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Research article

Effects of online heutagogy approach in learning science via Telegram towards pupils' science process skills and creative thinking skills

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Abstract: The COVID-19 pandemic has necessitated the adoption of online learning methods worldwide, including in Malaysia. The Ministry of Education (MoE) in Malaysia has recognized the importance of online learning due to the implementation of Movement Control Order (MCO). However, the limitations of online learning, such as reduced interaction between teachers and pupils, have prompted educators to explore alternative approaches that emphasize self-directed learning. Hence, this study aimed to develop a learning method based on the heutagogy approach using the Telegram platform and examine its impact on science process skills and creative thinking skills in primary school pupils. The study employed a quantitative research design with a pre-experimental design and involved 20 Year 5 pupils. Pre-post tests were conducted to assess the skills, and the data were analyzed using descriptive and inferential analysis techniques. The descriptive analysis revealed a mean improvement in both Science process skills and Creative thinking skills following the intervention with the heutagogy approach. Furthermore, the inferential analysis confirmed a significant difference between pre- and post-test scores for both skills after integrating the heutagogy approach. The positive findings of this study shed light on the efficacy of the heutagogy approach in online learning, particularly in the context of science education for primary school pupils. These results offer valuable insights to educators who can consider incorporating the heutagogy approach into their teaching practices. By doing so, educators can enhance the learning experiences and outcomes of their pupils in science education.

Keywords:
online learning,
heutagogy,
science process skills,
creative thinking skills,
Telegram

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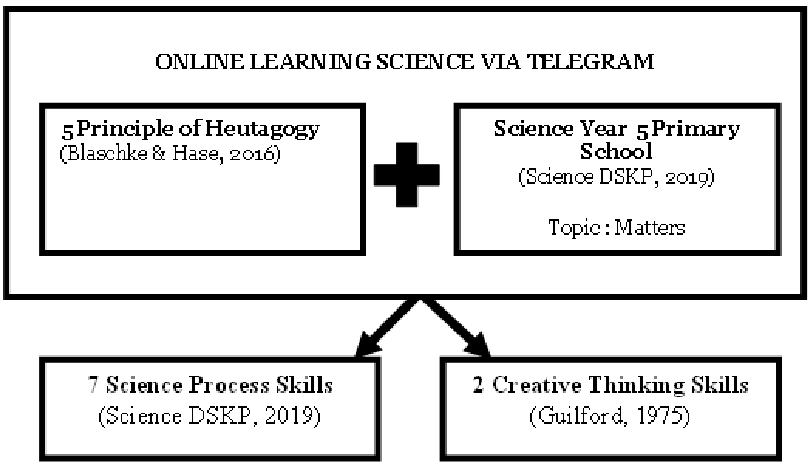

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1 Introduction

During the COVID-19 pandemic, countries worldwide are facing severe challenges in the global economy, social events, and education. In Malaysia, the government implemented a Movement Control Order (MCO) in 2020 to combat the spread of the virus, resulting in the closure of all educational institutions, including schools. Regrettably, the closure of institutes and the scrutiny to complete the stipulated syllabus in a specified time frame in accordance with the academic calendar driven educational institutions to embrace their concerns and implement emergency remote education. Therefore, online learning emerged as the primary solution for the education sector (Tang et al., 2021).

However, only one-third of pupils were satisfied with online learning during COVID-19. This could be due to the instructor's teaching approach, communication style, attitude, and use of technology, as well as underlying latent concepts (Ahmed et al., 2023). Moreover, in areas with limited internet access, the adoption of online learning has proven to be difficult. Synchronous online learning, which relies on platforms like Google Meet, Zoom, or Webex, heavily depends on the quality of internet connectivity. According to Azlan et al., (2020) and Chen et al., (2023), the effectiveness of instruction delivery in synchronous learning is highly reliant on the internet access quality. A poor connection can lead to disruptions during live sessions, negatively impacting the quality of course delivery. This situation is particularly challenging for pupils residing in rural regions or areas with inadequate internet infrastructure, especially those who struggle to afford monthly data packages and must rely on pay-as-you-go internet services. This remains a significant issue, considering that 22 percent of Malaysians live in rural areas (Malaysia Demographics, 2020).

An alternative platform that is more user-friendly and utilizes low internet data, such as Telegram, should be used in synchronous online learning to meet this requirement. Telegram allows for multi-directional communication, not limited to just two-way conversations. Group conversations enable users to communicate collectively, and features like Voice Chat and persistent conference calls provide additional opportunities for live conversation in Telegram groups and channels without participant limitations (*Telegram Official Website*, 2021). These functionalities are suitable for synchronous online learning. Researchers have started recommending and studying the use of Telegram apps, particularly in education. For instance, Redondo et al., (2021) found that Telegram bots effectively support micro-learning by providing multimedia content and micro-quizzes. Meanwhile, Ong et al., (2021) discovered that using the Telegram Quiz Bot improved distance learning for students, with over 90% of respondents responding positively. Similarly, Topal et al., (2021) found that using features like the Telegram Chat Bot enhanced the online learning experience for school students.

