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UNIVERSAL DESIGN FOR LEARNING PRINCIPLES IN TECHNOLOGY-ENHANCED
ASSESSMENTS FOR ENGLISH FOR SPECIFIC PURPOSES COURSES IN HIGHER
EDUCATION

MA thesis

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Abstract

Universal Design for Learning principles in technology-enhanced assessments for English for Specific Purposes courses in higher education

The study is focused on the practical application of Universal Design for Learning (UDL) in enhancing diversity and eliminating learning barriers in reading and listening comprehension assessment in an English for Specific Purposes (ESP) course. The objective is to develop a technology-enhanced formative assessment based on UDL for reading and listening comprehension, employing the action research methodology. Additionally, this study aims to explore the impact of technology-enhanced, barrier-free formative assessment on learners' motivation. The study's data was gathered through the administration of questionnaires to students and the evaluation of their academic performance. The conclusion of the study suggests that the integration of UDL principles and the incorporation of technology positively impact the development of reading and listening comprehension abilities among students enrolled in ESP courses.

Keywords: Universal Design for Learning, reading and listening comprehension, educational technology, construct relevance.

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Introduction

Higher education has experienced a lot of transformations throughout history and educators had to integrate time-responsive concepts and methodologies. Universal Design for Learning (UDL) is a powerful and promising instructional approach that is aimed at fostering meaningful learning experiences, promoting learners' diversity, and eliminating learning barriers by integrating flexible multiple educational tools for materials representation, engagement, and action and expression (Mayer et al., 2014). The approach guides the design of instructions, methods, materials, and assessments with learner diversity in mind because the human ability to learn is a unique and multidimensional variable (Abell et.al., 2011). The UDL framework is relevant and of great consequence today as it reflects such global initiatives as inclusivity, diversity, and UNESCO's Sustainable Development Goals, one of which highlights the importance of inclusive and equitable lifelong learning for everybody. Moreover, UDL provides opportunities to master digital skills and literacy that are outlined in the Digital Competence Framework for Citizens developed by the Office of the European Union (Vuorikari, 2022). UDL offers guidelines on the design of educational courses, assessment strategies, methods, and materials that can be integrated into any discipline to ensure equal participation in meaningful and challenging learning (CAST, 2022).

UDL researchers and educators consider learner variability the norm and advocate the design of materials, methods, and assessments to benefit all students (Dalton et al., 2019). However, it creates some challenges for educators, in particular, related to assessment due to unawareness how to design universal assessment, the lack of subject-related guidelines, and well-documented materials as examples (Haynes, 2020).

Traditional assessment practices are aligned only with academic standards and do not correspond to the needs of all students because it is considered a standard to measure human potential concerning statistical averages. Educators have been creating instructions and assessments for an "average student" using standardized sets of activities, sets of tools, and assessment criteria. Students do not even have alternatives to demonstrate what they know. It creates a validity concern of such practices that can be solved by the integration of UDL-based assessment that responds to the validity concern by designing tools that equitably assess all students despite their variable characteristics. Another issue of standardized testing is that its content does not always correspond to the domain or construct that was intended to be assessed. Such assessment is regarded as construct-irrelevant (Li, 2013) and causes barriers for students. Construct-irrelevant barriers might be a requirement to read fluently, time management, cognitive characteristics, and biased oral or written instructions. In order to minimize

those barriers and reduce the level of subjectivity, it is critical to design tasks understandable for all students, so all students could comprehend the instruction, choose options for knowledge demonstration and be in equal time and effort conditions. The elimination of construct-irrelevant barriers in combination with the application of multiple means for students' engagement in the assessment process reduces the main barrier of assessment anxiety and gives educators more accurate results of what learners actually learned and what they struggle with in terms of an exact construct (knowledge, skill or ability). Thus, effective UDL-based assessments should be flexible, construct-relevant, engaging, focused on the learner's progress, and measure both product and process (Tai et al., 2021).

The learning process of academic disciplines is impossible without progress monitoring through formative or summative assessment. The English for Specific Purposes is not an exception. The ESP competences, as well as General English Language competences, are assessed with tests or tasks that are not always construct-relevant, students often fail tests due to construct-irrelevant factors (Torres & Rao, 2019). The complexity of the ESP tests lies in the fact that they are double-focused to measure professional content comprehensibility and language proficiency (Littlewood, 2014). Thus, there is a concern while analyzing the assessment results either the student did not comprehend the learning material and it should be revised or there were construct-irrelevant barriers that prevented students from objective assessment. Both options affect students' progress and educators should be aware of failure reasons and what should be changed to achieve better results. Therefore, it is necessary to implement modern assessment strategies that will support students' diversity and provide teachers with fair results. With this in mind, the goal of the study is to design a UDL-based technology-enhanced formative assessment focusing on reading and listening comprehension in higher education ESP course. By adopting the methodology of action research, this study intended to investigate the following research questions:

1. To what extent does eliminating of construct-irrelevant barriers in formative assessment affect learners' reading and listening comprehension in higher education ESP course?
2. How do education technologies increase the efficacy of barrier-free formative assessment and make assessment UDL-oriented?
3. How does technology-enhanced barrier-free formative assessment affect learners' motivation?

Therefore, the focus of the research is to create a barrier-free assessment of students' listening and reading comprehension skills and analyze what assessment strategies and technologies support diversity in the learning environment. The practical implication of the study is to provide ESP teachers with recommendations on UDL principles integration and application of technologies for the barrier-free formative assessment design.

1. Theoretical overview

1.1 Universal Design for Learning

Since the early 2000s, the role of students' engagement in the learning process has gained a lot of academic attention since there is a direct correlation between students' academic achievements and their engagement in learning (Finn & Zimmer, 2012). The concept of engagement is reflected through emotional, cognitive, and behavioral constituents. The efficient combination of them is reflected in the Universal Design for Learning (UDL) approach which is aimed at improving and optimizing teaching and learning for all learners by providing equal chances to succeed, offering flexibility in interaction with educational materials and self-expression, making teaching relevant to sustain motivation. The scientific background of the approach is nested in research in cognitive neuroscience that impacts the design of flexible learning environments adjusted to individual learning differences (Meyer et al., 2014). The approach is based on three key types of neurological networks that stimulate learning:

- affective network (incoming information affects intrinsic motivation, emotions, and self-regulation to launch the learning process);
- recognition network (selection and interpretation of the information, meaning construction);
- strategic network (responses, communication, and actions to plan the individual learning trajectory).

The UDL approach was designed to recognize and eliminate learning barriers with the following application of educational practices that tolerate learners' diversity by providing flexible educational strategies, accessible materials, and assessments. The flexibility is built through UDL principles aligned to three networks: multiple means of engagement, multiple means of representation, and multiple means of action and expression (Rogers-Shaw et al., 2017). Engagement is connected to the affective network that stimulates interest and persistence in learning. It provides options for optimizing individual choice and autonomy, sustaining efforts, developing self-assessment, and reflection. Representation refers to the recognition network that bridges the gap between old and newly acquired information with follow-up processing and storage. It helps students to become resourceful and knowledgeable. It provides options for content perception, instruction clarification, and better comprehension. Action and expression deal with the strategic network that helps communicate new information and demonstrate knowledge in the most meaningful and suitable way for a learner. The more these networks are stimulated, the more learning pathways are created in the brain. It maintains options for physical actions, communication, and executive function performance (CAST, 2022).

