Data and Metadata. 2025; 4:476
doi: 10.56294/dm2025476

ORIGINAL

Leveraging Smart Home Training Kits as an Innovative Educational Tool to Foster Higher-Order Thinking Skills

Aprovechamiento de los kits de formación para hogares inteligentes como herramienta educativa innovadora para fomentar las capacidades de pensamiento de orden superior

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Cite as: Sukardi, Candra O, Mirshad E, Zaus MA, Islami S. Leveraging Smart Home Training Kits as an Innovative Educational Tool to Foster Higher-Order Thinking Skills. Data and Metadata. 2025; 4:476. https://doi.org/10.56294/dm2025476

Submitted: 02-03-2024 **Revised:** 23-07-2024 **Accepted:** 13-11-2024 **Published:** 01-01-2025

Editor: Adrián Alejandro Vitón-Castillo

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ABSTRACT

This study examines the effectiveness of Smart Home Training Kits in enhancing Higher-Order Thinking Skills (HOTS) among vocational education students. The research follows a quasi-experimental design involving two groups: an experimental group utilizing Smart Home Training Kits and a control group employing traditional instructional methods. Pre-tests and post-tests were administered to evaluate improvements in critical thinking, problem-solving, and creativity. Results indicate a significant improvement in HOTS within the experimental group, demonstrating superior performance in analyzing, evaluating, and synthesis of potential solutions related to smart home concepts. Furthermore, the Smart Home Training Kits provided detailed, practical insights into technical principles, allowing students to gain a more realistic understanding of complex topics. The findings suggest that integrating Smart Home Training Kits into vocational curricula could bridge the gap between theory and practice, fostering critical thinking and innovation skills essential in addressing modern workplace challenges.

Keywords: Smart Home Training Kits; Higher-Order Thinking Skills; Vocational Education; Innovative Tools.

RESUMEN

Este estudio examina la eficacia de los kits de capacitación para hogares inteligentes para mejorar las habilidades de pensamiento de orden superior (HOTS) entre los estudiantes de educación vocacional. La investigación sigue un diseño cuasiexperimental que involucra dos grupos: un grupo experimental que utiliza kits de capacitación para hogares inteligentes y un grupo de control que emplea métodos de instrucción tradicionales. Se administraron pruebas previas y posteriores para evaluar las mejoras en el pensamiento crítico, la resolución de problemas y la creatividad. Los resultados indican una mejora significativa en HOTS dentro del grupo experimental, lo que demuestra un rendimiento superior en el análisis, evaluación y síntesis de posibles soluciones relacionadas con conceptos de hogar inteligente. Además, los kits de formación para el hogar inteligente proporcionaron información práctica y detallada sobre los principios técnicos, lo que permitió a los estudiantes obtener una comprensión más realista de temas complejos. Los hallazgos sugieren que la integración de kits de capacitación para hogares inteligentes en los planes de estudios vocacionales podría cerrar la brecha entre la teoría y la práctica, fomentando el pensamiento crítico y las habilidades de innovación esenciales para abordar los desafíos del lugar de trabajo moderno

Palabras clave: Kits de Formación Para Hogares Inteligentes; Habilidades de Pensamiento de Orden Superior; Educación Vocacional; Herramientas Innovadoras.

INTRODUCTION

Vocational education is very essential in developing the students to have the appropriate technical competencies for them to take to the job market. However, the problems characteristic of the 21st century require people more than simply having the necessary set of skills. Another component a student should demonstrate is higher-order thinking skills (HOTS) which include problem-solving, critical thinking, and innovation. HOTS is fast becoming indispensable because the current careers demand knowledge, and the ability to educate, adapt, and proactively design solutions. Thus, there is a necessity for the formation of the respective skills in the framework of vocational training, therefore, skills promoting the usage of such learning methods are required.[1]

This study aspires to identify various difficulties in the field of vocational education and one of them is the issue regarding the theory-practice relationship. Students have difficulties when applying certain concepts and knowledge they have in their heads to actual life scenarios. The use of project-based learning and mutual interactive tools can support this context. With the advancement in technology, the education sector is going through a major change with the help of new technological learning aids.[2] Another is Smart Home Training Kits which enables the students to learn directly through smart home technology training. Further, while computers and other technology media have advanced the classroom learning process, such tools used do not mimic real-life applications of the skills being taught to prepare learners for the marketplace. A vast majority of vocational education institutions are still deficient in learning tools to offer hands-on and in-depth practical to do with the existing and advanced technologies like smart homes. These limitations slow down the students from being able to come up with the critical analysis and problem-solving skills required as more industry problems are solved. Prior studies, for instance, have also given limited emphasis on training students in higher-order thinking skills that are paramount to the New Economy.[3] Additionally, studies exploring the use of smart home technology in vocational education are still limited, leaving a gap in the literature on how tools such as Smart Home Training Kits can be effectively used to develop HOTS in vocational students.[4]

Therefore, Smart Home Training Kits can help students develop HOTS through a project-based learning process. Students are invited to analyze problems, design solutions, and apply these solutions to smart home systems. This process stimulates critical thinking and creative problem-solving skills. The project-based approach allows students to work in teams, collaborate, and share ideas, and skills that are critical in the workplace. By using Smart Home Training Kits, learning no longer only focuses on teacher instructions, but also on exploration and innovation by the students themselves. In the context of HOTS development, Smart Home Training Kits enable students to think more deeply and critically about the technology they use. Students are encouraged to not only follow instructions, but also evaluate how the system works, identify potential problems, and look for ways to optimize system performance.[5] One of the main advantages of Smart Home Training Kits is their ability to provide a learning experience that is close to real-world conditions. With realistic simulations, students can learn in a context that is relevant to the latest technology trends, thereby preparing them for the challenges of the world of work.