However, to use Telegram effectively as an online learning application, it is important to establish an appropriate teaching and learning approach. In the context of children being at home with less teacher supervision, the heutagogy approach is considered suitable. Kung-Teck et al., (2020) concluded in their study that heutagogy learning is a powerful tool for teachers, especially when teaching materials are made available online. The integration of heutagogy with mobile learning has been found to improve pupils' interest, stimulate their curiosity, and increase their confidence in learning scientific concepts. Heutagogy allows students to go beyond the confines of the curriculum and develop their own capabilities and potential (Hase & Kenyon, 2007). Pupils can take the initiative in their own learning process (Canning, 2010). Teachers, on the other hand, assume the role of facilitators and providers of skills and knowledge rather than acting as gatekeepers or masters of knowledge. Oliver, (2016) discovered that when self-directed learning (heutagogy) is effectively incorporated into pupils' habits, they become proficient graduates who can contribute their skills and knowledge to the development of their communities. Additionally, the online heutagogy learning environment has been found to positively impact creativity in multimedia implementation, as well as creativity in content organization and delivery during English presentations among Form 3 students (Daut & Halim, 2021).

The effective curriculum materials and instructional practices are essential for engaging pupils in scientific phenomena and engineering design (Guzey & Li, 2023). However, the effectiveness of integrating the heutagogy approach using Telegram as a learning platform to enhance pupils' Science process skills and Creative thinking skills in primary school science subjects remains uncertain. Therefore, this study aims to assess the impact of this approach by designing online learning activities that foster pupils' creative thinking skills and mastery of science process skills in science. Previous research has shown positive results when using mobile applications to enhance Science process skills and integrating technology to improve critical and creative thinking skills (Ekici & Erdem, 2020 ; Yılmaz, 2021). Hence, this study explores the integration effect of the heutagogy approach with technological tools.

The research objectives include:

- To design online learning activities integrated with heutagogy approach for learning science via Telegram in primary school pupils.
- To investigate the effect of online learning activities integrated with heutagogy approach for learning science via Telegram towards pupil’s Science process skills.
- To investigate the effect of online learning activities integrated with heutagogy approach for learning science via Telegram towards pupil’s Creative thinking skills.

This study is being conducted concurrently to meet the first and second core objectives of Malaysia's Digital Education Policy 2023, which are to produce digitally fluent pupils and digitally competent educators (MoE, 2023) as well as to contribute to Malaysia's Sustainable Development Goal 4: improving educational quality by increasing net primary enrolment rates in primary education (Sustainable Development Report, 2024) .

2 Literature review

2.1 Telegram

Telegram is a messaging app with a focus on speed and security, it’s super-fast, user friendly, simple and free. We can browse our messages from multiple devices at the same time, which include computers and tablets. It is a cloud-based messenger with seamless sync that allows us to exchange an infinite number of images, videos, and files (mp3, doc, zip, and so on) up to 2 GB each (*Telegram Official Website*, 2021). This functionality may be utilised for asynchronous online learning, allowing instructors to exchange knowledge and instructional materials.

Moreover, Telegram is among the most user-friendly and successful online platforms. According to Selvaraj et al., (2021), applications with user-friendly criteria, such as WhatsApp and Telegram, are more preferred platforms (68%) compared to Google Meet, Zoom, YouTube, Microsoft teams, and Webex because they are simple to use and do not require any technical skills to operate, particularly by school pupils. It is a social media platform that goes beyond conventional text chatting. They have given its users with several tools through which they may share messages with huge audiences, in addition to real-time text, voice/video, and file transfer (Nobari et al., 2021). Therefore, a learning approach based on this application should be investigated to enhance online learning, particularly for pupils in Malaysia's rural and sub-urban regions. In this study, Telegram was used as the platform for learning, with the Telegram group function for distributing learning materials, conducting bilateral discussions between the teacher and the pupil via Telegram voice chat, selecting learning methods via Telegram polls and allowing pupils to lead idea-sharing sessions with other pupils and teachers.

2.2 Heutagogy approach

Heutagogy is the study of self-determined learning acknowledges that pupils seek out their own learning experiences, acquire learning capacity, reflect on their own learning processes, and apply information and skills to complicated challenges, frequently in unfamiliar or changing situations (Blaschke & Hase, 2016; Hase & Kenyon, 2007). Bykasova et al., (2021) stated that the mission of heutagogy is subject self-learning, and the teacher's task as a facilitator is to create situations for the subject's learning, facilitate specific resources, and deliver instructional content as part of the learning.