The implementation of UDL principles into practice allows educators to reduce physical, cognitive, emotional, and organizational learning barriers. From this perspective, a large and growing body of literature has investigated the concept of UDL integration into tertiary education. UDL approach is one of the philosophical paradigms that can be employed to guide further educational technological transformations and to contribute to the development of socially inclusive and responsible universities. There is a consensus among social scientists and the evidence from their empirical studies (Hockings et al., 2012; Kumar & Wideman, 2014) proves that UDL has considerable potential for an inclusive curriculum development. This view is supported by Baner and Behnke (2019) who conclude that UDL shares the same ideas as inclusive pedagogy because it promotes equality and social justice through design and flexible ways for expression in terms of students' learning styles, backgrounds, and needs.

Learner variability is considered a norm in the UDL environment, consequently, educators can integrate responsive and supportive alternatives beneficial for all learners. By drawing on the concept of inclusive instructional design, Rao and Torres (2016) identified learner variability factors: abilities and strengths, needs and possibilities, background and experiences, preferences and interests. However, educators often neglect diversity as it requires more thoughtful educational strategies. For this reason, the UDL principle of multiple means application for the content representation is aimed at the acceptance and finding of educational strategies for cognitively diverse students.

Low academic achievement can be related to learning barriers that students might experience: course or test format, anxiety about expectations and assessment challenges connected with technology use, excessive dependence on text-based educational means, competitiveness with the active performers, lack of motivation, cultural limitations of self-expression, difficulties in content perception, limited access to educational materials, peer pressure, fear of mistakes and exclusion, lack of goals and self-esteem (Kavaliauskiene & Anusiene, 2012). Researcher Smith (2012) performed an empirical study on the identification of learners' common barriers and specified seven groups: attitudes, lack of motivation, social and cultural barriers, curriculum, language, problems in understanding instructions, and personal differences. It is impossible to remove all barriers, however, by understanding and reducing them, we empower students and open the way to equal learning.

As one of the possible UDL solutions, Kumar and Wideman (2014) suggest proactive and learner's customized curriculum and claim that partnership with students' benefits learning goals achievement. Although matching learning goals and materials to the needs of all students might be time and resources consuming, the benefits, the approach brings to students and educators' staff, is undeniable (Kumar & Wideman, 2014; Smith, 2012). Their studies empirically prove that students have positive feedback towards courses where UDL was implemented (Dean et al., 2016) because

students' voices were heard and accepted. UDL also contributed to the concentration and attention capabilities improvement (Flagg-Williams & Bokhorst-Heng, 2016), increased self-confidence (He, 2014) and reduced anxiety (Kumar & Wideman, 2014). Teachers implemented the strategy of partnership where students were seen as an additional source of subject-related information as well as a source of personal learning related information. Students were given the opportunity to bring to the curriculum topics they wanted to learn and suggested additional materials to mandatory course topics.

1.2. UDL-based assessment

The necessity to assess academic achievement is an integral part of an educational process but may cause uncertainty or barriers for many students. Academic standards and tests are restricted, yet there are flexible, inclusive, and alternative educational approaches to their transformation and adaptation that make learning more engaging and meaningful for all students. The greater the variability of assessment practices, the more reasonable and objective the assessment is for all students. The key challenges are to identify assessment barriers and find practices that eliminate those barriers. However, the first step is to perceive UDL-based assessment meaning and its role for the whole UDL cycle.

Researcher Rao (2015) differentiated two processes: assessment design and assessment. They positioned the assessment design after the goal-setting step and variability analysis highlighting the close interrelation and logical sequencing of these steps before the materials and practices selection. Academic standards are fixed skills or knowledge that students should acquire. In the UDL process of goals setting an educator can modify the standard considering learning barriers and their impact on assessment and materials. This is a student-centered approach to the lesson planning as a teacher first considers how a student will be able to demonstrate an acquired skill and then what means of presentation to choose. The assessment itself is performed at the stage of the UDL lesson implementation and its results are used for the reflection stage because assessment demonstrates the results of the teacher's planning as well as student's achievements. This position also justifies the value of formative assessment for UDL planning because formative assessment is ongoing in nature, demonstrates the dynamics of learning, involves teachers and students in the learning process, provides information to react timely to students' needs, and immediately improves instructions (Rao,2015).

The transformation of traditional assessment to inclusive, accessible, sociocultural, and sociocognitive has been realized under the influence of the UDL framework. The concept of accessibility for assessment was studied by Katranci and Melanlioglu (2022) and researchers claim that an educational product (i.e. a test, an instruction) is accessible when it eliminates barriers and can be equally used by diverse students. Meyer, Rose, and Gordon (2014) developed criteria for efficient UDL assessment: it should be ongoing and flexible with a focus on the learner's progress; measure a

product as well as progress; demonstrate construct relevance; sustain engagement. Researchers also claim that flexible and customizable assessments intensify their relevance for students, thus, increasing motivation and persistence levels.

The level of accessibility is determined by the number of eliminated barriers. It is obvious that the range of assessment barriers is diverse, therefore, Meyer et al. (2014) differentiate assessment barriers according to three key UDL design principles:

- engagement: assessment anxiety, low level of engagement and high level of required persistence;
- representation: a single format for assessment practices and a single format of information representation in assessment tasks;
- action and expression: single format for the response.

UDL-based assessment strategies are a great possibility to focus on accessibility concerns, however, it requires an apprehensive recognition of students' abilities and ways students interact with assignments. These factors highlight the critical value of the assessment construct validity which implies the elimination of barriers caused by the construct-irrelevant variance. Construct validity is defined as "...evidence of a task's ability to measure the appropriate domains of interest that it purports to measure" (Dolan et al., 2013, p.12). The construct validity is reflected through the degree of connection between an assignment content, instruction, and a learning goal. Traditional assessment strategies represent the construct-irrelevant variance that causes barriers for diverse learners since they consistently increase or scale down scores for some students if the tasks are unrelated to what they imply to measure. Any factors or instructions that affect student achievements are construct-irrelevant. If an assignment is beyond a student's academic background, does not take into account personal characteristics, test-taking experience, cognitive and sensitive abilities, is not subject-related and provides limited tools for expression, it can be considered as construct-irrelevant (Elliot et al., 2018). For example, most tests require fluent reading skills, however, it is a construct-irrelevant variance that should not be measured. Learners who decode the written information slowly might skip some important items even though they have a good command of the subject-related concepts. Other construct-irrelevant factors are time management skills, extended interdisciplinary connections, motor coordination, ability to sustain concentration and attention for a long time, short-term and working memory, and the ability to make decisions under pressure.

