2022).

Validity and Reliability

The validity process is crucial to ensure that the items created effectively address the research question. An item or research instrument is deemed to possess high validity when the items within the questionnaire accurately measure the intended constructs. In this study, the researchers opted for face and content validity procedures (Fawns-Ritchie & Deary, 2020). A panel of four experts specialising in assessment and evaluation, mathematics education, curriculum development, and Malay studies were selected to execute the validity assessment. Following the expert evaluation, all items in the questionnaire with a content validity index exceeding 0.75 (Polit et al., 2007) were deemed valid and retained for further analysis.

Subsequently, the researchers undertook a reliability test. The primary objective of a reliability test is to evaluate the stability and consistency of a research instrument over time and across diverse situations (Sürücü & Maslakci, 2020). To conduct the reliability test, a pilot study involving 10 experts with characteristics similar to those selected for the main study was carried out by the researchers (Dawood et al., 2021). The outcome of this pilot study informed the final instrument, demonstrating strong consistency and effectiveness, as evidenced by the Cronbach's Alpha value of 0.93 for the 25 items (Fawns & Deary, 2020).

Analysis Procedure

In the use of the Fuzzy Delphi Method (FDM) for a study, there are steps that need to be followed for the study to be considered empirical. The sequence of steps to be adhered to is as follows:

Converting all linguistic variables into triangular fuzzy number

In this phase, the Likert Scale initially provided by experts has been transformed into a Fuzzy Scale. The utilised fuzzy numbers range from 0 to 1. To illustrate, if the first expert assigns a score of 7 to item 1, this score of 7 is then converted into 0.90 (m^1), 1.00 (m^2), and 1.00 (m^3). This conversion results in the generation of a Triangular Fuzzy Number utilised in the subsequent analysis. The Triangular Fuzzy Number comprises three values, specifically the minimum value (m^1), the most plausible value (m^2), and the maximum value (m^3). This conversion to fuzzy scales enables the researcher to delineate a range of potential scores that better reflect the experts' opinions.

Calculate the threshold value

Next, the researchers calculate the threshold value (d). This value acts as a quantitative measure, guiding researchers in evaluating the coherence and convergence of expert opinions in the Fuzzy Delphi Method (FDM). According to Wang et al. (2019) asserted that if the value of d is less than 0.2, then the experts are considered to have reached an agreement. The following formula is employed to determine d value.

$$d\,(m,n) = \sqrt{\frac{1}{3}((m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2)}$$

Calculate Expert Consensus

Following that, the researchers proceed to calculate the percentage of expert consensus, considering a permissible threshold value (d) below 0.2. According to Rahman et al. (2021), the designated percentage for expert consensus should be exceeding 75%. Conversely, Shubashini et al. (2015) asserts that the recognised percentage should be no less than 67%. In the context of this study, the researcher has embraced the perspectives of prior scholars, indicating that the acknowledged percentage for expert consensus surpasses 75%.

Defuzzification process

The final step involves the researchers conducting the defuzzification analysis. The purpose of the analysis is to transform triangular fuzzy numbers into precise values, facilitating the analysis and ranking of factors (Hasim et al., 2023). Consequently, the ultimate stage of data analysis will entail ranking the items based on the the Fuzzy Score (A). To meet the conditions of the third criterion, it is crucial that the obtained value of A is equal to or exceeds the median value (α-cut value), which is set at a minimum of 0.5 (Yusoff et al., 2021). The formula utilised for defuzzification is as follows:

$$Amax = \frac{1}{3}(m_1 + m_2 + m_3)$$

FINDINGS

Table 1 outlines teaching activities aligned with the heutagogical approach that mathematics teachers can employ. According to the expert group's perspectives and findings, there are 25 eligible and relevant teaching activities that mathematics teachers can implement during teaching and learning activities. The findings also show that teachers assign projects that require students to explore real-world applications of mathematical concepts, were ranked first, followed by other activities, while teachers arrange virtual sessions with guest speakers from the mathematics field to provide insights to real-world applications were ranked last.

