

INTEGRATING LANGUAGE LEARNING IN ENGINEERING EDUCATION: A CDIO APPROACH AT ETUT

Yslam Orazov, Nurjemal Bayramova, Ulugbek Jummanov

Cyberphysical systems department, Oguz han Engineering and technology university of Turkmenistan, Ashgabat, Turkmenistan

Lachyn Gurdova

Foreign languages for technical fields department, Oguz han Engineering and technology university of Turkmenistan, Ashgabat, Turkmenistan

ABSTRACT

This study investigates the integration of language learning within engineering education using the CDIO (Conceive, Design, Implement, Operate) framework at Oguz han Engineering and technology university of Turkmenistan (ETUT). The research aims to enhance both language proficiency and technical communication skills among engineering students, addressing the growing need for effective communication in a globalized workforce. A comparative study was conducted over a 12-week period, involving two groups of 25 students each. One group followed a CDIO-based curriculum, while the other used traditional teaching methods. The effectiveness of the approach was evaluated through pre- and post-tests assessing both technical knowledge and language skills. Results show that students in the CDIO group (hereinafter Group B) improved their overall performance by 19%, achieving an average score of 78% compared to 68% in the traditional group (hereinafter Group A). These findings suggest that a balanced application of the CDIO phases can effectively foster an educational environment that promotes linguistic competence alongside engineering excellence. This research contributes to the ongoing discussion on innovative approaches in engineering education, highlighting the potential of the CDIO framework in preparing students for successful careers in an increasingly interconnected world.

KEYWORDS

CDIO Framework, Language Learning in Engineering, CDIO method, Technical Communication Skills, Educational Methodologies, Standard 2,3,11.

INTRODUCTION

Context and Importance

In today's globalized world, the ability to communicate effectively in English is paramount, especially in engineering fields where collaboration often spans international borders. As engineering education evolves to meet the demands of a diverse and interconnected workforce, integrating language learning into the curriculum has become increasingly significant. Effective communication skills not only enhance students' understanding of technical concepts but also prepare them for real-world challenges where they must articulate ideas clearly and collaborate with peers from various cultural backgrounds (Leong, 2016). This integration is particularly crucial at ETUT, where students are being equipped to thrive in a competitive global market. The university offers a preparatory course before the bachelor's degree, during which we implemented the CDIO approach discussed in this paper.

Objectives of the Paper

This paper aims to explore the integration of language learning within engineering education through the application of the CDIO (Conceive, Design, Implement, Operate) framework. It focuses on how this approach can address specific challenges associated with Content and Language Integrated Learning (CLIL) and Project-Based Learning (PBL). By examining these frameworks, the research seeks to identify effective strategies for enhancing both language proficiency and technical communication skills among engineering students.

Study Rationale

While integrating language learning through the CDIO framework offers a promising pathway to enhance technical communication skills among engineering students, it is essential to address challenges such as the shifting focus from language acquisition to content mastery and the insufficient development of communication skills. This paper argues that a balanced application of CDIO phases can mitigate these challenges, fostering an educational environment that promotes both linguistic competence and engineering excellence.

THEORETICAL FRAMEWORK

Overview of CDIO

The CDIO (Conceive, Design, Implement, Operate) framework is a comprehensive educational model designed to enhance engineering education by focusing on the entire lifecycle of products, processes, and systems. It emphasizes the integration of technical knowledge with practical skills, ensuring that students are well-prepared for the challenges of modern engineering practice (Crawley et al., 2014). The CDIO (Conceive-Design-Implement-Operate) framework has been widely adopted to enhance engineering education by incorporating practical, real-world learning experiences. Recent studies have explored its application in language learning for engineering students. For instance, Weerakoon and Dunbar (2018) propose a structured approach that aligns second language acquisition with engineering learning outcomes, ensuring that communication skills are developed alongside technical expertise. Similarly, Wu et al. (2012) discuss the implementation of the CDIO concept in bilingual education, highlighting its effectiveness in non-English-speaking environments for courses such as Digital Image Processing. These studies underscore the importance of integrating language learning into engineering curricula, promoting both technical proficiency and communication skills essential for professional success.

The CDIO framework not only promotes disciplinary knowledge but also focuses on personal and interpersonal skills essential for effective teamwork and communication in engineering environments.