In order to create UDL-based assessment assignments, educators should identify issues related to construct-irrelevant variance and understand the structure of the UDL assessment as construct irrelevant variance can be found in the content, a test item or task situation. There are different views on the assessment structure. Almond, et al. (2010) focused on external factors as delivery modes and

singled out such constituents as test delivery options, items content and its presentation options, and responses presentation options. From the perspective of cognitive theory, Leighton and Gokier (2005) identified cognitive steps of students' problem solving interaction: task comprehension, mental representation, and problem space (Leighton & Gokiert, 2005). Teachers have to find out if students understand test items to evoke construct-related, cognitive processes. Comprehension creates a mental model of the given information that activates reasoning and problem-solving skills from long-term memory. These skills set up a problem space where students manipulate their knowledge to find a solution. Leighton and Gokiert (2005) concluded that there is a direct correlation between a student's comprehension level and assignment item clarity level. In other words, assignment designers should accurately address the construct being measured so that students stay cognitively focused. Otherwise, the assessment results will show deviated information on what students really know. Dolan et al. (2013) developed a framework that is based on Leighton and Goiter's study (2005) on cognitive processes how students interact with the assignments and respond to their specific features. However, they extended the previous framework and added construct-validity factors and information processing abilities (Appendix A). The first part of the framework explains the process of students' interaction with an assignment. Authors of the framework (Dolan et al., 2013) claim that this process is dynamic and iterative in terms of cognitive, motivational, and executive domains. The interaction progresses through three phases in which information processing and construction abilities are demonstrated: task presentation, strategic interaction, and response action (Dolan et al., 2013). Researchers emphasize that it is critical to sustain students' motivation and engagement through all phases of the problem-solving process and minimize the impact of construct-irrelevant factors.

Therefore, the second part comprises information on factors that affect construct validity. Dolan and colleagues (2013) consider that the task content, its clarity, and relevance to students' backgrounds, define task validity. They suggest seven task content characteristics: knowledge and skills relevant, corresponding to tools, materials, and environment known to students, realistic, synergistic, unambiguous, sensitive to students' diversity, and balanced cognitive load. Among task components, educators defined images, audio, video, texts, tables, links, multi-stage tasks, and constructed responses.

The third part outlines information processing abilities and challenges that affect students' interaction with an assignment in demonstrating their construct-relevant knowledge and skills. Following three UDL networks (recognition, strategic and affective), framework developers define six types of processing abilities: perceptual, linguistic, cognitive, motoric, executive, and affective.

Identification of construct-irrelevant variance and its sources allows a teacher to prevent unequal generalized assessment. Although it is impossible to remove all barriers, the awareness of their

presence and impact contributes to the development of valid and accessible student performance assessments.

Despite a great number of UDL-based assessment benefits, modified assessment cannot be equally accessible to all students. UDL improves assessment and makes it flexible and engaging, however, it does not mean that the same changes suit everyone in equal scope. The same test or assignment can be changed many times depending on students' diversity because accessibility is not a static feature of a test, but is an interaction between an assignment and personal characteristics. In order to implement UDL-based assessment in a proper way and provide the highest level of universality, teachers should keep in mind its specific features outlined by researchers (Abell, Jung & Taylor, 2011; Capp, 2017; Salvia, Ysseldyke, & Bolt, 2009): elimination of barriers to engagement and expression (inclusiveness, authenticity, accessibility, relevance and reduced anxiety); activation of previous knowledge; focus on weaknesses and uncertainties in assignment instructions, not on students' personal weakness; interactive and multimodal design of assessment; anticipation of learner variability; tolerance to mistakes and orientation on success; prioritizing of formative assessment; critical feedback. Thoughtful assessment design and implementation are crucial for effective teaching and learning, and universal design for learning equip educators with a framework and tools for accomplishing it. UDL-based assessment enhances communication between a teacher and a student, discloses learner's strength and makes academic standards more accessible, thus, achievable.

1.3. Synergy of UDL and technologies

The current shift to engaging technology-enhanced teaching requires thoughtful solutions based on philosophical assumptions and empirical evidence-based practices. Recent studies demonstrate a range of discussions in terms of technology associated with UDL since this approach was created to be accomplished with digital media. A great number of studies underline the efficacy and benefits of technologies and claim that full-scale UDL implementation is impossible without digital media that create a flexible, adjustable and engaging learning environment which is critical for sustainable motivation (Capp, 2017; Dean, Lee-Post & Hapke, 2016; Salend, 2009). Modern learning modes (blended, flipped, online, etc.) provide great opportunities for UDL integration (Rao et al., 2021). Existing research reports improvement of academic achievements in different subject areas due to the intervention of technology-enhanced UDL environments created by content acquisition podcasts (Kennedy, et al. 2014); scaffolding digital tools (Reynolds & Daniel, 2017); digital books and platforms (Basham, Meyer, & Ernest, 2010); and computer-based reading programs (Hall et al., 2015) or testing program (Russell et al, 2009).

CAST (2020) researchers claim that technology-enhanced assessment adds flexibility, real-time feedback and monitoring of student's achievements. Educators admit that digital tools being employed in classroom settings create a native digital environment for students and thus make assessment less stressful. Leu et al. (2019) concluded that digital tools are not only scaffolds for spelling literacy or vocabulary repository but they are cultural and educating tools that help students preserve their diversity and digital identity in and outside the classroom. This idea is in line with Vasinda and Pilgrim's (2023) study in which scholars advocate rethinking the notion of digital tools as scaffolding elements or mediators that provide the necessary support. Instead, they recognize technologies as "permanent new literacy options" (Vasinda & Pilgrim, 2023, p. 45) emphasizing their importance, sustainability, and availability for teachers and students. Researchers compare the nature of UDL and technologies as assisting multiliteracies and consider their synergy as a new notion of "Universal Access for Learning".

As it was mentioned above, a Universally designed assessment is critical for making assessment accessible, and digital tools increase the level of accessibility of tests. Apart from accessibility, technologies also impact the level of assessment adaptability to students' academic background level or cognitive possibilities. In 2017, the U.S. Department of Education, Office of Educational Technology prepared a report on technology's role in education (ISTE, 2017) where it was mentioned that tests aligned with students' ability level presented more accurate scores and provided a more holistic understanding of students' possibilities to work on.

Much of the current literature on UDL pays particular attention to how technologies promote UDL principles (Rao, 2021; Vasinda & Pilgrim, 2023). I have singled out the most commonly expressed ideas: technologies provide a wide range of accommodations; improve communication options; extend education beyond the classroom eliminating obstacles of time and distance; adapt educational materials to students' strengths and levels.

Multimodality of the learning environment framed by UDL and technologies transforms the pedagogy of "four designs: audio, visual, kinesthetic and tactile" (Cope & Kalantzis, 2022, p. 2353) into the pedagogy of multimodality which implies the communication of information through diverse designs: audio, written, oral, spatial, visual, gestural, and tactile. The pedagogy facilitates freedom of choice, exposes strengths rather than highlighting efforts, and supports students' intentions to become designers of their own learning environment and educational artifacts with the integration of personal cultural, linguistic, and cognitive features that represent the unique outlook of every student. Cope and Kalantzis (2022) call such an environment „productive diversity“ in which transformations, sharing, discussions, and designing foster the creation of new personalized meanings. Authors conclude that

due to UDL integration teachers and students see digital tools as permanent options to create content, engage in assessment, and showcase learning authentically.

However, the employment of digital media alone without thoughtful pedagogical consideration does not make learning more accessible or minimize barriers. Indeed, the cornerstone of efficient technology-enhanced UDL lies in understanding which options of digital tools either in instructional or assistive ways support learner diversity and provide multimodal ways of expression. Despite all benefits, technologies sometimes interfere the UDL integration through the increased cognitive load, restricted connection accessibility or device compatibility, constant technology updates, quick monetizing of the most usable platforms, dependence on technical skills while presenting learning outcomes, prioritizing of means of learning (video recording) over learning skills (reading), privacy and copyright issues (Hamutoglu & Basarmak, 2020; Leahy, Holland & Ward, 2019). Other researchers raise the problematic issues of reducing UDL as an approach that suggests only assistive technologies (Izzo, 2012) or presents risks of a construct simplification (Watchorn et al., 2013). Too many digital tools might overwhelm students with the necessity to learn new technologies for different subjects (Vasinda & Pilgrim, 2023). However, the greatest threat is the application of technology for technology's sake instead of correlation to learning outcomes and students' needs (Hollingshead & Carr-Chellman, 2019).