Table 1
Teaching activities aligned with the heutagogical approach

No.	Activities	Threshold value (d)	Expert consensus	Score value (A)	Ranking
1	Teachers support students in choosing a specific area of mathematics for an in-depth project.	.150	94.4%	.837	21
2	Teachers present students with challenging mathematical problems.	.094	100.0%	.867	3
3	Teachers engage students in creating mathematical models to solve real-world problems.	.165	100.0%	.841	18
4	Teachers incorporate interactive online platforms that allow students to explore mathematical concepts.	.153	100.00%	.876	2
5	Teachers guide students to document their exploration of mathematical concepts.	.129	94.44%	.867	3
6	Teachers incorporate hands-on activities with manipulatives to facilitate a concrete understanding of abstract mathematical concepts.	.188	88.89%	.843	16
7	Teachers encourage students to create educational games that reinforce mathematical principles.	.165	88.89%	.841	18
8	Teachers utilise online platforms for collaborative projects.	.155	94.44%	.843	16
9	Teachers have students create digital videos explaining mathematical concepts.	.124	94.44%	0.861	8
10	Teachers assign projects that require students to explore real-world applications of mathematical concepts.	.119	94.44%	.881	1
11	Teachers foster collaboration between mathematics and other subjects.	.150	94.44%	.863	6
12	Teachers arrange virtual sessions with guest speakers from the mathematics field to provide insights to real-world applications.	.168	94.44%	.833	25
13	Teachers establish online forums where students can discuss mathematical concepts, ask questions, and share resources beyond the classroom.	.140	94.44%	.837	21
14	Teachers implement peer teaching sessions where students take turns explaining mathematical concepts to their classmates.	.162	88.89%	.867	3
15	Teachers organise a mathematics exhibition where students showcase their projects and discoveries.	.118	94.44%	.841	18
16	Teachers facilitate the formation of study groups where students can collaborate, discuss, and share resources.	.183	88.89%	.876	2
17	Teachers assign complex problems that require collaborative efforts.	.173	88.89%	.867	3
18	Teachers conduct seminars where students engage in deep discussions about mathematical concepts.	.126	94.44%	.843	16
19	Teachers initiate a class blog where students can share their mathematical creations, solutions, and insights with their peers.	.135	94.44%	.841	18
20	Teachers organise debates on mathematical problems.	.165	88.89%	.843	16
21	Teachers incorporate feedback loops, allowing students to revise their work based on peer and teacher feedback.	.183	88.89%	0.861	8
22	Teachers assign reflective journal entries where students analyse their learning experiences, challenges faced, and insights gained.	.150	94.44%	.881	1
23	Teachers guide students in setting personal learning goals and regularly tracking their progress.	.169	88.89%	.863	6
24	Teachers create a shared repository of challenging mathematical problems contributed by students.	.129	94.44%	.833	25
25	Teachers guide students in developing portfolios that display their work, along with reflections on the learning journey and personal development.	.157	88.89%	.861	8

DISCUSSION

The expert group's perspectives and research findings outline a comprehensive list of 25 eligible and pertinent teaching activities suitable for mathematics teachers during instructional sessions. These activities, firmly grounded in the heutagogical approach, underscore the importance of fostering student-centred and self-directed learning experiences. The primary research findings reveal that the first-ranked teaching activity involves teachers assigning projects that require students to delve into real-world applications of mathematical concepts. The research underscores the significance of exploration and creation in the learning process. Assigning students projects that prompt them to explore diverse paths and tap into various knowledge sources empowers students to embark on unique educational journeys (Cruz et al., 2023; Hariyanto et al., 2023). This method not only fosters a sense of autonomy but also motivates students to take ownership of their learning (Perera & John, 2020). The heutagogical principles manifest through the active encouragement of exploration, hypothesis formulation, and problem-solving extending beyond the realm of mathematics and are crucial for lifelong learning (Chimpololo, 2021). Moreover, the creation aspect of heutagogy becomes evident as students actively translate theoretical knowledge into practical application through project work. This dynamic process not only reinforces theoretical concepts but also instills a sense of creativity and innovation. Students are challenged to think critically, apply mathematical principles to real-world problems, and generate solutions, thereby fostering a learning environment where students actively contribute to their education, transcending the traditional role of passive information recipients (Gillaspy & Vasilica, 2021).