Introduction to Language Learning Frameworks for Engineering students

The importance of integrating language skills in engineering education is increasingly recognized, as seen in the work of Rinder et al. (2020) and other studies. Content and Language Integrated Learning (CLIL) is an educational approach that combines language learning with subject content instruction. It aims to foster language acquisition in meaningful contexts by using a foreign language as the medium of instruction for subjects such as science or mathematics (Coyle et al., 2010). CLIL encourages active engagement and promotes cognitive skills by integrating language practice with content learning (Mehisto et al., 2008).

Project-Based Learning (PBL), on the other hand, is an instructional methodology that engages students in real-world projects over extended periods. PBL emphasizes student-centered learning, critical thinking, collaboration, and communication skills as students work together to solve complex problems (Thomas, 2000). While both CLIL and PBL have proven effective in enhancing language proficiency and subject-specific knowledge, they also present challenges. For instance, there can be a tendency for students to focus more on content mastery at the expense of developing their language skills, leading to insufficient communication abilities in professional contexts (Ball et al., 2015).

Intersection of Frameworks

Integrating CDIO with CLIL and PBL creates a powerful synergy for engineering education, addressing language acquisition challenges. CDIO provides a structured framework for CLIL, offering practical contexts for language use within engineering problems. Similarly, CDIO enhances PBL by structuring project development and emphasizing communication throughout.

CDIO's phases scaffold language learning in project activities, especially during the "Operate" phase, where students present projects using technical knowledge and advanced language skills. This approach ensures that students not only engage deeply with content but also develop their ability to communicate complex ideas clearly throughout the learning process (Crawley et al., 2014; Rinder, J. et al., 2016).

By combining CDIO's practical application, CLIL's content-language integration, and PBL's collaborative focus, educators create a comprehensive learning environment. This prepares students for engineering careers where both technical expertise and effective communication are essential.

CURRICULUM COMPARISON

Previous Curriculum: General English

ETUT's prior curriculum emphasized General English, Japanese, and Turkmen, aiming for communicative competence in four key skills via traditional methods like grammar drills. However, students, though proficient in general English, lacked technical language skills necessary for engineering (Zhou, 2015). Feedback revealed a gap in discipline-specific vocabulary and context, hindering their ability to articulate complex engineering concepts

(Sanchez Palacios, 2021). This necessitates a more engineering-focused language curriculum. The distribution of study hours across different courses can be seen in the accompanying table. See Table 1.

Table 1: Distribution of Study hours in the Previous Curriculum

	Name of the courses	Distribution by three periods			
		Total number of hours	1st Trimester Number of hours	2nd Trimester Number of hours	3rd Trimester Number of hours
1	Turkmen	72	24	24	24
2	Japanese	396	132	132	132
3	English	1044	348	348	348
	Total:	1512	504	504	504

Current Curriculum: Scientific English + General English

To address the lack of engineering-specific language skills, ETUT's revised curriculum now integrates Scientific English alongside General English. Scientific English focuses on technical vocabulary and reading comprehension through scientific texts, covering subjects like physics and mathematics, preparing students for professional communication (Chen et al., 2024). General English maintains broader language skill development, ensuring a well-rounded linguistic education. Table 2 shows the distribution of study hours, including optional engineering subjects.

Table 2: Distribution of Study hours in the Current Curriculum

	Name of the courses	Distribution by three periods			
		Total number of hours	1st Trimester Number of hours	2nd Trimester Number of hours	3rd Trimester Number of hours
1	Turkmen	72	24	24	24
2	Japanese	396	132	132	132
3	English	720	240	240	240
4	Optional subjects	324	108	108	108
	Total:	1512	504	504	504

Note: 1. Computer science, physics, mathematics, biology, and chemistry courses are taught in English.

CHALLENGES FACED

Focus Shift in Language Learning Frameworks for Engineering Students

CLIL and PBL, while beneficial, pose challenges to language acquisition. CLIL risks prioritizing content over English articulation, leading to strong subject knowledge but weak communication (Uemura, 2017; Pratap & Alapati, 2020). Similarly, PBL's project focus can overshadow language development, with students neglecting English proficiency for project completion (Peachey Publications, 2024; Zhang, 1992). Both methods require careful

integration of language objectives to ensure balanced content mastery and communication skills.

Challenges of Language Variability in Technical education

Another significant challenge is the variability in language proficiency among students within integrated curricula. In any given classroom, students may possess varying levels of English proficiency, which can create disparities in participation and learning outcomes. Those with lower proficiency levels may struggle to engage fully with both the content and the language components of the curriculum, leading to feelings of frustration and disengagement (Su, 2008). This variability necessitates differentiated instructional strategies that accommodate diverse learning needs while ensuring that all students have opportunities to develop both their technical knowledge and language skills effectively (Rinder, J. et al., 2016).