Together these studies provide important insights into the critics and benefits of technology-enhanced UDL. Digital technologies offer a more flexible and responsive platform for constructing accessible assessments. That adjustability fosters accurate measurements of both an extended and deeper scope of constructs and a more extensive range of students.

2. METHODOLOGY

This chapter of the thesis moves on to describe the research methods and tools employed to perform the study on the effect of UDL-based technology-enhanced assessment on reading and listening comprehension, as well as students' motivation changes.

2.1 Sample

The convenience non-probability sampling methodology was used in the study as this technique allows observing the target audience's opinions and viewpoints in close relation with the set of criteria (Patton, 2014) that is in line with action research methodology. Participants from two academic groups were chosen due to their proximity and accessibility. To collect necessary information for the research questions, I applied a few criteria to sample selection: students of 3-4 courses majoring in engineering and studying ESP, language competence level B1 (CEFR), and previous experience with standardized

assessment tests. The criterion of previous test experience is important for the study since it can be regarded as a learning barrier in case of its negative impact. Some students had experience with the language competence standardized tests taking and all students passed the national standardized test on the English language before entering the university. The sample size was 38 students, and the average age was 20-22 years old, with 6 female and 32 male students. The sample size was defined taking into account the margin of error (2.5%) and sampling confidence level (95%). All research participants gave their permission to be part of the study, by signing the consent for participation in educational research.

2.2. Research design

Action research is used in this study as a qualitative research approach to collaborate with students in real-world problem identification and finding evidence-based solutions, promoting reflective practice, and producing solutions, actions, and changes. It involves ongoing data collection, analysis, and reflection, encouraging continuous improvement in teaching and learning practices, and providing a mechanism for evaluating the effectiveness of changes made in the classroom (O'Leary, 2007). The benefits of this research methodology include active participation of stakeholders, collaboration with students to develop and implement solutions, customization and flexibility tailored to specific classroom needs, self-management of the study process, and transferability of findings to other contexts.

2.3 Research procedure

The intervention took place at Igor Sikorsky Kyiv Polytechnic Institute as a part of an ESP course facing low student results on formative assessment of reading and listening comprehension. Prior to the study, students underwent two surveys on learning profiles variability and post-assessment reflection. The Personal Learning Profile questionnaire (Appendix B) was suggested to students to identify the scope of the study participants' variability. A short reflective post-assignment questionnaire was conducted to find out the causes of the assessment-related problems, and an assumption regarding the construct-irrelevant variance of the assessment was developed, outlining the key idea of the study.

The study involved three stages: an original formative assessment assignment, a modified assessment assignment based on UDL recommendations, and a technology-enhanced barrier-free assessment task. The grading scale for academic outcomes was applied to compare results and answer research questions regarding the impact of construct-irrelevant barriers on reading and listening comprehension and the efficacy of education technologies in barrier-free assessment. Assessment

outcomes were compared twice: after the second stage results were compared with the initial results (RQ1) and after the third assessment with technology results were compared with the second stage results (RQ2). It allowed tracing the dynamic of changes with and without the technology integration and demonstrating evidence of how education technologies contribute to the efficacy of UDL barrier-free assessment.

The potentially construct-irrelevant barriers were identified while the assessment design audit using the classification of construct-irrelevant barriers developed by Dolan et al. (2013) and recommendations on construct-relevant assessment suggested by the International Test Commission and Association of Test Publishers (Bartram, 2009).

After the completion of the assignment students were asked to reflect on their experience answering questions of the survey (Appendix C). The survey included questions on students' attitude towards construct-irrelevant assessment, technology integration and motivational changes to provide answers to the third research question (RQ3).

2.4 Data collection tools

To obtain persuasive evidence and answer the research questions, academic outcomes scoring rubrics, tests results comparison through ANOVA statistics, assessment design through learning barriers analysis and three self-report questionnaires were used. The data for RQ1 was evidenced by the results collected from the academic outcomes scoring rubric and questions from the first part of the final reflective questionnaire on the attitude toward UDL-related changes. The answers to RQ2 were obtained by academic outcomes scoring comparison and questions from the second part of the final reflective questionnaire on the students' perception of technologies' effect on their outcomes. The information on RQ3 was received from the third part of the final reflective questionnaire on changes in students' satisfaction and motivation levels. The questionnaires, employed for this study, were based on the learning theories for UDL assessment including constructivism, cognitivism, sociocultural theory, brain-based learning theory, and multiple intelligence theory. Each of these learning theories provides insight into the way students learn and how best to assess their understanding.

The first questionnaire Personal Learning Profile (Bray & McClaskey, 2016) was aimed at learning more about a students' learning preferences, obstacles, and modes of expression with regard to access, engagement, and expression. The questionnaire included 27 close-ended statements with a Likert scale 5-rating multiple choice (Appendix B). The questionnaire was given before the first experimental intervention. The questionnaire was designed based on the theoretical frameworks of metacognition, self-regulation, and UDL guidelines. The questionnaire had three parts: Access, Engagement, and Expression. Access assessed how well students could understand educational

materials, including visualizing information, making connections, and self-directed learning. Engagement measured students' involvement, learning style, workload management, organization, and collaboration. Expression evaluated students' ability to communicate their comprehension using different modes such as speaking, visual aids, and creative projects. Based on the questionnaire results, I tailored my teaching assessment strategies to improve learning outcomes by addressing students' diverse strengths, challenges, and preferences.

The second pre-intervention questionnaire (Appendix E) was focused on the causes of low level academic outcomes of reading and listening comprehension that was observed prior to the study intervention. The questionnaire was adapted from the Post-test Self-Assessment developed by educators from the University of Calgary (Student Success Centre, 2014). The questionnaire was administered in the first stage of the study after the completion of the original non-modified assignment. The questionnaire included seven close-ended questions: two rating scale multiple choice questions (e.g. To what extent...); four dichotomous questions; one checklist types multiple choice question. The survey provides information on students' reflections on the assessment assignment quality and potential causes of poor outcomes.

The third post-intervention reflective questionnaire (Appendix C) was designed to collect data on students' perception of modified UDL-based technology-enhanced assessment and if such assessment impacted their motivation level. The theoretical background for the survey served the theory of self-determination (Ryan & Deci, 2017), UDL Guidelines on the approach implementation (CAST, 2020), and recommendations from UDL researchers (Novak & Rodrigues, 2016). The questionnaire consists of three sections: perception of barriers-free UDL-based assignment (10 questions), attitude toward technology integration (5 questions), and motivational changes (12 questions). Students were asked to rate their responses according to Likert 5-points scale ranging. The level of motivational changes was evaluated using the Reduced Instructional Materials Motivation Survey (RIMMS) developed by Keller (2010). The survey is based on four motivation components known as the ARCS Motivational Model: Attention, Relevance, Confidence, and Satisfaction (Keller, 2010). It comprises 12 items rated on a 5-point Likert scale ranging from 1 for "not true" to 5 for "very true" (Appendix G).