In contrast, teachers arranging virtual sessions with guest speakers from the mathematics field, aimed at providing insights into real-world applications, emerge as the least favoured activity, as per indications from the expert group. Despite the acknowledged potential value of guest speaker sessions in offering valuable perspectives and establishing connections with real-world applications, this specific activity may not align as effectively with certain facets of the heutagogical approach (Baharman et al., 2022). While the undeniable contribution of guest speaker sessions to bringing real-world relevance to the classroom is acknowledged, their effectiveness in promoting specific aspects of heutagogy might be limited. This limitation stems from the perception that virtual guest speaker sessions are more passive, positioning students as recipients of information rather than active participants in their learning journey (Kim, 2022). This passive characteristic of the activity raises questions about its compatibility with the principles of heutagogy, which emphasise self-directed learning, exploration, and creation. The potential variance in effectiveness is rooted in the inherent structure of virtual guest speaker sessions, where the interaction may be perceived as less dynamic compared to more hands-on and participatory activities (Karataş & Arpaci, 2021). Within the context of heutagogical learning, which thrives on actively engaging students in the learning process, this perceived passivity could be a significant factor contributing to the lower favorability of this teaching method.

CONCLUSION

In summary, the study meticulously outlines 25 relevant activities firmly rooted in heutagogical principles, placing a significant emphasis on fostering student-centred and self-directed learning experiences. The primary research findings underscore the effectiveness of mathematical projects, especially those integrating real-world applications, as the most impactful teaching activity. This departure from traditional methods serves as a testament to the dynamic and engaging educational model advocated by the study, effectively bridging the gap between theoretical knowledge and practical utility. This alignment with heutagogical principles reflects a contemporary and innovative approach to mathematics education. In essence, the study concludes that mathematics teachers can use the comprehensive list of teaching activities provided as a valuable guide to incorporate the heutagogical approach into their mathematics lessons. By leveraging these activities, teachers have the potential to facilitate a transformative shift in their instructional practices, promoting active engagement, exploration, and creativity among students. However, it is important to acknowledge a limitation of the study, which is the absence of implementation of the identified teaching activities in real educational contexts. This limitation may raise questions about the practical applicability and effectiveness of these activities in real classroom settings. In the future, other researchers can leverage the identified teaching activities as a foundation for designing and developing new teaching models. These models could further enhance the integration of heutagogical principles into real educational contexts. The findings open the door for ongoing exploration and innovation in instructional approaches, encouraging teachers and researchers alike to continue advancing teaching methodologies that align with the evolving landscape of education.

ACKNOWLEDGEMENT

This work was supported/funded by the Ministry of Higher Education under Fundamental Research Grant Scheme (FRGS/1/2023/SS107/UTM/02/20).

REFERENCES

Abdullah, S. A., Saud, M. S., Hisham, M. H. M., Wahid, N., Arsat, M., Suhairom, N., & Aripin, M. A. (2021). Determining elements in mobile learning implemention among instructors in vocational Colleges: A Fuzzy Delphi method. *IEEE Access*, *9*, 150839–150845. https://doi.org/10.1109/access.2021.3121703.

Abraham, R. R., & Komattil, R. (2017). Heutagogic approach to developing capable learners. *Medical Teacher*, *39*(3), 295-299. http://dx.doi.org/10.1080/0142159X.2017.1270433.

Agonács, N., & Matos, J. F. (2019). Heutagogy and self-determined learning: A review of the published literature on the application and implementation of the theory. *Open Learning: The Journal of Open, Distance and e-Learning*, *34*(3), 223-240. https://doi.org/10.1080/02680513.2018.1562329.

Alias, A. and Matore, M. (2023). Mathematics secondary school teacher readiness in applying heutagogical approach for teaching and learning. *International Journal of*

Academic Research in Progressive Education and Development, 12(1). https://doi.org/10.6007/ijarped/v12-i1/14794.