Assessment Methods

Finally, assessing both language skills and engineering knowledge presents its own set of challenges. Traditional assessment methods often prioritize content knowledge over language proficiency, making it difficult to evaluate students' overall competence effectively (Ball et al., 2015). Furthermore, developing fair and transparent assessment criteria that recognize collaboration while rewarding individual effort can be complex within project-based contexts (Peachey Publications, 2024). Educators must create assessment frameworks that capture both linguistic competencies and technical understanding to provide a holistic view of student performance.

EXPERIMENTATION METHODOLOGY - APPLICATION OF CDIO PHASES AS A SOLUTION

Experimental Design

In this research, the CDIO (Conceive, Design, Implement, Operate) approach was implemented in a preparatory course at ETUT to evaluate its effectiveness compared to traditional teaching methods. The study involved two groups, each consisting of 25 students. Students were assigned to either the traditional group (Group A) or the CDIO group (Group B) based on random assignment to ensure equal distribution of prior language proficiency. Group A followed the traditional instructional method, while Group B engaged in the CDIO approach, incorporating elements of Content and Language Integrated Learning (CLIL).

The study spanned 12 weeks during the second trimester. Each 80-minute lesson was structured around one of the CDIO phases. Both groups underwent a pre-test at the beginning of the course to assess their initial language proficiency and understanding of engineering concepts. The pre-test assessed their ability to understand and explain basic engineering principles in English, including vocabulary, grammar, and reading comprehension related to technical topics. It included a combination of multiple-choice questions, short-answer questions. A post-test was administered after the course to evaluate their progress in both areas. The post-test evaluated the same skills as the pre-test, but with more complex engineering concepts and a greater emphasis on technical writing and oral communication. It included problem-solving questions, a technical report writing assignment.

Group A primarily followed lecture-based instruction, where students passively listened to lecturers and were expected to comprehend and process the material independently. In

contrast, Group B was divided into five smaller groups of five students each, with one team leader per group. Lessons were designed to actively engage students through the CDIO phases, integrating engineering topics with English language learning. The following describes the implementation of each CDIO phase for Group B:

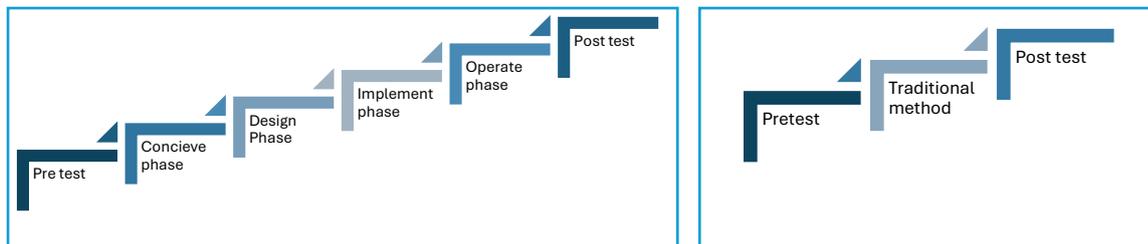


Figure 1. On the left side, the 'CDIO' teaching method; on the right side, the 'Traditional' teaching method

Conceive Phase

In this phase, students explored the topic of the lesson under lecturer guidance. They were encouraged to search for information online related to engineering subjects integrated with English. For example, in a lesson on "Movement," students learned about directional movement concepts relevant to fields such as robotics, mechatronics, and transportation.

- Content Focus: Engineering topics like how objects move (e.g., fluid flow or electric current).
- Grammar: Adverbials of direction (e.g., "can," "cannot," "imperative + present simple," "when clause").
- Vocabulary: Engineering-specific terms such as "up," "down," "forwards," "vertically," "degrees," "ascend," "descend," "joystick," and "slider."

Students worked individually or in pairs to research these concepts and grammar rules online or through lecturer-provided materials. This phase allowed them to build foundational knowledge for subsequent phases.

Design Phase

In this phase, students worked cooperatively while the lecturer acted as an observer and facilitator. The focus was on organizing information collected during the Conceive Phase.