Various studies have shown that interactive technology-based learning can significantly increase student engagement and learning outcomes. Using tools such as Smart Home Training Kits can make learning more interesting, increase student motivation, and encourage them to learn independently.[6] In vocational education, where technical skills are often a primary focus, it is important to incorporate learning approaches that develop higher-order cognitive skills. Thus, Smart Home Training Kits are an excellent means for achieving this goal because the training based on them combines both theory and practical application. Technology overall does hold massive potential in redefining education but it must be done so with the right learning methodologies in mind.[7] In this study, the quasi-experimental research design provides intentions of establishing the efficiency of using Smart Home Training kits in enhancing HOTS in vocational education students. The quasi-experimental method was chosen because it allows researchers to compare two groups of students: an experimental group that uses Smart Home Training Kits and a control group that uses the more conventional methods.[8] This approach gives more understanding of the effects these tools have on the thinking of the students more than a general observation. Therefore, this research seeks to establish the extent to which Smart Home Training Kits may be used as an innovative tool to enhance the teaching of HOTS. This research will also evaluate how these tools shift thinking about smart home technology amongst students in context.[9]

The expected results imply that this research will be significant in enhancing the curriculum of vocational education. If it undergoes the test and rates positive, Smart Home Training Kits could be embraced even more by technical learning thus preparing students for a constantly aspiring industry. Moreover, it is believed that this research will make a valuable contribution to the understanding of how interactive technology can be applied to enhance critical and innovative thinking in vocational education. We hope that the results of this research will be helpful to educators, curriculum developers, and representatives of educational policies. As the world of work transforms and keeping in mind the rapid advancement in technology it becomes imperative for students in vocational education to be equipped not only with technical skills but much more critical

https://doi.org/10.56294/dm2025476

attributes of creativity, innovation, and analysis.[10]

Smart Home Training Kits are a way to practice such a thing in a more interesting and closely resembling real-life setting. In the long run, the concept of Smart Home Training Kits in vocational training education means that the workforce is more adequately equipped to handle the challenges of the new age. Employment opportunities in this world of work will prefer students who can think critically and creatively alongside social skills be imparted to enable him or her to fit into the larger society. Hence, rather than it is a study of how students can gain technical skills using Smart Home Training Kits as a device, this research also delves into how such a tool for learning can revolutionize the vocational training mode of learning by deepening skills, relevance, and creativity.[11]

Vocational education is one of the education systems to equip students with relevant practices and technical know-how to function effectively in the workplace. Thus, in the conditions of a constantly growing number of globalization competitors and the development of new technologies, vocational education is emerging as a necessity. The skills that one has developed through vocational education are relativity significant in industry since there is always new technology that is being developed in organizations hence changing how work is conducted.[12] However, despite these various changes that have been made and undergone through the improvement processes in vocational education, there are still issues encountered, they include; low or no participation of industry players; educational programs being irrelevant to the market; and low-quality standards of the teachers taking in institutions. This results in a discrepancy between school-based skills and work-based skills.[13]

This is one of the considerations that have to be considered as regards the educational process as well as curriculum planning: the development of HOTS. HOTS comprise the ranging of complex and more sophisticated thinking skills such as analysis, synthesis, evaluation and creation. HOTS has been defined as an ability apart from the cognitive and knowledge acquisition IQ: The ability to not only recall and comprehend knowledge, but apply, reason and judge the content in a higher order manner. In vocational education, the development of HOTS is very crucial because students encounter situations that call for problem solving; critical thinking and decision making. By developing these skills the students are in a better position to compete in the global market and also are well prepared for change in, for example, technology.[14]

Generally, development of HOTS in the context of vocational education can be viewed as a work in progress if the learning methods applied are still predominantly rote based or standard procedures. As a result, the new concept of education is required which will train people to be effective in the chosen professions but at the same time will help them develop their efficient thinking. To this end, technology can be incorporated in the learning process in order to make learning enjoyable as well as relevant and up to date. ICT strategies could be a tool that support learning to improve interaction, participation in group activities, creative thinking and learning.[15] With ICT the students find learning more enjoyable and fun and are in a better position of dealing with challenges they will come across at the work place. There is one way of incorporating technology in education that will be discussed here and those are simulation-based learning tools including smart home training kits. This tool is intended to teach the students in energy management, security and home automation. Smart Home Training kits not only familiarizes students with new ideas in Smart Home technologies but also provides hands-on experience on systems that are as close to real life as it can get.[16] With these tools, students can perform experiments and run simulations that enable the students to grasp the technicalities behind smart home system. This interaction with technology directly helps students to build skills that are actually required by industries out there. Having outlined the benefits of using Smart Home Training Kits, this paper will now discuss the various advantages accrued to vocational education institutions as well as the learner by including the training kits in their curriculum. For the first reason, this tool enables the students to have direct contact with some of the technological tools adopted in teaching them this knowledge, which enhances their learning. One of the ways that will make learning more meaningful and relevant is through activities that enable the students to observe how what they learn in class is used in practice. Second, the use of this tool can enhance the participation of students in the learning process.[17]

Students tend to be more motivated to learn when they can interact with tools, they find interesting and useful. Third, this tool supports HOTS development through a project-based learning process, where students are invited to analyze problems, design solutions, and apply these solutions to smart home systems.[18] Project-based learning is a very relevant approach in the context of vocational education. This method prioritizes student involvement in the learning process by working on real projects related to the subject matter. Project-based learning encourages students to work in teams, collaborate, and solve problems creatively. Project-based learning can improve critical thinking skills, communication skills, and collaboration abilities, all of which are important components of HOTS. In vocational education, project-based learning can allow students to apply technical knowledge in real-world situations, as well as develop interpersonal skills that are much needed in the workplace.[19,20]

The integration of Smart Home Training Kits in the vocational education curriculum can be an innovative

step to improve HOTS development. By using this tool, students not only learn theory but also practice applying their knowledge in situations relevant to the world of work. For example, students can learn about smart home security systems, and then design and implement appropriate security solutions for a home. The learning process using Smart Home Training Kits can create an environment that supports exploration and innovation. Students are invited to think critically about how smart home systems work and how they can optimize the system's performance. This process stimulates critical thinking and creative problem-solving skills.[21]