Amiruddin., Baharuddin, F. R., Takbir., Setialaksana, W., & Nurlaela. (2023). Andragogy, peeragogy, heutagogy and cybergogy contribution on self-regulated learning: A structural equation model approach. *International Journal of Instruction, 16*(3), 551-572. https://doi.org/10.29333/iji.2023.16330a.

Andriani, N., Ulfatin, N., Imron, A., & Sumarsono, R. B. (2023). Heutagogy and Indigenous knowledge in integrated thematic instruction and character education. *RGSA: Revista De Gestão Social E Ambiental, 17*(7), e03692. https://doi.org/10.24857/rgsa.v17n7-030.

Arayathamsophon, R., Jedaman, P., & Jongmuanwai, B. (2020). Developed to basic mathematic instructional activity of flipped mastery approach classroom via selfdirected learning for supporting analytical thinking skills and achievement of 11 great students. *International Journal of Innovative Science and Research Technology, 5*(9), 490-495. https://doi.org/10.38124/ijisrt20sep341.

Blaschke, L. M. (2019). The pedagogy–andragogy–heutagogy continuum and technology-supported personal learning environments. *Open and distance education theory revisited*, 75-84. https://doi.org/10.1007/978-981-13-7740-2_9.

Blaschke, L. M. (2021). The dynamic mix of heutagogy and technology: Preparing learners for lifelong learning. *British Journal of Educational Technology*, *52*(4), 1629-1645. https://doi.org/10.1111/bjet.13105.

Blaschke, L. M., & Hase, S. (2019). Heutagogy and digital media networks. *Pacific Journal of Technology Enhanced Learning*, *1*(1), 1-14. https://doi.org/10.24135/pjtel.v1i1.1.

Blaschke, L. M., & Marin, V. (2020). Applications of heutagogy in the educational use of e-portfolios. *Revista de Educación a Distancia (RED),* 20(64). https://doi.org/10.6018/red.407831.

Chamo, N., Biberman-Shalev, L., & Broza, O. (2023). 'Nice to meet you again': When heutagogy met blended learning in teacher education, post-pandemic era. *Education Sciences*, *13*(6), 536. https://doi.org/10.3390/educsci13060536.

Chan, C. G., Embi, M. A. B., & Hashim, H. (2019). Primary school teachers' readiness towards heutagogy and peeragogy. *Asian Education Studies*, *4*(1), 11. https://doi.org/10.20849/aes.v4i1.602.

Chimpololo, A. (2021). Disciplinary variations in the diffusion of heutagogical use of mobile technologies among student-teachers. *Education and Information Technologies*, *26*(4), 4821-4837. https://doi.org/10.1007/s10639-021-10505-3.

Cruz, S., Lencastre, J. A., & Viseu, F. (2023). Heuristics and usability testing of a project-based learning online course: A case study with structural mathematical concepts. *International Journal of Instruction, 16*(3), 465-488. https://doi.org/10.29333/iji.2023.16325a.

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020). Transformation of the mathematics classroom with the internet. ZDM, 52, 825-841. https://doi.org/10.1007/s11858-020-01176-4.

Fawns-Ritchie, C., & Deary, I. J. (2020). Reliability and validity of the UK Biobank cognitive tests. *PLOS ONE*, *15*(4), e0231627. https://doi.org/10.1371/journal.pone.0231627.

Gillaspy, E., & Vasilica, C. (2021). Developing the digital self-determined learner through heutagogical design. *Higher Education Pedagogies*, *6*(1), 135-155. https://doi.org/10.1080/23752696.2021.1916981.

Hainsworth, N., Dowse, E., Cummins, A., Ebert, L., & Foureur, M. (2022). Heutagogy: A self-determined learning approach for Midwifery Continuity of Care experiences. *Nurse Education in Practice*, *60*, 103329. https://doi.org/10.1016/j.nepr.2022.103329.