The data collection process follows the principle of triangulation data verification which means that data are collected through multiple sources: questionnaires, assessment design audit for construct irrelevant variance and barriers, and academic scoring rubrics. The questionnaires were shared with students in Google Forms format. and they were translated into Ukrainian to avoid misinterpretation

The assignment design audit was performed applying UD-CBT guidelines (Dolan et al., 2013). The researchers (Dolan et al., 2013) distributed barriers into the groups according to the type of information processing that students apply while interacting with the assignment components:

perceptual, cognitive, linguistics, motoric, executive, and affective. The types reflect UDL networks and specify factors that affect the academic performance of all students. I adapted the classification in accordance with the context of the research – ESP listening and reading comprehension assessment. Therefore, I added the potential sources to linguistics barriers (specialism-related terminology, functional language collocations), cognitive barriers (inferential thinking skills required for reading comprehension, lack of comprehension strategies suggested in instructions), and executive barriers (shifting attention from listening to reading or writing, switching to different listening skills to accomplish listening goals: listening for specific information, listening for gist) Due to this classification of barriers (Appendix F). I identified sources of construct irrelevance and potential learning barriers from a UDL perspective.

The analysis of the assignment design went through three stages: item design evaluation for construct validity, item design evaluation for the source of construct irrelevance, and item delivery modes and tools evaluation (Doland, 2013). During the first stage, the construct was identified and task instructions were inspected for the measuring exactly intended construct. In the second stage, it was important to determine if the item design and mode of its delivery contained sources of construct irrelevance by requiring additional skills or knowledge for the task completion. For each assignment item, I determined which processing categories were construct-relevant and found the sources of variance which could contribute to the processing category. The third stage was aimed at incorporating the transformations and evaluation according to feasibility, target audience needs, and academic subject-related standards compliance. Having verified that construct irrelevance was minimized, technologies were added to provide variety for students' expression. The key purpose of these stages is to modify assignments and make them universal so that they could match the needs of all students. While all potential barriers cannot be eliminated immediately, it is assumed that a systemic evaluation could facilitate the creation of UDL-based technology-enhanced assessment items with a high level of accessibility and relevance.

2.5. Data Analysis

In this study, various methods were used to collect data, including questionnaires, test scoring rubrics, and RIMMS surveys. The data collected through these methods were then analyzed using ANOVA statistical method, chi-square test for independence for RIMMS and content analysis for tasks instructions audit. Questionnaires were administered through Google Forms and results were accumulated using Excel spreadsheets with a separate response for every student. Academic achievements were reflected in tests scoring rubrics that demonstrated students' correctness and accuracy of answers. The number of right answers was analyzed in Excel and it allowed showing the

dynamic of changes. The results of students' assessments (2 for reading comprehension and 2 for listening comprehension) were distributed into 3 columns (initial assignment, UDL-modified assignment without technologies, and UDL-modified assignment with technologies) with personalized attribution to separate lines for every student. The inclination of data observed among outcomes was determined by analysis of variance (ANOVA) to find out if there was a significant difference between three assessment trials.

The survey findings were analyzed through the Likert scale. To ascertain whether there was a notable distinction among the results of the three evaluation trials, an analysis of variance (ANOVA) was performed to determine the data's tendency. Due to a four-factor structure of the RIMMS survey, it was possible to analyze the level of attention, relevance, confidence, and satisfaction using chi-square test for independence. The chi-square test for independence is non-parametric and doesn't require normally distributed data, it is frequently employed for Likert scale data as it allows to determine whether there is a meaningful correlation between the parameters.

Results

This section reports the results in accordance with the sequence of the research questions:

1. **To what extent does eliminating of construct-irrelevant barriers in formative assessment affect learners' reading and listening comprehension in ESP course?**

The statistical analysis was performed using ANOVA analysis. The null hypothesis asserted that there was not a significant difference between an assignment that pertained to the construct being assessed and an assignment that was extraneous to the construct being evaluated. The H1 posited a significant difference between an assignment that is construct irrelevant and one that is relevant to it. The student participants underwent four assessments, encompassing two iterations of listening comprehension and two iterations of reading comprehension. The findings are presented in the Appendix section. The F-ratio value obtained for the initial assessment on listening comprehension is 33.35. The p-value equals 0.00001, $[p(x \leq F) = 1]$. Since $p\text{-value} < \alpha$, H_0 is rejected. The f-ratio value obtained for the second listening assignment is 54.64. The statistical analysis resulted in a p-value of 0.00013, indicating strong evidence against the null hypothesis. The p-value equals 0.00013, $[p(x \leq F) = 1]$. Given that the p-value is less than the level of significance (α), it is justifiable to reject the null hypothesis (H_0). The obtained f-ratio value for the initial reading comprehension task is 47.74. The statistical significance for the analyzed data is demonstrated by a p-value of 0.0001. Given that the p-value is less than the significance level α , the null hypothesis (H_0) is rejected, following established statistical principles. The F-ratio value obtained for the second reading comprehension assignment is 106.3,

based on the relevant statistical analysis. The p-value is < 0.0001003 . Since $p\text{-value} < \alpha$, H_0 is rejected. The statistical analysis demonstrates that students exhibited enhanced performance while completing modified tasks, thereby confirming the considerable influence of construct irrelevance on the improvement of both reading and listening comprehension abilities.

The responses of the students to the reflective questionnaire concerning their attitude towards modifications in academic tasks were evaluated utilizing a Likert scale with five points. The frequency analysis is delineated in the appended table (Appendix C). A reflective questionnaire was administered to students as a means of evaluating their attitude towards modifications in course assignments. The findings indicate that a significant proportion of participants (approximately 76.3%, or 29 out of 38 respondents) expressed positive receptivity towards the alterations and concurred with the assertions put forth (Appendix D). However, a subset of participants ($n=12$) expressed concerns, specifically regarding the task correspondence with their levels of professional experience and comprehending the justification for the task's specificity. The survey revealed that a majority participant ($n=28$) experienced feelings of safety and acceptance within the classroom environment. Furthermore, they acknowledged the provision of various instructional tools, including but not limited to choice options, contextual clues, and educational tools, which facilitated their ability to effectively convey their grasp of the material learned. However, there is an opportunity for enhancement concerning the educator's comprehension of the students' interests and educational and professional background. The survey comprising thirty-four ($n=34$) students revealed their comprehension of the assigned tasks and their perception of access to supplementary information as sufficient. Nevertheless, it is recommended that the instructor enhance the clarity of and justification for their selection of subject matter and literary materials. The research findings indicate that the students perceived themselves as possessing the ability to exercise control over the level of challenge posed by academic assignments. Overall, the study suggests that it may be necessary to further refine the assignment selection process to ensure optimal alignment with each student's individual proficiency level.

2. How do education technologies increase the efficacy of barrier-free formative assessment?

In order to answer this question, the data collected after the second intervention (first modification without technologies) was compared with the results of the third task completion (modification with technologies). The difference between two sets of the results was calculated using ANOVA to verify if there is a significant difference between the means of two assessments. A one-way ANOVA on that the effect modification with technologies was significant for listening comprehension improvement,

$F=42,29$, p -value equals 0.000011 , [$p(x \leq F) = 1$] (Appendix G). Since $p\text{-value} < \alpha$, H_0 is rejected. The F -ratio value for the reading comprehension assignments is $11,63$, $p\text{-value} = 0,0001001$, [$p(x \leq F) = 1$]. Since $p\text{-value} < \alpha$, H_0 is rejected. The findings indicate a positive trend in the academic achievements in listening comprehension of students, implying that there has been an improvement in the outcomes. Furthermore, it was found that H_1 was accepted for all tests, indicating that the integration of educational technologies into construct relevant assignments enhances students' reading and listening comprehension. The comparison of listening comprehension assessment results is demonstrated in Figure 1.