The success of using Smart Home Training Kits in vocational education is also influenced by the quality of teaching and the pedagogical approach used by educators. A student-centered approach that prioritizes students' active participation in the teaching and learning process is very important to achieve the expected results. Therefore, educators need to be equipped with the knowledge and skills necessary to use these tools effectively. Training and professional development for educators are essential to ensure that they can integrate technology into the learning process in appropriate and effective ways.[22]

Although technology has great potential in improving education, its implementation must be based on appropriate learning methodologies. The quasi-experimental approach used in this research aims to test the effectiveness of Smart Home Training Kits in increasing HOTS in vocational education students. The quasi-experimental method was chosen because it allows researchers to compare two groups of students: an experimental group that uses Smart Home Training Kits and a control group that uses traditional learning methods. This approach provides deeper insight into the impact of these tools on students' thinking skills.[23]

Previous research has also tended to focus more on developing technical skills alone, without paying enough attention to developing higher-order thinking skills that are essential for success in the digital era. Additionally, studies exploring the use of smart home technology in vocational education are still limited, leaving a gap in the literature on how tools such as Smart Home Training Kits can be effectively used to develop HOTS in vocational students. Therefore, this research aims to fill this gap by exploring how this tool can be used as an innovative tool to support the development of HOTS.[24]

Several studies have shown that interactive technology-based learning can significantly improve student engagement and learning outcomes. Using tools such as Smart Home Training Kits can make learning more interesting, increase student motivation, and encourage them to learn independently. In vocational education, where technical skills are often a primary focus, it is important to incorporate learning approaches that develop higher-order cognitive skills. Smart Home Training Kits provide the ideal platform to achieve this goal as they combine theory with real practical application.[25]

In the context of vocational education, where students often face challenges in applying their knowledge, Smart Home Training Kits provide opportunities for students to learn through practice. The learning process no longer only focuses on teacher instructions, but also on exploration and innovation by the students themselves. By using this tool, students are invited to actively participate in the learning process, develop critical thinking skills, and strengthen their understanding of the concepts being taught. Additionally, these tools also enable students to work in teams, share ideas, and collaborate on completing projects, skills that are critical in the workplace.[26]

Along with the increasing complexity of technology and demands in the world of work, vocational education must be able to adapt to meet these needs. Using Smart Home Training Kits as an innovative learning tool can help prepare students to face the challenges of an ever-evolving industry. Students skilled in smart home technology not only have a competitive advantage in the job market but are also able to contribute to the development of better technology solutions.

In the long run, it can be seen how technologies like Smart Home Training Kits are useful in preparing a better workforce in the Vocational Education System. Critical and creative students will be special because really jobs are dominated by technology.[27] Hence, this work incorporates not only the use of Smart Home Training Kits as technological training aids but also considers how the use of such aids transforms the technique used by students in the development of higher-order thinking skills.[28] In creating a further advanced and high standard of vocational education there is a need to engage not only industrialists, educators, and government agencies. In my opinion cooperation between the education sector and industry will assist in the development of a curriculum that meets the marketplace. Besides that, policy support and subsidies from the government are also crucially needed to guarantee that the field of vocational education will be able to progress and introduce novelties. If everyone moves positively to develop vocational education and training, with cooperation and a technology-oriented perspective, it is believed that vocational education would have been parity for future challenges and have the potency to be an instrument in designing human capital in this country.[29]

Finally, the Smart Home Training kits can be also seen as an opportunity for the development of vocational education and increasing HOTS among students as facing the challenges of the digital world. With these tools, the abilities of students to learn interactively sharpen their knowledge, create, innovate, and collaborate.[30] On the right note and with adequate political backing from all the strata, vocational education can sustainably prove useful in molding itself to be relevant in the ever-emerging globe of work complexity. It is hoped that this

research can make an important contribution to developing the vocational education curriculum and improving the quality of education in Indonesia, with the hope of creating graduates who are not only technically skilled but also have the high-level thinking skills needed in the world of work. This power and contribution is in the light of the government's quest to enhance the quality of vocational education in the country through curriculum development that should produce graduates who possess not only technical competencies required in workplaces all over the world but also high-order thinking skills as well.[31]

METHOD

Research Design

This research uses a quasi-experimental approach with a non-equivalent control group design, where two groups of students are used: the teaching experimental group and the teaching control group.[32] The subjects of the experimental group will include Smart Home Training kits while for the control group, no gadgets in their learning process will be used. This research design involved two principal assessments including a pre-assessment test and post post-assessment test which were used in a bid to determine the HOTS of students before and after the intervention. This measurement seeks to know if there is a rise in HOTS among the two groups and thereby enable a comparison of STM with conventional methods. participants of the study were students in vocational education enrolled in one of the vocational educations that offered automation technology as a subject. The sample was obtained using a purposive sampling procedure involving two classes with similar initial skills and demographics. The first class was used as the experimental class while the second class was used as the control class. The groups comprise 30 students each.

Hypothesis

The hypothesis proposed in this research assumes that the use of Smart Home Training Kits can improve Higher-Order Thinking Skills (HOTS) in vocational education students compared to conventional learning methods. The following are the hypotheses tested in this research:

Null Hypothesis (H_0)

There is no significant difference between students who use Smart Home Training Kits and students who use conventional learning methods in terms of HOTS improvement.

Alternative Hypothesis (H_1)

Students who use Smart Home Training Kits show more significant improvements in HOTS compared to students who use conventional learning methods.

Data Collection Instrument

The following instruments were used in data collection in this research. Pre-Test and Post-Test: The HOTS that this test is aimed at assessing relates to the student before and after the intervention. This test comprises questions that assess arguments, problem-solving, analysis, evaluation, and organization. The tests are designed according to Bloom's taxonomy and then modified according to the learning context using Smart Home Training Kits. Observation: Hence, methods used by researchers to assess student engagement during the learning process for the experimental and control groups were made during the learning process. We will observe the student behaviours when working with the Smart Home Training Kits and how they address issues to do with the projects assigned to them. User Experience Questionnaire: This self-administered questionnaire is used to obtain information about students' attitudes about their learning experience with Smart Home Training Kits. They include ease of use, interest, motivation, and relevance to the learning activities and objectives as would be assessed by the completed questionnaires. Semi-Structured Interviews: To get a rich understanding of how students and teachers using Smart Home Training Kits felt about the experience, several of them from the experimental group will be successfully interviewed. These interviews are planned to add the qualitative characteristics to the results and shed more light on the efficiency of the too.