This study draws on heutagogy learning approach Blaschke & Hase, (2016), as a theoretical lens to explore the efficacy through the online learning. There are five principles adapted into the learning approach of online learning in primary school. This principle covers how to create a heutagogical lesson which will be implemented throughout the online learning via the Telegram platform with an emphasis on many concepts that distinguish it from the pedagogy and andragogy approaches. A concise overview of the five fundamental principles in heutagogy based on Blaschke and Hase (2016) is presented in Table 1.

Table 1. Overview on heutagogy principle

Heutagogy principle	Description
Learner-centered and learner determined	In the learning environment, the heutagogy approach gives pupils autonomy. Pupils are given the opportunity to choose what they will study and how it will be carried out and evaluated.
Capability	Capability evaluates pupils' ability and competency in communication, creativity, self-efficacy, positive values and teamwork.
Self-reflection and meta-cognition	Pupils could self-reflect on what they've learned and how they learned it in a comprehensive way.
Double-loop learning	Pupils should be able to be psychologically and behaviorally engaged in double-loop learning. They should be able to discern how new information affects their belief system and values.
Nonlinear learning and teaching	The pupils define the teaching and learning environment. Since learning is self-determined, it will take a nonlinear format.

2.3 Science process skills

According to Ekici & Erdem, (2020), one of the primary goals of science education is the mastery of science process skills. Science process skills are the abilities necessary to solve issues and make choices in a methodical manner. These skills are selected because it is the main fundamental skills in the conceptual framework for Malaysian Science Curriculum, which are required to carry out tasks that use scientific methods such as experimentation and project management (BPK, 2019).

Science process skills were divided into two categories: basic and integrated skills. Basic skills serve as the foundation for acquiring more sophisticated integrated skills. The basic skills are classifying, observing, measuring and using numbers, making inferences, communicating, and predicting, whereas the integrated skills include interpreting data, defining operationally, making hypothesis, experimenting, using space-time relationship and controlling variables (BPK, 2019) .

Previous researcher has shown that using a mobile application on science process skills makes pupils more active and motivated (Ekici & Erdem, 2020). This study is also supported by Elfeky et al., (2020), who found that using advance organisers via Learning Management System (LMS) on economic pupils promoted their science process skills better than skills promoted by their colleagues who did not use advance organisers. Moreover, Khamhaengpol et al., (2021) discovered that using the proposed Science, Technology, Engineering and Mathematics (STEM) activity, the performance of pupils on the basic science process skills was rated as good and fair, respectively.

However, a study conducted by PISA (Program for International Pupil Assessment) in 2018 found that Only 1% of Malaysian pupils were top scorers in science, indicating they were skilled at Level 5 or 6. (Organisation for Economic Co-operation and Development, OECD average: 7 percent) (Markus, 2019). Therefore, this study urges a more in-depth study to improve primary school pupils' science process skills. However, the researcher will concentrate on only seven science process skills in this research based on the suitability of the topic studied which are observing, classifying, making inferences, predicting, interpreting data, controlling variable and making hypothesis.

2.4 Creative thinking skills

Apart from Science process skills, another skill that is key to learning and become a demand in the twenty-first century workforce is Creative thinking skills. Correspondingly, when pupils develop new ways and solutions to resolve issues, they employ both creative thinking and fundamental scientific process skills (Ozdemir & Dikici, 2017). Creative thinking skills is the ability to solve a problem and the creation of an organised style of thinking logically connected to the substance of knowledge (Prusak & Hershkowitz, 2015). Hanifah & Subiyantoro, (2020) in their research stated that Creative thinking skills is one of three keys to innovative learning skills for twenty-first Century.

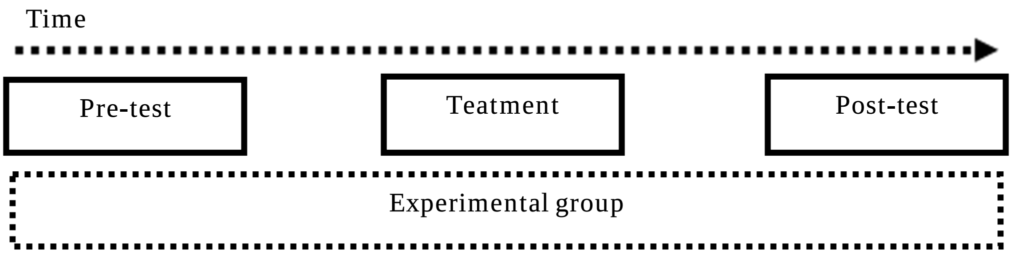
Saeed & Ramdane, (2022)highlighted the significance of developing creative thinking abilities in the field of education, stating that education should be focused on growing pupils' creativity so that they may fulfil the demands and needs of the country's people. Likewise, Yılmaz, (2021) discovered that gradual integration of technology into the education process results in a positive change in prospective teachers' critical and creative thinking. Meanwhile, Yildiz & Yildiz, (2021)in their study stated that the connection between the two sets of skills (science process skills and creative thinking skills) be investigated to create appropriate environments for cultivating these training provides pupils with 21st century skills. Exploring the connection between creative thinking and scientific process skills could provide researchers with new insights into the nature of these skills. Hence, creative thinking skills is one of the interesting elements to be studied along with science process skills. However, the researcher will concentrate on only two creative thinking skills in this study, that are fluency and flexibility. These skills are selected based on the suitability of the topic studied (Topic Matter in Science year 5).