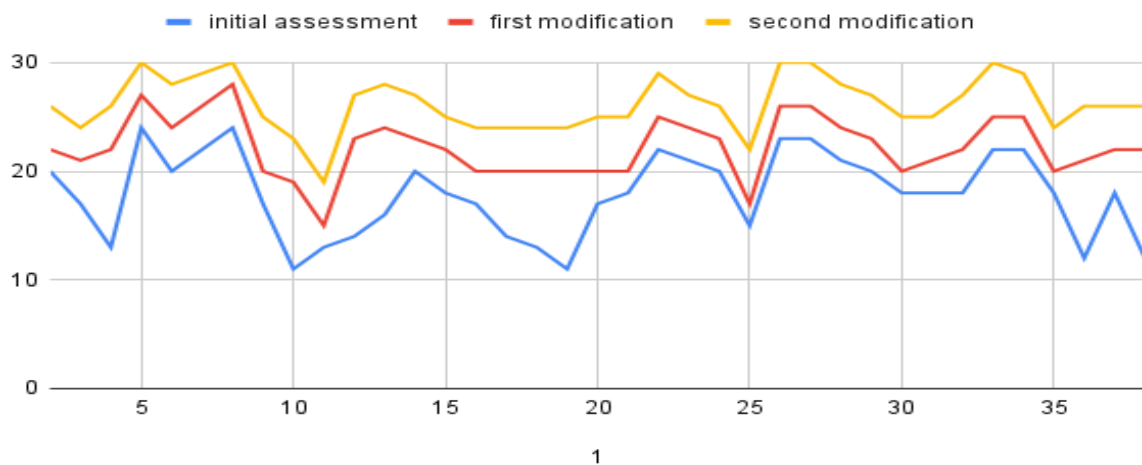


Figure 1. Comparison of listening comprehension assessment results

The comparison of reading comprehension assessment results is demonstrated in Figure 2

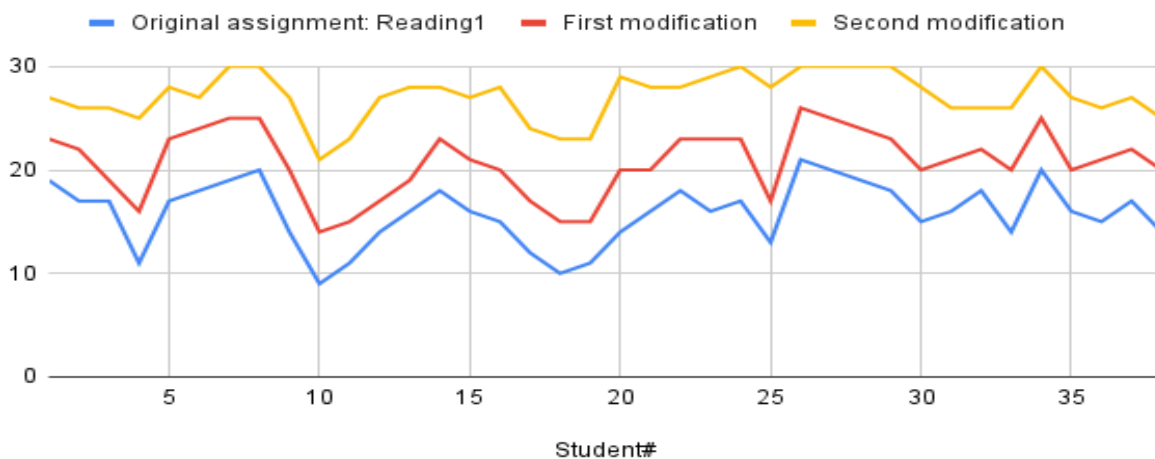


Figure 2. Comparison of reading comprehension assessment results

In order to find out students' perception regarding the technologies integration into the assessment, students were asked to answer questions on technology integration of the reflective questionnaire (Appendix C). The findings indicate that the use of technology helps students to manage with the assignment (Fig.3).

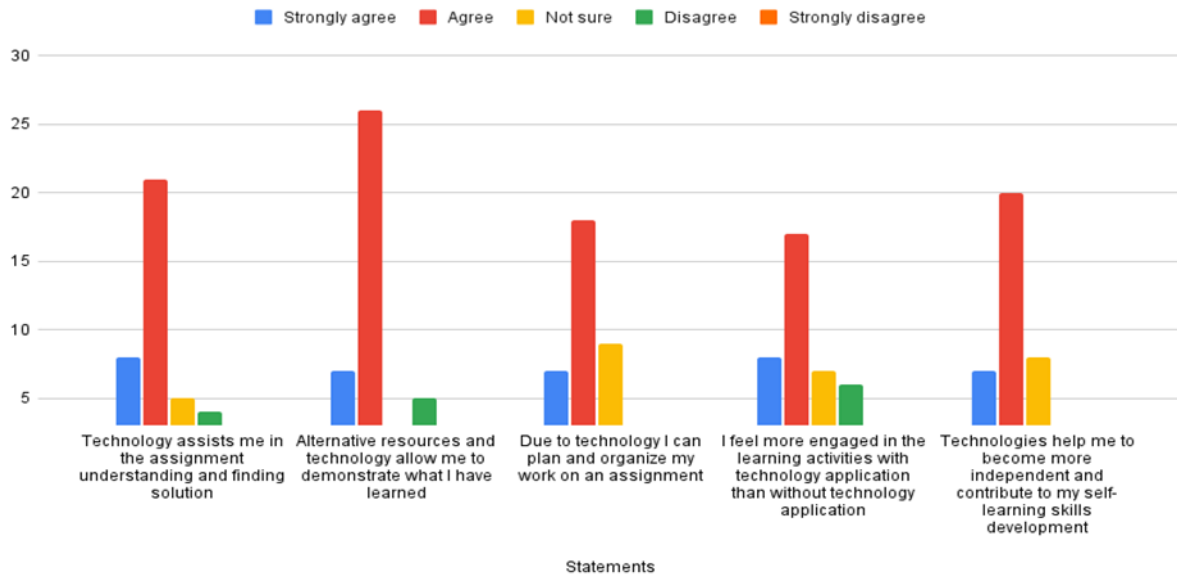


Figure 3. Students' responses on the effect of technology integration

Ultimately, the outcomes of the questionnaire reveal that a significant proportion of respondents hold a stance of agreement, or indeed, strong agreement, with regards to the notion that technology has a positive impact on their acquisition of knowledge and skills.

3. How does technology-enhanced barrier-free formative assessment affect learners' motivation?

The third part of the reflective survey aimed to evaluate the motivational dynamics that resulted from the implementation of technology-enhanced assessments that were specifically designed to address and assess relevant constructs. The objective of the RIMMS instrument was to evaluate learners' engagement and levels of involvement in their learning experiences through an assessment of key factors that encompass attention, relevance, confidence, and satisfaction (ARCS) (Appendix H). The mean value of the attention factor demonstrated an average of 7.6 with a standard deviation of 4.2. The research results suggest that the utilization of relevant task content and a diversity of resources can positively impact learners' level of engagement and attention (Appendix I). The columns pertaining to the measure of attention, namely "The quality of the content helped to hold my attention" (14), "The way the information is arranged helped keep my attention" (11), and "The variety of resources helped keep my attention" (14), exhibit the highest values for the assessment of "Mostly true". In a general sense, the outcomes pertaining to the Attention construct reveal that the students (55%) provided responses that were characterized by predominance of agreement across the majority of statements

(Fig.4).