Smart training kits learning procedures

As for learning-teaching activities in the experimental group, the process of learning was provided by the application of the project-based approach (Project-Based Learning) with the use of Smart Home Training Kits. The first is an awareness of smart homes that includes students in learning, security, and device automation. The teacher just goes through how the individual components in the Smart Home Training Kits function, so that the students will have some background knowledge. Lastly, students are divided into small groups with each being assigned a project of designing, planning, and improving a smart home system. Some teams are composed to design security systems that include motion sensors and cameras while others volunteer to work on energy systems for electrical optimization. In both the implementation and testing phases, each group employs Smart

Home Training Kits to design innovative technologies based on the project under consideration.

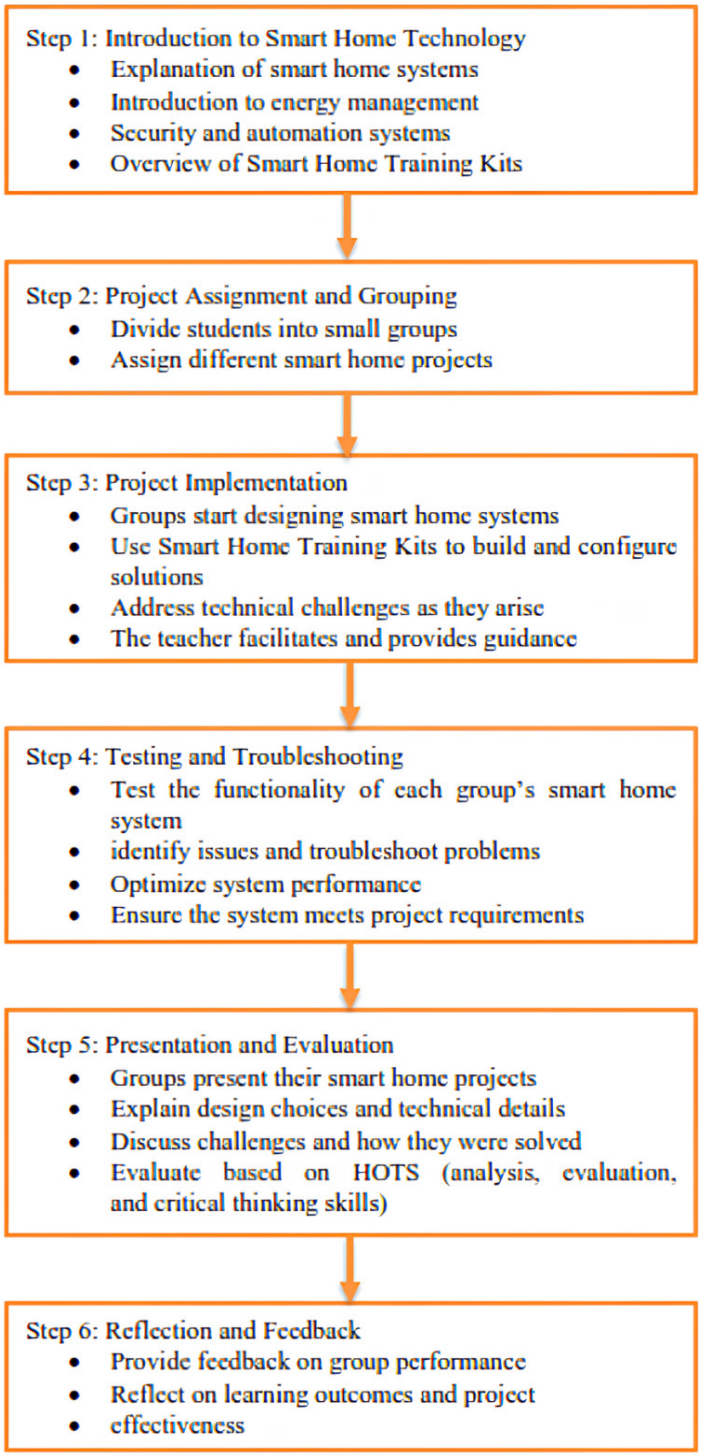

Figure 1. Smart training kits learning procedures

Educational activities imply that students should be able to solve technical problems that occur when accomplishing a task with limited help from a teacher who is a guide. In the end, all groups share their findings, demonstration of the proposed smart home system design, problem encountered, and solution implemented. Amalgamated project outcomes are assessed and rated using HOTS analysis including problem analysis, solution evaluation, and technical decision. However, for the learning process to occur several project rules should be followed by students. Every person participating in the group is required to contribute to the creation and application of the solution. There has to be cooperation within a team; roles and responsibilities cannot be favourited. Students should also be capable of finding solutions to some of the challenges faced during the project, by applying reasonable and rational processes. Organizations trying to apply this change are free to

https://doi.org/10.56294/dm2025476

be creative and innovative, which in this case, allows each group to change or add new features to existing systems. In addition, each group is required to document the entire project development process and present the results to the class, including the steps taken, challenges faced, and solutions implemented.