Handayani, S. M., Yeigh, T., Jacka, L., & Peddell, L. (2021). Developing a heutagogy approach to promoting teacher competencies in Indonesia. *Cypriot Journal of Educational Sciences*, *16*(3), 939-951. https://doi.org/10.18844/cjes.v16i3.5765.

Hariyanto, V. L., Hidayah, R., Pratama, G. N. I. P., & Syamsudin, R. N. (2023). Projectbased learning at vocational schools: A case study of the implementation of entrepreneurship learning model. *International Journal of Instruction*, *16*(3), 283-306. https://doi.org/10.29333/iji.2023.16316a.

Hasim, M. A., Jabar, J., Sufian, A., Ibrahim, N. F., & Khalid, F. A. (2023). Employing fuzzy delphi techniques to validate the components and contents of e-learning antecedents and usage behavior towards e-learning performance. *European Journal of Educational Research*, *12*(1). https://doi.org/10.12973/eu-jer.12.1.467.

Hidayat, R., Wahyudin, W., Jailani, J., & Setiadi, B. (2020). Improving elementary students' mathematical reasoning abilities through sociohumanistic-based learning. *Journal for the Education of Gifted Young Scientists, 8*(4), 1457-1469. https://doi.org/10.17478/jegys.750033.

Jones, C., Penaluna, K., & Penaluna, A. (2019). The promise of andragogy, heutagogy and academagogy to enterprise and entrepreneurship education pedagogy. *Education+ Training*, *61*(9), 1170-1186. https://doi.org/10.1108/ET-10-2018-0211.

Kamrozzaman, N. A., Badusah, J., & Ruzanna, W. M. (2020). Development of heutagogy approach in M-learning for sustainability education. *Education and Information Technologies, 25*, 3035-3047. https://doi.org/10.1007/s10639-020-10101-x.

Karataş, K., & Arpacı, İ. (2021). The role of self-directed learning, metacognition, and 21st century skills predicting the readiness for online learning. *Contemporary Educational Technology, 13*(3), ep300. https://doi.org/10.30935/cedtech/10786.

Kelly, C., & Lynes, A. (2023). Grand Theft Heutagogy: A reflection on the utilization of video games as a teaching tool in the lecture theatre. *Journal of Criminal Justice Education, 34*(4), 617–633. https://doi.org/10.1080/10511253.2022.2154375.

Kim, J. (2022). The interconnectivity of heutagogy and education 4.0 in higher online education. *Canadian Journal of Learning and Technology, 48*(4). https://doi.org/10.21432/cjlt28257.

Lim, S. B., Malek, J. A., Yussoff, F. Y., & Yiğitcanlar, T. (2021). Understanding and acceptance of smart city policies: Practitioners' perspectives on the Malaysian Smart City Framework. *Sustainability, 13*(17), 9559. https://doi.org/10.3390/su13179559.

Lock, J., Lakhal, S., Cleveland-Innes, M., Arancibia, P., Dell, D., & De Silva, N. (2021). Creating technology-enabled lifelong learning: A heutagogical approach. *British Journal of Educational Technology*, *52*(4), 1646-1662. https://doi.org/10.1111/bjet.13122.

Lynch, M., Sage, T., Hitchcock, L. I., & Sage, M. (2021). A heutagogical approach for the assessment of Internet Communication Technology (ICT) assignments in higher education. *International Journal of Educational Technology in Higher Education*, *18*(1), 55. https://doi.org/10.1186/s41239-021-00290-x.

Mohammadi, Z. N., Shafiei, N., & Araghieh, A. (2023). Identifying the dimensions and components of the heutagogical curriculum of the secondary high school. *Education*, *9*(2), 275-286. https://doi.org/10.22034/ijes.2021.541983.1184.

Moore, R. L. (2020). Developing lifelong learning with heutagogy: Contexts, critiques, and challenges. *Distance Education, 41*(3), 381-401. https://doi.org/10.1080/01587919.2020.1766949.

Mustapha, R., Mahmud, M., Paris, T. N. S. T., Musa, M. S., Awang, H., & Burhan, N. M. (2023). The factors of the drug addict relapse in Malaysia: the experts views and consensus. *Open Journal of Social Sciences, 11*(04), 160–173. https://doi.org/10.4236/jss.2023.114013.