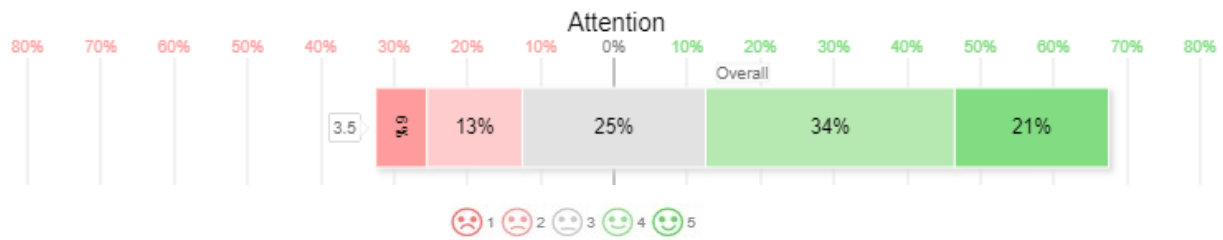


Figure 4. Overall result for the Attention factor (%)

The statistical analysis conducted using a chi-square test of independence revealed a noteworthy correlation between the criteria of the Attention factor, denoted by $X^2(8, N = 38) = 15.58, p = .04$. The results imply that the variables are not independent of each other. In other words, the existence of one variable is related to the existence of the other variable, and this relationship isn't likely to be due to chance.

The mean of the Relevance factor was 7.6 with a standard deviation of 5.1. Based on the statistical data and the responses obtained from the Likert scale (Appendix I), it can be inferred that the pertinence of the assignment content, instructions, and information offered play a critical role in shaping students' perceptions and level of engagement. The present study identified that the column concerning the perceived worth of technology proficiency in completing the assignment attained the highest value of 17, predominantly indicative of a true perception. In addition, the column assessing the perceived utility of the content and instructions scored the second highest value of 12, indicating a moderate level of agreement. Overall, the outcomes pertaining to the Relevance factor reveal that the most students (57%) provided positive responses towards the Relevance factor changes (Fig.5)

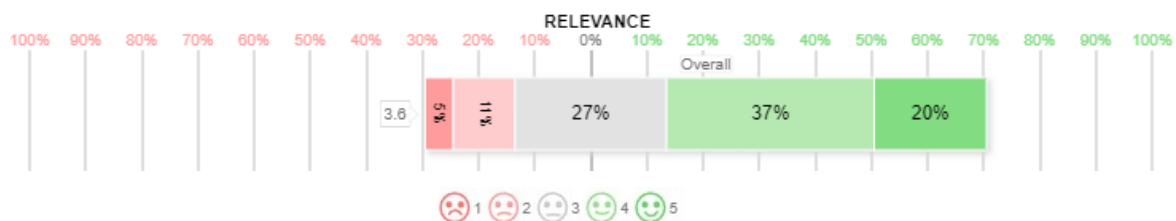


Figure 5. Overall result for the Relevance factor (%)

A statistical analysis utilizing the chi-square test of independence indicated that there exists a consequential relationship between the criterion of Relevance factor, with $X^2(2, N = 38) = 19.91$, and a significance of $p = .01$. The results imply that the variables are not independent of each other. In other words, the existence of one variable is related to the existence of the other variable, and this relationship isn't likely to be due to chance.

The results of the study reveal that the average confidence factor score among the student participants was 7.6, with a standard deviation of 5.4. Such findings suggest that a considerable

number of students possess a notable level of confidence and motivation towards the completion of the assignment. However, the considerable standard deviation score implies a broad spectrum of responses among the participants. The Likert scale responses unveiled that the clarity of the instructions, the organization of the content, and the complexity of the exercises exert an impact on students' levels of confidence and motivation (Appendix I). The statement that "Upon studying the designated instructions, I possessed a strong conviction in my ability to successfully execute the exercises" attains the highest rating of 17 on mostly true, indicating predominance of veracity. On the other hand, the assertion concerning the effectiveness of content organization and instructions in fostering confidence in one's ability to conduct the task of exercise completion attains the second highest rating of 13, indicating a moderate level of veracity. The overall results on the Confidence factor demonstrated that 61% of students admitted positive changes in this motivation domain (Fig. 6)

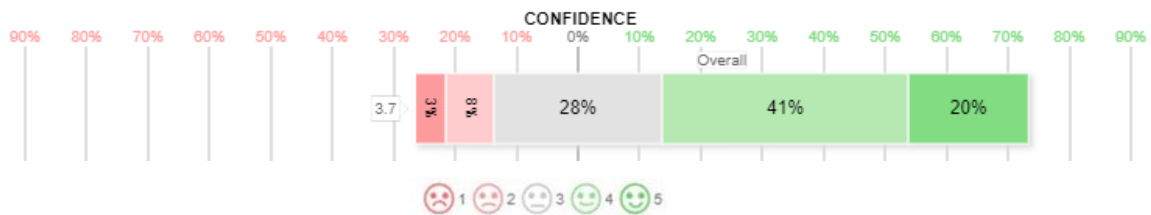


Figure 6. Overall result for the Confidence factor (%)

Based on the results of a chi-square test of independence, it can be inferred that a noteworthy correlation exists between the Confidence factor criteria. Specifically, the obtained values for $\chi^2 (2, N = 38) = 16.05$ and $p = .04$ indicate statistical significance. The results imply that the variables are not independent of each other. In other words, the existence of one variable is related to the existence of the other variable, and this relationship isn't likely to be due to chance.

The results reveal a mean satisfaction factor value of 7.6 (SD=5.7), serving as evidence that there exists a certain degree of variation in the participants' satisfaction levels. According to Likert scale findings, the statement "Working with well-designed instructions was an enjoyable experience" is assigned the highest value of 15, indicating a degree of moderate truth (Appendix I). In general, Overall, 62% of students had a positive attitude regarding the modifications made to the Satisfaction factor (Fig.7).

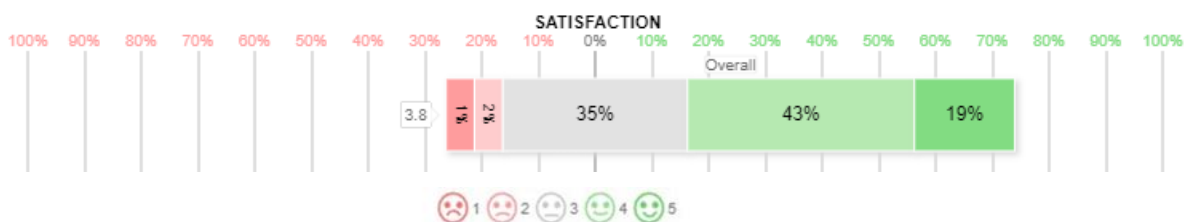


Figure 7. Overall result for the Satisfaction factor (%)

A statistical analysis utilizing the chi-square test of independence revealed a statistically significant relationship between the criteria for the factor of satisfaction, as indicated by $X^2(2, N = 38) = 16.21, p = .03$. The results imply that the variables are not independent of each other. In other words, the existence of one variable is related to the existence of the other variable, and this relationship isn't likely to be due to chance.