Data Analysis Techniques

It is therefore proposed that data collected from the pre-test and post-test as well as other instruments developed will be analyzed using statistical techniques to test the proposed hypothesis. Also used in the study was the normality test, before conducting the hypothesis test the data will be checked for its normality to determine whether it has a normal distribution or not. To check the normalization the Kolmogorov-Smirnov of Shapiro-Wilk test was done. Homogeneity Test: Before the implementation of the homogeneity test we can compare the variances of the control and experimental groups. On the other hand, Levene's test of homogeneity of variance can be performed to compare the variance of groups. Paired Sample t-Test: This test is applied to determine the change that was recorded in the post-test results of both the experimental and the control group in as much as HOTS is concerned. However, if the data is not normally distributed, a non-parametric test like the Wilcoxon Signed-Rank Test will be employed. Independent Sample t-test: This test was administered to allow the researcher to determine the magnitude of the difference between the experimental group and the control group post the post-test exercise. The purpose of this test is to determine if using Smart Home Training Kits produced a statistically significant increase in the HOTS methodology than traditional learning methodologies.[33]

RESULTS AND DISCUSSION

Data Analysis and Findings

The finding of this study seeks to test the formulated hypothesis regarding the impact of incorporating Smart Home Training Kits in enhancing the HOTS of students in vocational education. Based on the quasi-experimental method applied, the results are divided into two main parts: HOTS were assessed using pre- and post-test scores as well as from the data collected such as the rating of user experience, observation checklists, brief interviews, and project notes. Nevertheless, the instruments used in the research first have to undergo validation by the experts before the research is conducted. Table 1 shows the validity expert results test:

Table 1. Results of the validity expert result test

Aspects	Pre-Test Score	Post-Test Score	Questionnaire Score	Rubric Score
Relevance	4,7	4,8	4,6	4,7
Clarity	4,5	4,6	4,7	4,6
Equity & Difficulty	4,6	4,7	4,5	4,5
Completeness	4,8	4,9	4,8	4,8

Descriptive analysis results for pre-test and post-test in the experimental and control groups. The table shows 2 descriptive analysis results for the pre-test and post-test:

Table 2. Results of the descriptive analysis results for pre-test and post-test

Group	Average Pre-Test Score	Pre-Test Standard Deviation	Average Post-Test Score	Post-Test Standard Deviation
Experiment Group	65,4	4,2	85,3	5,0
Control Group	64,9	4,0	75,6	4,8

According to the result tabulated in the table above, the experiment group had a greater improvement of the post-test average score compared to the control group which substantiates the usefulness of Smart Home Training Kits in the improvement of HOTS. Furthermore, the normality test was applied to determine the suitability of the data to inferential tests regarding the degree to which it was normally distributed. The results of the Shapiro-Wilk test were used to determine the distribution of the data.

Table 3. Results of the Shapiro-Wilk test

Group	Pre-Test (p-value)	Post-Test (p-value)
Experiment	0,145	0,067
Control	0,132	0,089

https://doi.org/10.56294/dm2025476

The results show that the data in both groups, for both pre-test and post-test, were normally distributed (p > 0,05). Levene's Test was used to examine the homogeneity of variances between the experiment and control groups.

Table 4. Results of Levene's Test

Variable	F	Sig. (p-value)
Pre-Test	1,432	0,236
Post-Test	2,108	0,152

The analysis indicates that the variances of the experiment group to the control group were similar (p > 0,05) suggesting that the groups could be compared parametrically. In this case, the data collected was analyzed using the Paired Sample T-Test in order to compare pre-test and post- test scores in each group. To establish the researching hypothesis the two condition Independent Sample T-Test was used to compare the post test results between the experimental and control groups.

Table 4. Results of T-Test

Test Type	Variable	t	Sig. (p-value)	Interpretation
Paired Sample T-Test (Experiment Group)	Pre-Test vs Post-Test	10,547	<0,001	Significant improvement in HOTS within the experiment group after using Smart Home Training Kits.
Paired Sample T-Test (Control Group)	Pre-Test vs Post-Test	6,837	<0,001	Significant improvement in HOTS within the control group, but smaller than the experiment group.
Independent Sample T-Test	Post-Test	5,467	<0,001	Significant difference between post-test scores of experiment and control groups; larger increase in HOTS in the experiment group.

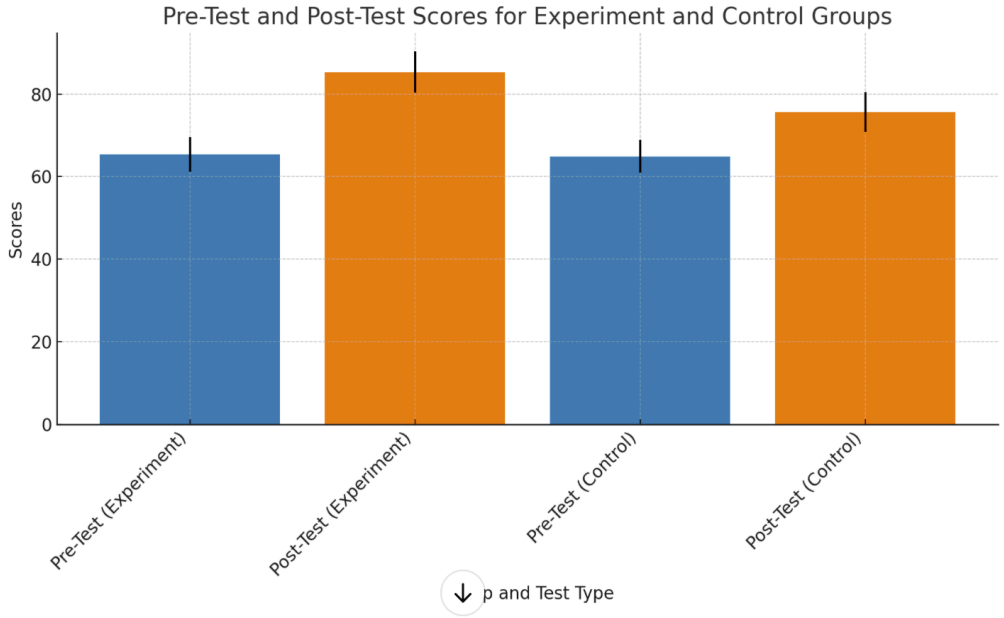

Figure 3. Pre-Test and Post-Test Scores

The studies of this investigation also offer strong empirical support for the utilization of Smart Home Training Kits in increasing higher-order thinking skills (HOTS) in the vocational training context. The findings suggest that applying the kits positively affected the student's performance in analytical, evaluative, and innovational activities when used in combination with project-based learning.[34] These results partially support and build on the findings of prior research in which the impact of technologies incorporated into learning environments on cognitive skills was examined. Studies show that the use of ICT in learning and teaching improves critical and problem-solving abilities.[35] However, this study goes further than just the overall application of technology to address HOTS using the Smart Home Training Kits. Through their incorporation into the PMB format, these kits helped students not only be mere consumers of the information but also actual contributors to the formulation,

deployment, and fine-tuning of prototypical smart home systems. This is consistent with the observations of [36] and [37] who broadly pointed out that PBL enhances students' deep learning when learners independently work and solve problems in context.