Nasution, E., Alsa, A., & Indrawati, E. (2022). Self-regulated learning as mediator on the determinants of mathematics achievement in junior high school students in the city of dki jakarta pusat. *Journal Research of Social Science Economics and Management, 1*(10), 1791-1803. https://doi.org/10.36418/jrssem.v1i10.185.

Paris, T. N. S. T., Sundram, P. G. P. H., Mustapha, R., & Razlan, R. M. (2022). Revalidation of grammar attitude scale: the fuzzy delphi method approach. *International Journal of Academic Research in Business and Social Sciences, 12*(9). https://doi.org/10.6007/ijarbss/v12-i9/14882.

Perera, H. N., & John, J. E. (2020). Teachers' self-efficacy beliefs for teaching math: Relations with teacher and student outcomes. *Contemporary Educational Psychology*, *61*, 101842. https://doi.org/10.1016/j.cedpsych.2020.101842.

Rusli, R., Rahman, A., & Abdullah, H. (2020). Student perception data on online learning using heutagogy approach in the Faculty of Mathematics and Natural Sciences of Universitas Negeri Makassar, Indonesia. *Data in brief*, *29*, 105152. https://doi.org/10.1016/j.dib.2020.105152.

Samin, S. M., Pebrian, R., & Zulkifli, A. (2020). Heutagogy approaches for arabic learning in higher education in industrial revolution 4.0. *Revolution*, *4*, 454-457. https://doi.org/10.5220/0009382304540457.

Sholikhah, N., Pamungkas, H. P., Surjanti, J., & Sakti, N. C. (2022). E-Module of Mathematics Economic Using Heutagogy Approach for Distance Learning: Is it effective? *Journal of Education Technology*, *6*(2), 182–190. https://doi.org/10.23887/jet.v6i2.45619.

Stoten, D. W. (2020). Practical heutagogy: Promoting personalized learning in management education. *Adult Learning*, *31*(4), 161-174. https://doi.org/10.1177/1045159520905364.

Stoten, D. W. (2023b). *Positioning through epistemic cognition in higher education: conceptualising the ways in which academics in a business school view heutagogy*. Higher Education. https://doi.org/10.1007/s10734-023-01048-2.

Sürücü, L., & Maslakci, A. (2020). Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*, *8*(3), 2694-2726. http://dx.doi.org/10.15295/bmij.v8i3.1540.

Wang, J. C., Huang, K. T., & Ko, M. Y. (2019). Using the fuzzy delphi method to study the construction needs of an elementary campus and achieve sustainability. *Sustainability*, *11*(23), 6852. https://doi.org/10.3390/su11236852.

Webb, N. M., Franke, M. L., Ing, M., Turrou, A. C., Johnson, N. C., & Zimmerman, J. (2019). Teacher practices that promote productive dialogue and learning in mathematics classrooms. *International Journal of Educational Research, 97*, 176–186. https://doi.org/10.1016/j.ijer.2017.07.009.

Wiles, R., Thoeni, R. F., Barbu, S. T., Vashist, Y. K., Rafaelsen, S. R., Dewhurst, C., & Roberts, S. A. (2017). Management and follow-up of gallbladder polyps. *European Radiology, 27*(9), 3856-3866. https://doi.org/10.1007/s00330-017-4742-y.

Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 1-19. https://doi.org/10.1186/s41039-019-0100-9.

Yusoff, A. F. M., Hashim, A., Muhamad, N., & Hamat, W. N. W. (2021). Application of fuzzy delphi technique towards designing and developing the elements for the e-PBM PI-Poli Module. *Asian Journal of University Education*, *17*(1), 292-304. https://doi.org/10.24191/ajue.v17i1.12625.

Zulkifli, H., Rashid, S. M. M., Mohamed, S., Toran, H., Raus, N. M., Pisol, M. I. M., & Suratman, M. N. (2022). Designing the content of religious education learning in creating sustainability among children with learning disabilities: A fuzzy delphi analysis. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.1036806.