3 Methodology

3.1 Research design

This research employed a quantitative research design called a pre-experimental design, specifically a one-group pre and post-test design. The aims of using pre-experimental designs are to determine causal relationships identical to using experimental designs. Pre-experimental designs are chosen because they are frequently utilised in contexts when pure randomization is not possible, making them better suited to real-world settings, particularly education (Shadish et al., 2002). Purposive sampling was used to select 20 respondents from year 5 pupils (11 years old) from a primary school in Malaysia which they have access to the internet with appropriate gadgets to involved in this study. All participants received the same treatment and evaluation, and the effects of the treatment were measured by comparing the scores from the pre-test and post-test. The research design for this study is depicted in Figure 1 below.

Figure 1. Research design



The purpose of this design was to assess the level of mastery in science process skills and creative thinking skills using the heutagogy approach, specifically in the science year 5 lesson focused on the topic of Matter. An overview of the research procedure can be found in Table 2.

Table 2. Research procedure

Phase	Activities
Phase 1	Lesson Design • Designing online heutagogy based-lesson in science via Telegram
Phase 2	Instruments Development • Science process skills test • Creative thinking skills test
Phase 3	Pilot Study
Phase 4	Treatment • Pre-test - Implementation of heutagogy-based lesson – Post test
Phase 5	Data Analysis

In Phase 1: Lesson Design, the researchers developed a lesson using the heutagogy approach for online science learning on the Telegram platform. Phase 2 involved the development of two sets of questions as the main instruments. One set assessed Creative thinking skills, while the other set evaluated the pupils' mastery of science process skills in the topic of Matter.

Phase 3 consisted of a pilot study to assess the validity and reliability of the instruments. Content experts, including science teachers, officials from the state department, and senior lecturers, reviewed the rubrics to ensure they aligned with the research criteria and addressed the research questions. The pilot study involved with respondents who had similar characteristics to the actual respondents. The researcher reviewed the items and analyzed the data using Statistical Package for Social Science (SPSS) 22, employing the method of Cronbach's Alpha. Table 3 below indicate the result of science process skills and Creative thinking skills instrument reliability.

Table 3. Reliability Statistic for science process skills and creative thinking skill test

Tests	Cronbach's Alpha	Cronbach's Alpha based on standardized items
Science process skill	.93	.94
Creative thinking skill	.88	.90

The obtained alpha values for the Science process skill Test (0.93) and Creative thinking skills (0.88) indicate high reliability, as suggested by Hussin, (2014) where alpha values of 0.80 and above are considered reliable.

The main part of the research procedure is Phase 4: Intervention, which comprises three stages: pre-test, implementation of heutagogy-based lessons, and post-test. A total of 20 respondents were purposively sampled from Year 5 pupils and participated in online heutagogy learning lessons in science using the Telegram platform. The treatment phase begins with a pre-test to assess the pupils' initial level of knowledge using the designed instruments. Subsequently, science learning sessions utilizing an online heutagogy approach were conducted for two weeks, divided into three parts: goal setting, taking action, and tailoring goals and planning. Each section applied the relevant heutagogy learning principles. After the treatment phase, the pupils were evaluated again using the same instruments to determine the effectiveness of the learning strategy in the post-test. The study was conducted within a two-week timeframe, aligning with the time allocated by the Ministry of Education Malaysia for the subject's syllabus DSKP Science. The final phase is Phase 5: Data Analysis. Data from the pre-test and post-test using both instruments will be evaluated using the SPSS.

3.2 Heutagogy learning environment

For science learning sessions utilizing an online heutagogy approach, the treatment phase was divided into three main parts viz Setting Goal, Taking Action and Tailor Goal & Planning. In learning phase 1: Setting Goal, researchers created a "Heutagogy Science Year 5" group on the Telegram as a primary platform used in heutagogy's approach for online science learning in this research. Following group formation, researchers provide guidance on the textbook-based content to be studied. Guidance was given for learning sessions for every week for 2 weeks according to the learning content standard. Using a voice-chat app, the researchers then discussed with respondents about the best way to learn each topic. This is a two-way communication where pupils discuss and express their opinions on the best way for them to learn each content standard. This step indirectly increases pupils' capabilities, especially in communication and self-efficacy. Following a two-way discussion, pupils select the best method of learning that suits their ability. Teachers created a poll for pupils to vote on the best learning methods of their choice. This is aligning with the pedagogical framework of heutagogy, which emphasises granting pupils an opportunity in determining both the content and the methods of their learning, as well as the means of evaluating their progress.