That the HOTS significantly increased in the experiment group (t = 10,547, p < 0,001) gives evidence that the Smart Home Training Kits did more than train ICT knowledge and cognizance. While working with the kits, students acquired practical skills in search and identification of issues, in addition to design and optimization, which are recognized as the elements of a technologically sustainable knowledge base of the XXI century. Thus, the experiment group involved in the activity demonstrated a more varied approach toward learning, while the control group received rather conventional targeted instructions; that is why in the course of the experiment, the knowledge level of the experiment group appeared higher. The results of the paired sample t-tests suggest that both groups benefited from the pre- and post-test since the differences as well as the learning effect were observed in both settings. However, the degree of improvement was, for the most part, markedly divergent. Many treatments used to teach the experiment group, which participated in the study using Smart Home Training Kits, exhibited satisfactory improvement in HOTS scores, which went up to an average of 85,3 in the post-test from the previous average of 65,4. The control group, however, achieved a mean score of 75,6 on the post-test, from a mean score of 64,9 on the pre-test. Both groups presented learning gains but to a different extent in which the experiment group's gains were much higher, therefore, approval that the kits had enhanced the learning experience.[38]

The lesser t-value of the independent sample t-test adds more credibility to the study to the assertion that the Smart Home Training Kits positively affected student performances. This means the extent of improvement seen in the HOTS in the experiment group post-test was much higher than that seen in the control group post-test and the difference between the two groups is statistically significant (t = 5,467, p< 0,001). This could be attributed to the fact that; the kits made the students practice the theoretical activities as they undertook different practical as practical problem-solving tasks that helped them develop their skills and cognitive abilities. Therefore, the normality and homogeneity tests were conducted before the inferential tests, as a way of ensuring the subsequent analysis would be valid. The Shapiro-Wilk normality test showed that both the pre-test and post-test scores of the experiment and control groups followed a normal distribution (p > 0,05). Furthermore, the results obtained from Levene's test for homogeneity of variance indicated that the groups studied had homogeneous variance (F (2,102) = 2,87; p > 0,05) hence suiting the parametric analysis. These preliminary tests show that the assumptions required for carrying out the paired sample t-test as well as the independent sample t-test have been met hence the validity of the results. That the HOTS of the experiment group improved significantly could be due to the active learning brought by the Smart Home Training Kits. This kind of problem also helped in related educational schemes, altogether because the students were able to interrelate with the kits and perform based on real-life problems to solve, design systems, and manage projects.[39] This accords with Bloom's Taxonomy especially the analytical, synthetic, and evaluative domains that constitute HOTS. The integration of these kits availed students practical chances to solve technical problems, mash in group efforts in handling complex tasks, and come up with new solutions to new smart home challenges. It might have also helped the students sharpen their critical thinking skills and gain solutions-focused perspectives to problems.[40]

The kits were useful in a cognitive and extrinsic motivational sense where students were more interested in the results of these work than in a control group setting. Consequently, this study offers practical insights to educators and curriculum developers in vocational education. It is also important to understand how tools like smart home training kits can further improve the employability of the matter by extending the theory-practice course.[41] These results indicate that such tools do not only enhance students' activity but yield more significantly enhanced learning outcomes in HOTS, as students will encounter such technical tasks in their work in the future. Subsequent studies should extend the analysis into the later stages of students' careers and understand the effects of Smart Home Training Kit equipment and other developing tools that prepare students for an improved employability level and better performance at work in technical professions. Moreover, using such tools in other courses including engineering, automation, and IT professions could also provide more proof of the usefulness of such tools in improving higher cognitive skills in different fields.[42]

CONCLUSION

This study confirms that integrating Smart Home (SH) Training Kits into Project-Based Learning (PjBL) effectively enhances students' Higher-Order Thinking Skills (HOTS) in vocational education. The experimental group, using SH Training Kits, demonstrated a significantly greater improvement in HOTS compared to the control group. This finding supports the value of combining tangible, tech-enhanced resources with active learning approaches to develop flexible thinking, problem-solving skills, and practical technical knowledge. PjBL, combined with SH Training Kits, allows students to work on real-world projects like designing energy management or security systems, which fosters engagement, creativity, teamwork, and critical thinking—

all essential components of HOTS. This hands-on approach helps prepare students for technical careers by enhancing cognitive skills and encouraging collaborative problem-solving. The implications of this study are significant for educators and curriculum developers, suggesting that vocational education should incorporate tools like SH Training Kits and PjBL to better align with industry demands. Future research should explore the long-term impact of these tools on employment outcomes and investigate their applicability in other fields, such as engineering and IT.