- Students collaborated within their groups to create sentences using:
 - Lesson content (e.g., movement principles).
 - New vocabulary (e.g., "ascend" or "descend").
 - Grammar structures learned earlier (e.g., adverbials of direction and zero conditional sentences).
- Team leaders divided tasks among group members to ensure equal participation.
- The lecturer provided clarification and resolved any issues that arose during group discussions.

This phase emphasized teamwork and critical thinking as students synthesized information into coherent ideas.

Implement Phase

During this phase, students transformed their collected data into a formal presentation.

- Group members discussed their findings and exchanged opinions while preparing slides or other visual aids.
- They integrated vocabulary, grammar structures, and engineering concepts into their presentations.
- The lecturer provided guidance when necessary but allowed students to take ownership of their work.

This phase encouraged creativity and collaboration while reinforcing both language skills and technical understanding.

Operate Phase

In the final phase, each group presented their projects to the class.

- Presentations included:
 - A demonstration of materials used.
 - An explanation of strategies employed during research and preparation.
 - Examples showcasing how they applied vocabulary, grammar, and engineering concepts.
- After each presentation:
 - The lecturer provided structured feedback on both technical content and communication skills.
 - Other groups offered peer feedback based on predefined criteria.

This phase helped students refine their public speaking skills while reflecting on their learning process.

RESULTS AND DISCUSSION

Findings Overview

The data collected from the pre-tests and post-tests provided valuable insights into students' attitudes toward language integration in their engineering education. The performance of both groups was assessed based on their pre- and post-test results; however, their communication skills could not be evaluated in the same way due to differences in their learning approaches. Students in Group B expressed a positive attitude toward the integration of language learning with technical content. Many reported that the structured phases of the CDIO approach created a more engaging and interactive learning environment. Feedback indicated that students appreciated the collaborative nature of group work, which not only enhanced their understanding of engineering concepts but also improved their ability to communicate effectively in English. Additionally, students noted that the emphasis on real-world applications made the learning experience more relevant and motivating.

Pre-Test vs. Post-Test (Paired t-test)

The paired t-test revealed a significant improvement in the group B performance from pre-test to post-test ($t(df) = 4.899$, $p = 0.0000117$). This indicates that the CDIO framework effectively enhanced students' language proficiency and technical knowledge over the course of the study period. The extremely low p-value provides strong evidence against the null hypothesis.

Group A vs. Group B (Independent t-test)

The independent t-test showed no statistically significant difference between the post-test scores of the group B and the traditional group ($t(df) = 2.92$, $p = 0.05311$). While there was a

numerical difference in favor of the group B, the p-value is above the conventional significance level of 0.05, indicating that the observed difference may have occurred by chance.

Table 3: Statistical Analysis of group A and B Performance: t-test Results

Test Type	Mean (CDIO)	Mean (Comparison)	t-value	p-value
Paired t-test	Pre: 67.57%	Post: 78.42%	4,89015	0.0000117
Independent t-test	Group B: 78.42%	Group A: 68%	2,92009	0.005316311

Impact on Learning Outcomes

The implementation of the CDIO (Conceive, Design, Implement, Operate) framework at ETUT effectively enhanced student performance, addressing challenges often associated with CLIL and PBL. As shown in Figure 2, Group B (CDIO) improved by 19.01% from pre-test (59.41%) to post-test (78.42%), outperforming Group A by 10.85% on the post-test.

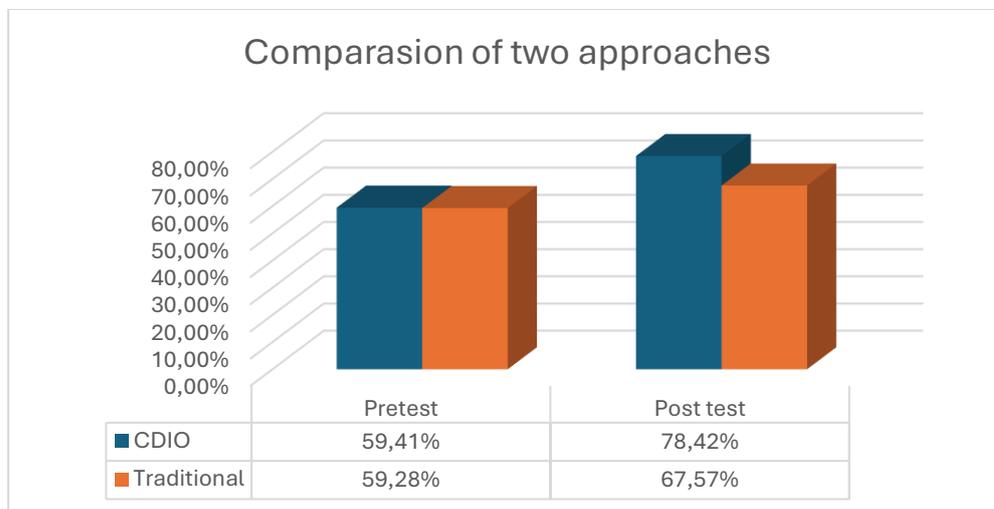


Figure 2. Results of the pre-test and post-test for the two groups.