During the second phase: Take Action, pupils incorporate lessons into their preferred method. In the chat group, pupils shared pictures or videos of their preferred learning methods. Pupils then complete the liveworksheet.com module assigned by the teacher for each content. Furthermore, for nonlinear learning and teaching elements, teacher leads idea-sharing sessions in the Telegram group on how pupils learn each topic on a regular basis. Teachers share notes, videos, links and course materials to expand the topic's source of information. In addition, pupils were also tested using training modules from liveworksheet.com platforms and quizzes from the Quizziz app to assess their capabilities. Accumulated scores were given to each module, and pupils were able to compare their abilities to those of their peers.

In the third phase: Tailor Goal & Planning, teacher leads a discussion session to go over the module's learning outcomes. Pupils used two-way communication via audio/video chat to identify their weaknesses and make improvements. Pupils also reflect on their work again based on the outcomes of the discussion session. This step emphasis on self-reflection and metacognition principle in which pupils could conduct a comprehensive self-reflection on what they have learned and how they have acquired it. In the final step of this phase, drive by double-loop learning principle, pupils improve the outcomes of each other's work based on discussions with the teacher and colleagues. The final product of work was sent for evaluation in the form of drawings, mind maps, models, and so on as per selected by pupils. Additionally, Table 4 provides detailed information on the learning environment developed for the two-week lessons.

Table 4. Heutagogy learning environment in science lesson

Learning phase	Heutagogy principle	Activities
Phase 1: *Setting Goal*	Learner-centered and learner-determined	Pupils identify and choose the content to be studied. Pupils will complete the following items; i) The content to be studied based on textbook. ii) The methods they will learn the content. Example of methods are; • Reading notes. • Watching and learn from videos. • Carry out activities/ experiment in textbook. Pupil will choose at least one their own learning method for the selected content via Telegram poll.

	Capability	Using the voice chat feature in the Telegram, pupils discussed the best methods they choose for learning the content. Teachers guide and give examples on how pupils might learn about the content.
	Self-reflection and metacognition	Pupils will reflect and select the most effective method for themselves (reading notes/watching videos/conducting activities) to learn the content.
Phase 2: *Take Action*	Nonlinear learning and teaching	Pupils incorporate lessons using their preferred method. Pupils will complete the module in liveworksheet.com given by teacher for the content.
		Teacher guides idea-sharing sessions regarding how pupils learn each content from time to time in Telegram group. Teachers share notes, videos and quiz to increase the source of information on the topic.
	Capability	Pupils achieve their learning objectives by complete the module.
Phase 3: *Tailor Goal & Planning*	Nonlinear learning and teaching	Teachers conduct a discussion session to discuss the learning outcomes in the module.
	Double-loop learning	Pupils reflect again on their work in module based on output of discussion session. Pupils revise their works and learning method based on the output.
	Learner-centered and learner determined	Pupils make improvements/corrections on their work in module based on output of discussion session.

3.3 Research instrument

3.3.1 Science process skills test

In this research, science process skills is one of the skills being measured. Science process skills refers to the abilities needed to solve problems and make decisions in a systematic manner, as defined in the curriculum standard document and Year 5 Primary School Science assessment, DSKP Science. The measurement of pupils' mastery of Science process skills is based on the definition provided in the curriculum and the assessment format used in the Primary School Assessment Test (UPSR) paper 2. A total of seven SPS were selected, based on their relevance to the topic of Matter under the Material Science theme. The details distribution of questions and marks for seven types of science process skills adapted from DSKP Science 2019 will be measured in this study are as shown in Table 5 below.

Table 5. Distribution of questions and marks for science process skills test

Science process skills	Total of questions	Total of marks
Observing	3	4
Classifying	1	3
Making inferences	3	3
Predicting	3	3
Interpreting data	3	4
Controlling variable	1	2
Making hypothesis	1	1
Total	**15 Questions**	**20 Marks**

3.3.2 Creative thinking skills Test

Another skill measured in this research is creative thinking skills, which refers to the ability to generate novel and valuable ideas through imaginative and unconventional thinking, as defined in the DSKP Science 2019. Creative thinking skills in this study is assessed using the subjective section format of UPSR questions and guided by the indicators proposed by Guilford (1975), specifically fluency and flexibility, as mentioned by Adhiriyanthi et al., (2021). The selection of creative thinking skills items is based on their relevance to the topic of Matter in Science Year 5. Table 6 provide the details for distribution of questions and marks for two Creative thinking skills adapted.