REFERENCES

1. Li J, Wiemann K, Shi W, Wang Y, Pilz M. Vocational education and training in Chinese and German companies in China: a 'home international' comparison. Int J Train Dev [Internet]. 2019 Jun 29;23(2):153–68. Available from: https://onlinelibrary.wiley.com/doi/10.1111/ijtd.12151

2. Sun H, Xie Y, Lavonen J. Effects of the use of ICT in schools on students' science higher-order thinking skills: comparative study of China and Finland. Res Sci Technol Educ [Internet]. 2024 Apr 2;42(2):276–93. Available from: https://www.tandfonline.com/doi/full/10.1080/02635143.2022.2116421

3. Siew NM, Basari J. The Integration Of Problem-Based And Collaborative Learning Assisted By Geometer's Sketch Pad: Its Effects On Students' Higher-Order Thinking Skills And Collaborative Skills. Probl Educ 21st Century [Internet]. 2024 Apr 30;82(2):275–93. Available from: https://www.scientiasocialis.lt/pec/node/1722

4. Li M. Smart Home Education and Teaching Effect of Multimedia Network Teaching Platform in Piano Music Education. Int J Smart Home [Internet]. 2016 Nov 30;10(11):119–32. Available from: http://gvpress.com/journals/IJSH/vol10_no11/11.pdf

5. Lin H. Intelligent Teaching System of Vocational Education Based on a New Generation of Information Technology. In: Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering [Internet]. 2022. p. 606–16. Available from: https://link.springer.com/10.1007/978-3-031-04245-4_53

6. Wang J, Zhang J, Fan J, Zhang S, Wang J, Geng Y. Design and Application of Smart Vocational Education Platform Based on New Generation Information Technology. In: 2020 International Conference on Computer Vision, Image and Deep Learning (CVIDL) [Internet]. IEEE; 2020. p. 505–9. Available from: https://ieeexplore.ieee.org/document/9270564/

7. Balyk N, Leshchuk S, Yatsenyak D. Developing a Mini Smart House model. CEUR Workshop Proc. 2019;2546:198–212.

8. Susantini E, Isnawati, Raharjo. HOTS-Link Mobile Learning Application: Enabling Biology Pre-service Teachers to Devise HOTS-Based Lesson Plans. J Sci Educ Technol [Internet]. 2022 Dec 15;31(6):783–94. Available from: https://link.springer.com/10.1007/s10956-022-09993-w

9. Affandy H, Sunarno W, Suryana R, Harjana. Integrating creative pedagogy into problem-based learning: The effects on higher order thinking skills in science education. Think Ski Creat [Internet]. 2024 Sep;53:101575. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1871187124001135

10. Li W, Huang J-Y, Liu C-Y, Tseng JCR, Wang S-P. A study on the relationship between student' learning engagements and higher-order thinking skills in programming learning. Think Ski Creat [Internet]. 2023 Sep;49:101369. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1871187123001372

11. Alturki N, Alharthi R, Umer M, Saidani O, Alshardan A, Alhebshi RM, et al. Efficient and Secure IoT Based Smart Home Automation Using Multi-Model Learning and Blockchain Technology. Comput Model Eng Sci [Internet]. 2024;139(3):3387–415. Available from: https://www.techscience.com/CMES/v139n3/55617

12. Boonk LM, Gijselaers HJM, Ritzen H, Brand-Gruwel S. Student-perceived parental involvement as a predictor for academic motivation in vocational education and training (VET). J Vocat Educ Train [Internet]. 2022 Apr 3;74(2):187–209. Available from: https://www.tandfonline.com/doi/full/10.1080/13636820.2020.1745260

13. Mutanga BM, Lecheko M, Revesai Z. Navigating the Grey Area: Students' Ethical Dilemmas in Using AI

Tools for Coding Assignments. IJIE (Indonesian J Informatics Educ [Internet]. 2024 Aug 14;8(1):15. Available from: https://jurnal.uns.ac.id/ijie/article/view/90385

14. Antonio RP, Prudente MS. Effects of Inquiry-Based Approaches on Students' Higher-Order Thinking Skills in Science: A Meta-Analysis. Int J Educ Math Sci Technol [Internet]. 2023 Oct 23;12(1):251–81. Available from: https://ijemst.net/index.php/ijemst/article/view/3216

15. Demetrion G. Mediating Work and Culture through Dewey's Integrative Vision of Vocational Education. Adult Lit Educ Int J Literacy, Lang Numer [Internet]. 2022 Jun 1;4(2):4–17. Available from: https://www.proliteracy.org/wp-content/uploads/2023/07/4.2.01-Research-Article-Demetrion.pdf

16. Rahman NA, Idris MR, Baharudin KS. Development of educational kit for IoT online learning. Int J Technol Innov Humanit [Internet]. 2020 Oct 21;1(1):26–32. Available from: http://journal.iicet.org/index.php/ijtih/article/view/10

17. Sapci A, Sapci H. The Effectiveness of Hands-on Health Informatics Skills Exercises in the Multidisciplinary Smart Home Healthcare and Health Informatics Training Laboratories. Appl Clin Inform [Internet]. 2017 Dec 22;08(04):1184–96. Available from: http://www.thieme-connect.de/DOI/DOI?10.4338/ACI-2017-08-RA-0136

18. Sukir S, Asnawi R, Taruno DLB, Hanif NM. The Feasibility of the Smart Building Training Kit as Learning Media for Electrical Lighting Installation Practices in Vocational High Schools. J Edukasi Elektro [Internet]. 2023 May 30;7(1):36–43. Available from: https://journal.uny.ac.id/index.php/jee/article/view/60894

19. Jalinus N, Syahril, Nabawi RA, Arbi Y. How Project-Based Learning and Direct Teaching Models Affect Teamwork and Welding Skills Among Students. Int J Innov Creat Chang. 2020;11(11):85–111.

20. Zaus MA, Krismadinata, Syah N, Jalinus N, Wulansari RE, Islami S. Development instructional media on static and dynamic electrical based on android as student center learning media. Int J Sci Technol Res. 2019;8(11).

21. Zubaidah S, Corebima AD, Mahanal S, Mistianah. Revealing the relationship between reading interest and critical thinking skills through remap GI and remap jigsaw. Int J Instr. 2018;11(2):41–56.

22. Ambiyar, Yondri S, Irfan D, Putri MU, Zaus MA, Islami S. Evaluation of packet tracer application effectiveness in Computer Design Networking subject. Int J Adv Sci Eng Inf Technol. 2019;9(1).

23. Islami S, Zaus MA, Zaus AA. Development of an Online Project-Based Learning Assessment Instrument for Vocational Education Students. JKIP J Kaji Ilmu Pendidik. 2024;4(2):291–9.