CDIO's structured phases balanced technical knowledge with language development. The "Conceive" phase allowed students to address real-world problems while practicing communication skills. The "Design" phase fostered collaborative learning, reinforcing both technical and language abilities. During "Implement and Operate," students presented projects, receiving feedback that improved their confidence and communication of complex ideas.

Overall, the CDIO framework fostered a synergistic learning environment, preparing students for global engineering careers by effectively integrating technical content with language proficiency, addressing the focus shift issues common in CLIL and PBL.

CONCLUSION

The integration of language learning within engineering education through the CDIO framework represents a significant advancement in addressing the challenges students face

in acquiring both technical knowledge and effective communication skills. Findings from our study at ETUT demonstrate that the CDIO approach fosters active engagement and collaborative learning, leading to improved academic performance and enhanced language proficiency. By structuring lessons around the CDIO phases, educators can create a dynamic learning environment that emphasizes both technical content and essential communication skills. This integrated approach equips students with the competencies necessary to thrive in a globalized workforce.

While this study provides valuable insights into the immediate benefits of the CDIO approach, the relatively small sample size (n=25 per group) suggests that the findings should be interpreted with caution. Future research with larger cohorts is needed to confirm these results and explore the broader applicability of the CDIO approach. Further research could also explore the long-term impacts on graduates' employability and communication skills. Specifically, future studies could investigate how well-prepared students feel upon entering the workforce and whether their experiences with integrated language learning influence their professional success. Additionally, longitudinal research could assess how the skills developed through the CDIO framework contribute to overall educational outcomes, including critical thinking and adaptability.

In conclusion, integrating language learning within engineering education through the CDIO phases not only addresses current challenges but also lays a foundation for developing well-rounded graduates equipped to meet the demands of an increasingly interconnected world. This study contributes to the existing body of knowledge by demonstrating the effectiveness of the CDIO framework in enhancing both language proficiency and technical communication skills among engineering students in an engineering program.

ACKNOWLEDGEMENTS

The authors received no financial support for this work.

REFERENCES

- Ball, P., Kelly, K., & Clegg, J. (2015). *Putting CLIL into Practice*. Cambridge University Press.
- Chen, W., et al. (2024). Multi-method integrated experimental teaching reform of a C Language Programming course based on OBE-CDIO. *Nature*. Retrieved from Nature
- Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL: Content and Language Integrated Learning*. Cambridge University Press.
- Crawley, E. F., Malmqvist, J., Östlund, S., & Brodeur, D. R. (2014). *Engineering Education: Research and Practice*. Springer.
- Leong, T. W. (2016). *Designing a CDIO Programme: The CDIO Syllabus and Standards*. Retrieved from CDIO
- Mehisto, P., Marsh, D., & Frigols, M. J. (2008). *CLIL Essentials for Teachers*. Cambridge University Press.
- Peachey Publications. (2024). *Unlocking the Power of Project-Based Learning in ELT: Challenges, Benefits, and AI Solutions*. Retrieved from Peachey Publications
- Pratap, C., & Alapati, R. N. H. (2020). CLIL: A New Trend Of Teaching English To Engineering Students. *Journal of Namibian Studies, Special Issue on Multidisciplinary Research*. Retrieved from Namibian Studies
- Rinder, Jamie & Richter, Tanja & Geslin, Teresa & Tual, David. (2020). *The Global Engineers Language Skills (GELS) Network: An Update*