Table 6. Distribution of questions and marks for Creative thinking skills Test

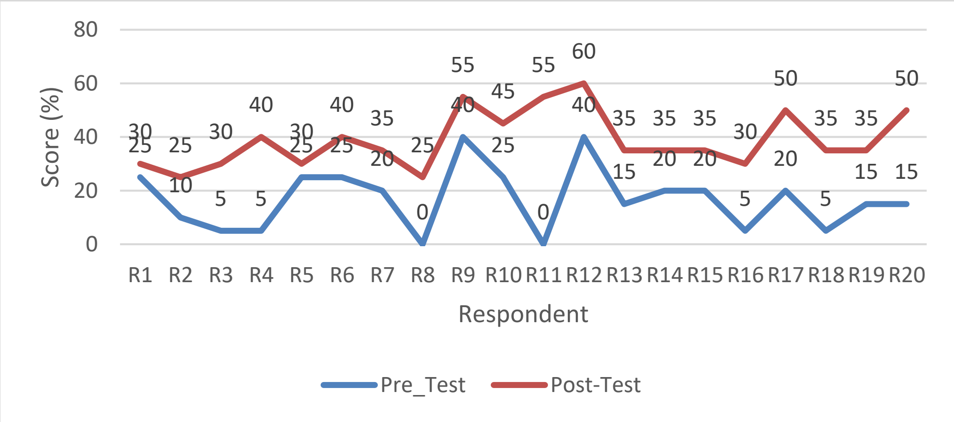
Creative thinking skills	Total of questions	Total of marks
Fluency	2	10
Flexibility	2	10
Total	**4 Questions**	**20 Marks**

4 Result and discussion

4.1 Science process skills analysis and discussion

To achieve the research questions on “What are the effect of online learning activities integrated with heutagogy approach for learning science via Telegram towards pupil’s Science process skills?”, the scores for the pre and post-tests of the Science process skills Test were analyzed using descriptive and inference methods. The maximum score for each test is 20 marks, but to facilitate understanding, the scores were converted into percentage values. Figure 2 illustrates the differences in scores before and after the treatment intervention for each participant.

Figure 2. Comparison of pre-post-test score for science process skills



Based on the analysis of mean scores for each Science process skill, as shown in Table 7, the total mean score for the pre-test of 20 respondents was 17.00%, while the total mean score for the post-test was 38.50%. This indicates an increase of 21.50% in the mean score after implementing the intervention using the online heutagogy approach. Therefore, it can be concluded that pupils' Science process skills improved after completing the online learning process with this heutagogy approach. Among the different skills, observing showed the highest increase in the mean score, with a change of 7.75, while controlling variable skills exhibited the least increase, with a mean score change of 0.50. Making hypothesis skills did not experience any change in the mean score. Overall, all Science process skills tested in the pre-post tests showed an increase in the mean score, except for making hypothesis skills.

Table 7. Comparison of mean score for each Science process skills measured

No	Science process skills score (%)	Pre-test mean score (%)	Post-test mean score (%)	Pre-post test mean difference
1	Observing (20m)	1.50	9.25	+7.75
2	Classifying (15m)	9.00	12.75	+3.75
3	Making Inferences (15m)	3.00	7.00	+4.00
4	Predicting (15m)	3.25	6.5	+3.25
5	Interpreting Data (20m)	0.00	2.25	+2.25
6	Controlling Variable (10m)	0.25	0.75	+0.50
7	Making Hypothesis (5m)	0.00	0.00	0.00
	Total mean overall score	**17.00**	**38.50**	**21.50**

*m = marks

To support this finding, the researcher also conducted an inferential analysis to determine the significance of differences in the mean scores of the Science process skills tests. Since the number of respondents is fewer than 30, the Wilcoxon Signed Rank test was chosen for this analysis. The hypotheses for this test are as follows:

H0: There is no significant difference in the mean score between the pre-test and post-test for science process skills after undergoing online learning using the heutagogy approach in science lessons via Telegram.

H1: There is a significant difference in the mean score between the pre-test and post-test for science process skills after undergoing online learning using the heutagogy approach in science lessons via Telegram.

Table 8. Wilcoxon signed ranked test for Science process skills test

Ranks				
		N	Mean rank	Sum of ranks
Post-test - Pre-test	Negative ranks	0[a]	.00	.00
	Positive ranks	20[b]	10.50	210.00
	Ties	0[c]		
	Total	20		
a. Post-test < Pre-test, b. Post-test > Pre-test, c. Post-test = Pre-test				

Test statistics[a]	
	Post-test - Pre-test
	-3.938[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test, b. Based on negative ranks.	

The Wilcoxon signed rank test (Table 8) revealed a significant difference in the scores for the Science process skills Test between the pre-test and post-test ($Z = -3.938$, $p < .001$), indicating an improvement in the scores after implementing the heutagogy approach. All 20 post-test scores were higher than the pre-test scores, with a mean increase of 10.50 ranks ($M+ = 10.50$, $M- = 0.00$), demonstrating a positive enhancement in skills. The total increase in marks amounted to 210.