24. Rusnawati M, Santyasa IW, Tegeh IM. The Effect of Project Based E-Learning Models toward Learning Outcomes and Critical Thinking Skills of Vocational High School Students. JPP (Jurnal Pendidik dan Pembelajaran) [Internet]. 2021 Mar 3;27(2):57–64. Available from: http://journal2.um.ac.id/index.php/jpp/article/view/15587

25. Sukardi, Jalinus N, Islami S, Sakti RH, Husnuzhan, Zaus AA, et al. Soft Skills and Hard Skills Needed in Industry 4.0 for Electrical Engineering Students. J Appl Eng Technol Sci. 2023;5(1):142–9.

26. Sakti RH, Jalinus N, Sukardi S, Hidayat H, Wulansari RE, Tin CT, et al. Diving into the Future: Unravelling the Impact of Flowgorithm and Discord Fusion on Algorithm and Programming Courses and Fostering Computational Thinking. Int J Learn Teach Educ Res [Internet]. 2024 Jul 30;23(7):347–67. Available from: https://ijlter.org/index.php/ijlter/article/view/10726

27. Ortega-Gras J-J, Gómez-Gómez M-V, Bueno-Delgado M-V, Garrido-Lova J, Cañavate-Cruzado G. Designing a Technological Pathway to Empower Vocational Education and Training in the Circular Wood and Furniture Sector through Extended Reality. Electronics [Internet]. 2023 May 22;12(10):2328. Available from: https://www.mdpi.com/2079-9292/12/10/2328

28. Grobbelaar W, Verma A. Vocational Training and Industry IR 4.0 in a Smart City. In: International Conference on Sustainable Computing in Science, Technology & Management SUSCOM-2019 [Internet]. 2020. p.

1–11. Available from: https://ssrn.com/abstract=3713947

29. Riyanda AR, Jalinus N, Abdullah R, Ranuharja F, Islami S, Adi NH, et al. The New Paradigm of Technical and Vocational Education and Training (TVET). Edukatif J Ilmu Pendidik. 2021 Dec 19;4(1):364–71.

30. Jalinus N, Rizal F, Wulansari RE, Zaus MA, Islami S. Design and need analysis of Computer Devices' expert system using forward chaining method. Int J GEOMATE. 2019;17(61):202–7.

31. Chapron K, Thullier F, Lapointe P, Maître J, Bouchard K, Gaboury S. LIPSHOK: LIARA Portable Smart Home Kit. Sensors [Internet]. 2022 Apr 7;22(8):2829. Available from: https://www.mdpi.com/1424-8220/22/8/2829

32. Cham H, Lee H, Migunov I. Quasi-experimental designs for causal inference: an overview. Asia Pacific Educ Rev [Internet]. 2024 Sep 26;25(3):611–27. Available from: https://link.springer.com/10.1007/s12564-024-09981-2

33. Lestari EF, Firdaus M, Yukamana H. The Relationship Among Seventh Grade Students' Participation in Online Games, English Vocabulary Mastery, and Learning Motivation. JET (Journal English Teaching) [Internet]. 2024 Feb 10;10(1):76–91. Available from: http://ejournal.uki.ac.id/index.php/jet/article/view/5292

34. Markula A, Aksela M. The key characteristics of project-based learning: how teachers implement projects in K-12 science education. Discip Interdiscip Sci Educ Res [Internet]. 2022 Dec 6;4(1):2. Available from: https://diser.springeropen.com/articles/10.1186/s43031-021-00042-x

35. Das K. The role and impact of ICT in improving the quality of education: An overview. Int J Innov Stud Sociol Humanit [Internet]. 2019;4(6):97–103. Available from: http://dx.doi.org/10.2139/ssrn.3585228

36. Cuckle P, Clarke S. Mentoring student-teachers in schools: views, practices and access to ICT. J Comput Assist Learn [Internet]. 2002 Sep 11;18(3):330–40. Available from: https://onlinelibrary.wiley.com/doi/10.1046/j.0266-4909.2002.00244.x

37. Hmelo-Silver CE. Problem-Based Learning: What and How Do Students Learn? Educ Psychol Rev [Internet]. 2004 Sep;16(3):235–66. Available from: http://link.springer.com/10.1023/B:EDPR.0000034022.16470.f3

38. Binsaleh S, Binsaleh M. 4P-2E Model: Teaching and Learning Process Through ICT Integration for Private Islamic Schools in Thailand. Asian J Univ Educ [Internet]. 2021 Jan 24;16(4):71. Available from: http://myjms.mohe.gov.my/index.php/AJUE/article/view/11944

39. Mielikäinen M, Viippola E. ICT Engineering Students' Perceptions on Project-Based Online Learning in Community of Inquiry (CoI). SAGE Open [Internet]. 2023 Jul 8;13(3). Available from: http://journals.sagepub.com/doi/10.1177/21582440231180602

40. Arochman T, Margana M, Ashadi A, Achmad S, Nugrahaeni DA, Baihaqi I. The effect of project-based learning on English writing skill for EFL learners. J Pedagog Res [Internet]. 2024 May 12; Available from: https://www.ijopr.com/article/the-effect-of-project-based-learning-on-english-writing-skill-for-efl-learners-14611

41. Sarac H. Use of Instructional Technologies by Teachers in the Educational Process: Metaphor Analysis Study. Eur J Educ Res [Internet]. 2018 Apr 15;volume-7-2(volume7-issue2.html):189–202. Available from: https://www.eu-jer.com/use-of-instructional-technologies-by-teachers-in-the-educational-process-metaphor-analysis-study

42. McNaughton S, Jesson R. How a Digital Intervention in Schools Contributed to Students' Social and Emotional Skills, and Impacted Writing. New Zeal J Educ Stud [Internet]. 2023 Dec 25;58(2):361–77. Available from: https://link.springer.com/10.1007/s40841-023-00296-1

FINANCING

I would like to express my special gratitude and thanks to Lembaga Penelitian dan Pengabdian Kepada Masyarakat (LPPM) Universitas Negeri Padang for the research grants with contract number 1785/UN.35/LT/2024.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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https://doi.org/10.56294/dm2025476