- Rinder, J., Geslin-Sweeney, T. & Tual, D (2016). A framework for language and communication in the CDIO syllabus. Proceedings of the 12th International CDIO Conference. Turku, Finland: Turku University of Applied Sciences. Retrieved from http://www.cdio.org/files/document/cdio2016/72/72_Paper_PDF.pdf
- Sanchez Palacios, M. D. C. (2021). Combining CLIL and PBL to Facilitate Learning in Vocational Education and Training Programs. Retrieved from UNIR
- Su, Y.-C. (2008). Students' Changing Views and the Integrated-Skills Approach in Taiwan's EFL College Classes. ERIC. Retrieved from ERIC
- Thomas, J. W. (2000). A Review of Research on Project-Based Learning. Retrieved from Buck Institute for Education.
- Uemura, T. (2017). CLIL and Its Possible Application to Engineering Education to Enhance Undergraduates' Academic and Subject-specific English Literacy. International Journal of Educational Innovation Management, 7(2), 13-21. Retrieved from IRE Asia
- Weerakoon, A., & Dunbar, N. (2018). A Framework for Second Language, Communication and Engineering Learning Outcomes. Proceedings of the Xth International CDIO Conference, (p.572). Kanazawa, Japan
- Xi Wu, Jin He, Wuzhong Bi, Yu Wang, Jianxin He, Mingyuan Xie (2012). Implementation CDIO Concept in Bilingual Teaching in Non-English-Speaking Country: A Course Studying in Digital Image Processing. Proceedings of the 8th International CDIO Conference, Brisbane, Australia
- Zhou, Aijun. (2015). The Design of the College English Curriculum from the Perspective of International Engineering Education Accreditation. Journal of Curriculum and Teaching, 10(1), 18-30. doi:10.5430/jct.v10n1p18

BIOGRAPHICAL INFORMATION

Yslam Orazov is currently head of the Cyberphysical systems department at Oguz han Engineering and technology university of Turkmenistan. He holds a Ph.D. degree in physical and mathematical sciences. While his interests include natural sciences, he is also chair of the committee which is responsible for the international relations of the Oguz han Engineering and technology university of Turkmenistan.

Lachyn Gurdova is currently head of the Foreign Languages for Technical Fields Department. She holds a Ph.D in Philological sciences. She is one of the most active members of the university's International Relations Committee since the early years of the university's opening.

Nurjemal Bayramova is the student of Physics of modern technologies major. She is an active member of the International Relations Committee of the university, volunteering in most of the events organized by the university.

Ulugbek Jummanov is the student of Automation and Control major. A highly engaged member of the University's International Relations Committee, he actively participates in a majority of university-organized events.

Corresponding author

Yslam Orazov
Oguz han Engineering and technology
university of Turkmenistan, Taslama №100,
Koshi, Ashgabat, Turkmenistan
oguzhantech25@gmail.com



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

APPENDIX

Due to confidentiality reasons, only a small portion of the pre-test can be shared. Below is a sample excerpt from the pre-test:

1. Which of the following sentences is grammatically correct?
 - a) I have been waiting for her since two hours.
 - b) I have been waiting for her for two hours.
 - c) I am waiting for her since two hours.
 - d) I wait for her for two hours.
2. "To put something off" means:
 - a) To complete something quickly.
 - b) To postpone or delay something.
 - c) To find something easily.
 - d) To understand something clearly.
3. Choose the correct form of the verb in the sentence: "If I _____ more time, I would travel the world."
 - a) have
 - b) had
 - c) will have
 - d) am having
4. Which preposition best completes the sentence: "She is very good _____ playing the piano."
 - a) at
 - b) in
 - c) on
 - d) for
5. "He is always complaining; he's such a _____."
 - a) optimist
 - b) pessimist
 - c) realist
 - d) idealist
6. Which sentence uses the passive voice correctly?
 - a) The dog chased the cat.
 - b) The cat was chased by the dog.
 - c) The cat chases the dog.
 - d) The dog is chasing the cat.

Below is a sample excerpt from the post-test:

1. What is the term for moving down?
 - A) Ascend
 - B) Descend
 - C) Flow
 - D) Slide
2. Which word means to move up?
 - A) Down
 - B) Forwards
 - C) Ascend
 - D) Backwards
3. What do we use to control movement in robotics?
 - A) Joystick
 - B) Hammer
 - C) Screwdriver
 - D) Wrench
4. What does "fluid flow" mean?
 - A) The movement of solids
 - B) The movement of liquids and gases
 - C) The movement of light
 - D) The movement of sound
5. Which sentence is an example of a command?
 - A) You should check the connections.
 - B) Please turn on the device.
 - C) If you press the button, it will move.
 - D) I will fix it later.
6. What does "forwards" mean?
 - A) Moving back
 - B) Moving ahead
 - C) Moving sideways
 - D) Staying still