In this study, the researchers examined seven Science process skills, categorized into basic and integrated skills, through pre-post-tests. The results indicated that pupils showed better proficiency in basic skills, with mean score increases ranging from +3.25 to +7.75, compared to integrated skills, which only had a range of 0.00 to +2.25. However, the overall scores for pupils remained relatively low, ranging from 25% to 60% even after the treatment. It is worth noting that none of the pupils answered the question on scientific process hypotheses correctly, indicating a lack of mastery in this skill. Similarly, there was only a minimal mean increase of 0.5% for the question on controlling variables, which highlights the need for further emphasis and instruction on these integrated skills.

To address these findings, the heutagogy approach used in the study emphasized non-linear teaching and learning activities, such as videos and teacher notes on the Telegram platform. This approach aims to facilitate a deeper understanding and mastery of integrated science process skills. The importance of incorporating heutagogy teaching frameworks, which support flexible, interactive, and multi-modal learning, was also recognized by Kung-Teck et al., (2020). By implementing innovative teaching methods, there is a potential for significant improvement in pupils' development of creative thinking and scientific process skills, as highlighted by Mohd Yunos et al., (2017).

4.2 Creative thinking skills analysis and discussion

To answer the next research questions on "What are the effect of online learning activities integrated with heutagogy approach for learning science via Telegram towards pupil's creative thinking skills?", the instrument named Creative thinking skills test was distributed pre and post intervention with a total of 20 points each. These scores are converted to percentage values for better comprehension. Figure 3 displays the results of the pre- and post-test marks for Creative thinking skills on 20 respondents, including the score differences between the two tests for each individual.

R3 achieved the lowest score of 5% in the pre-test, while R19 obtained the highest score of 50%. In the post-test, R1 and R17 had the lowest scores (20%), while R9 achieved the highest score of 75%. The score range for the Creative Thinking Pre-Test was between 5% and 50%, and for the Creative Thinking Post-Test, it was between 20% and 75%. Out of the respondents, 17 showed an increase in scores, while three did not experience any changes. The highest score improvements were observed in R9 and R12, with a 40% increase. On the other hand, the lowest score improvements were seen in R10 and R15, with only a 5% increase. Notably, three respondents did not exhibit any changes in their scores. The research focused on two Creative thinking skills, namely fluency and flexibility, based on the topics covered. Table 9 summarizes the mean improvements in the pre-post-skill test for each of these Creative thinking skills.

Figure 3. Overall difference score for Creative thinking skills test

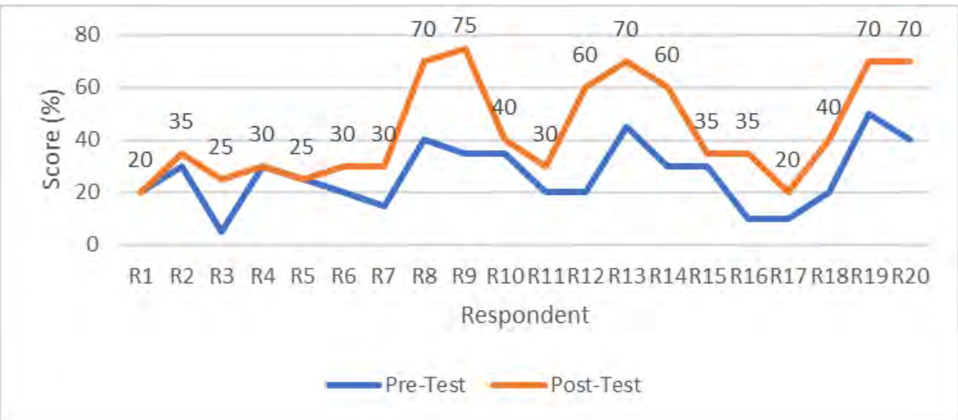


Table 9. Comparison of mean score for each Creative thinking skills measured

No	Creative thinking skills score (%)	Pre-test mean score (%)	Post-test mean score (%)	Pre-post test mean difference
1	Fluency (50 marks)	17.25	26.25	+9.00
2	Flexibility (50 marks)	9.75	17	+7.25
	Total mean overall score	27	43.25	+16.25

The pre-test mean score for the 20 respondents in Creative thinking skills was found to be 27.00%, while the post-test mean score was 43.25%. This indicates an increase in the mean score of 16.25% after implementing the online heutagogy approach intervention. When comparing the two skills, it was observed that fluency showed the highest increase in the mean score, with a value of 9.00, while flexibility exhibited the lowest increase, with a mean score increase of 7.25. Overall, both Creative thinking skills demonstrated an increase in the mean score in the pre-post-tests, indicating an improvement in pupils' Creative thinking skills after completing the online learning process using the heutagogy approach.

In the inferential analysis for Creative thinking skills, the Wilcoxon Signed Rank Test was used. The hypotheses for this analysis were as follows:

H0: There is no significant difference in the mean score between the pre-test and post-test for Creative thinking skills after undergoing online learning using the heutagogy approach on science's lessons via Telegram.

H1: There is a significant difference in the mean score between the pre-test and post-test for Creative thinking skills after undergoing online learning using the heutagogy approach on science's lessons via Telegram.

The Wilcoxon Signed Rank Test (Table 10) was conducted to analyze the pre- and post-test scores for the Creative thinking skills Test. The obtained Asymp. Sig. (2-tailed) score was 0.000, indicating a significant difference between the two test scores. The Z-score of -3.631 and the p-value of $p (0.000) < 0.05$ further support the rejection of the null hypothesis. The rank analysis revealed that 17 post-test scores were higher than the pre-test scores, with a mean positive rank value of 9.00 compared to a mean negative rank value of 0.00. This indicates an average score increase of 9.00 (total increase of 153 scores) from the pre-test to the post-test. Hence, it can be concluded that online learning via Telegram, using the heutagogy approach in science lessons, significantly improved pupils' Creative thinking skills ($p < 0.05$).

Table 10. Wilcoxon signed ranked test for Creative thinking skills test

Ranks				
		N	Mean rank	Sum of ranks
Post-test - Pre-test	Negative ranks	0[a]	.00	.00
	Positive ranks	17[b]	9.00	153.00
	Ties	3[c]		
	Total	20		

a. Post-Test < Pre-Test, b. Post-Test > Pre-Test, c. Post-Test = Pre-Test

Test statistics[a]	
	Post-test - Pre-test
Z	-3.631[b]
Asymp. sig. (2-tailed)	.000

a. Wilcoxon signed ranks test, b. Based on negative ranks.

In this study, researchers examined two of Guilford's Creative thinking skills: fluency and flexibility, using pre-post-tests. The results showed that pupils demonstrated greater proficiency in fluency skills, with a mean score increase of +9.00, compared to flexibility skills, which had a mean score increase of +7.25.

However, it is important to note that the implementation of the online heutagogy approach has not yet reached its full potential. The overall mean score for creative thinking skills remained low, with an average of 47.65%, indicating that pupils' creative thinking skills still have room for improvement. This finding aligns with previous studies by Hanifah & Subiyantoro, (2020) and Leasa et al., (2021), which also found low levels of creative thinking skills among participants even interventions.

To address this issue, improvements can be made in phase 2: Take Action. Diversifying learning activities and modules, such as puzzles, small experiments, and problem-solving tasks, can be incorporated to encourage pupils to think more creatively and enhance their creative thinking skills. Additionally, integrating game-based modules using mobile applications within the online heutagogy approach can make the learning process more engaging for pupils and indirectly contribute to the improvement of their creative thinking skills. This finding is supported by Yılmaz, (2021), who discovered that gradually integrating technology into the educational process leads to positive changes in critical and creative thinking abilities.

5 Conclusions

In sum, this study aimed to explore the impact of online learning activities integrated with a heutagogy approach on science education via Telegram on pupils' science process skills and creative thinking skills. The study successfully achieved its research objectives and found that this online teaching environment using the heutagogy approach positively influenced the development of both science process skills and creative thinking skills in pupils. It suggests that the heutagogy approach can be adapted in science teaching for primary school education, particularly in self-learning situations where pupils have more control over their learning.

Additionally, this research highlights Telegram as a viable online learning platform that meets the minimum requirements for effective online teaching. While it may not have all the features of platforms like Google Meet or Zoom, Telegram enables teachers to deliver online lessons effectively and allows for diversification of teaching platforms based on pupils' access to learning gadgets and local internet availability. By integrating Telegram with the heutagogy approach, it is anticipated that it will foster the development of more creative and competitive pupils who possess 21st Century Skills, including critical thinking, problem-solving, and life and career skills, aligning with the goals of the Ministry of Education Malaysia.

However, this study focused only on year 5 pupils from a single suburban school. Due to the limited number of respondents, it was not possible to form a control group to compare this heutagogy teaching approach to the traditional method of learning. As a result, the findings of this study cannot be generalized to the pupil’s population other than the study area.

The implications of this study extend to educators, providing them with insights into the potential benefits of integrating heutagogy and online learning platforms like Telegram. Furthermore, it suggests avenues for further research in exploring the effectiveness of this approach in different educational contexts and subject areas, as well as investigating additional factors that may influence the outcomes of online heutagogical instruction.

Research ethics

Author contributions

Abdullah Abdul Halim designed the study, performed data collection, and wrote the original manuscript with support and guidance from the other authors. Noor Dayana Abd Halim supervised the work as well as contributed to the planning, discussion of the results and the final manuscript. All authors read and approved the manuscript. All authors have read and agreed to the published version of the manuscript.”

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Conflicts of Interest

The authors declare no conflicts of interest.

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