The study indicated that the students' motivation was considerably high as they found the modified technology-enhanced assignments pertinent to the subject matter, engaging, enjoyable, and of substantial quality.

4. Discussion

Universities have recently placed a greater emphasis on the application of Universal Design for Learning (UDL), with a goal of developing lessons and assessments that are inclusive and accessible for all students. This approach is applicable for English for Specific Purposes (ESP) classes since students have different levels of English competence, educational and cultural backgrounds. This study's objective was to design a UDL-based, technology-enhanced formative assessment for reading and listening comprehension in ESP courses in higher education. The key findings and their significance for educators will be highlighted in further details in this discussion. In this section, I will first consider the importance of construct-irrelevant barriers elimination in formative assessment and how it affects students' reading and listening comprehension in ESP courses in higher education.

4.1. Construct-relevant assessment for reading and listening comprehension

Assessment in education is crucial for improving learning outcomes for students, whether it is for a statewide accountability system, classroom progress monitoring, or individual diagnostics. Today teachers find it difficult to deal with the increasing heterogeneity in classrooms. When it comes to formatively measuring learning, it presents numerous challenges because traditional forms of assessment do not accurately reflect the learning needs of all students (Schroeders & Wilhelm, 2011). The focus of a UDL method is on individualizing the learning process for each learner. In order to assist the learning of all students, UDL assessments put a strong emphasis on detecting weaknesses and external barriers, identifying strengths, challenges, preferences with follow up reflections and improvements. Overall, UDL assessment identifies how the current learning environment supports a learner and what can be done to make it optimal for each student.

With that in mind, before the intervention, students were asked to complete the Personal Learning Profile (Bray & McClaskey, 2016) to identify their educational strength, weaknesses and

preferences. The survey captures the learning preferences of each student in three UDL related categories: access, engagement and expression. In order to promote self-reflection and empower learners to make informed choices these categories included three subcategories: strength, challenges and preferences. The results of the questionnaire demonstrate that majority of students (n=26) expressed proficiency in verbal and visual expression. However, some of respondents (n=21) encounter difficulties in written expression and self-evaluation of their learning progress. Most students (n=31) chose non-traditional projects for assessment and diverse communication channels. Absolute majority of students (n=35) preferred tasks to be broken down into smaller, manageable parts and would feel more engaged in learning if tasks would be connected to real-world situations.

Having analyzed the results of the questionnaire, it was found out that among strengths the majority of students mentioned: ability to connect new knowledge with previous background, have a possibility to make their own decisions and choices, and visualize the content. These findings proved that students value autonomy, can critically analyze and juxtapose obtained knowledge with new information. It meant that it was necessary to integrate these strengths into the assignments so that students could feel more self-confident and stay persistent during the assignment completion. Among challenges the greater number of students marked difficulties with the comprehension of auditory format of information, struggling with multiple tasks and low level of self-monitoring skills. These findings were identified as potential learning barriers: perceptual, affective and cognitive. In order to eliminate these barriers, it was necessary to change the format of the assignment content representation, add supportive strategies and provide students with clearly structured instructions. Learning preferences also impacted the assessment transformations. Students' choice was rather obvious as today's students preferred multiple means of communication and expression, multiple formats of the content representation and application of supportive resources. The multiple media and format highlight the learners' variability that can be expressed through the diversified sources.

By incorporating these insights into assessment transformations, I could set up a more differentiated learning environment but first I had to identify the construct to measure. My choice was reading and listening comprehension skills as it is quite obvious that academic success often requires a high level of reading comprehension, including the ability to analyze complex sentence structures, understand academic vocabulary, and recognize implicit meaning. Under the comprehension skills educators (Wolf, et al., 2019) consider the ability to understand spoken, written, or visual content. Comprehension itself is an intentional and complicated cognitive process that implies simultaneous retrieving and generating meaning from the text (Spoden et al., 2020). The high level of comprehension skills is necessary for students to have a solid grasp of the terms and vocabulary used in their particular discipline. However, the assessment of these abilities is often affected by construct-

irrelevant tasks or teacher-related, student-related, classroom environment and course-related barriers. Among common factors that might affect reading comprehension, some of which are: text structure, lack of prior knowledge, fluency in foreign words decoding, motivation and interest, lack of attention and focus, working memory, and executive functions (planning, predicting, inferencing, self-regulation, self-monitoring).

During the process of constructing assignments that are relevant to reading comprehension, it is critical to remove potential obstacles and include activities aimed at enriching readers' comprehension through the cultivation of background knowledge, activating vocabulary through the provision of dictionary definitions, utilizing sentence-based gist strategies by selecting significant keywords, contextualizing information to foster inferencing abilities, and locating relevant information by means of synonymous matches. The development of a suitable assessment design for evaluating reading and listening comprehension was executed by following a sequence of steps:

1. identification of the construct for the assessment. It was done by checking on the learning objectives and standards for the task;
2. assessment of the arrangement between the construct and the evaluation. It is vital to look at the evaluation things and decide whether they are measuring the planning construct or aptitude;
3. acknowledgment of learning barriers by analyzing an individual profile, common misguided judgments, mistakes, or gaps in students' responses. These barriers may demonstrate that understudies are struggling to get it the concept being evaluated or that the evaluation isn't successfully measuring the planning construct;
4. analyzing the assessment format and structure to supply knowledge into construct relevance and learning barriers;
5. investigating student's execution on the assessment and analyzing students' feedback offer assistance identify areas where understudies were still struggling and where learning barriers can be display.

All things considered, the key to determining whether a set of assessment items is relevant to the intended construct or skill and whether there are any learning barriers is to carefully review the assessment items, assess how closely they align with the intended construct or skill, and search for signs of learning barriers in students' responses and performance. The initial version of assessment tasks suggested for the intervention were considered as construct-irrelevant due to the following barriers: cognitive overload, multitasking, questions that call for a personal background more than the text comprehension; low level of engagement; low level of self-regulation that leads to forced persistence and decreased motivation. It was difficult to understand what skill was implied for the assessment whether reading skill or general background.

The first assessment results of a traditional assignment clearly demonstrate that comprehension can be cognitively inaccessible when it necessitates the ability to choose and prioritize among numerous components or concepts and there are no alternatives for students with varying degrees of that ability. All students differ in their abilities to process information and access to prior knowledge to assimilate new information. I consider that the most neglected differentiation criterion is cognitive diversity which implies differences in information processing and ways of solution searching. Avoiding the acceptance of this diversity, creates more construct irrelevant barriers. To convert information into practical knowledge, it's important to teach students how to utilize cognitive strategies and skills of information processing and eliminate barriers that prevent efficient cognitive processes. One of the most effective ways to increase accessibility of information is by giving clear indicators or tips that help people focus on the most important aspects and ignore the less important ones. The cognitive strategies involve choosing and manipulating information in ways that make it easier to understand, organize, prioritize, put in context, and remember. While some students may already have these strategies and know when to use them, most do not. Therefore, the study findings confirm that well-designed construct relevant materials, which support the application of cognitive strategies, can serve as personalized, scaffoldings learning tools to help students with varying abilities use these strategies effectively (Elliot et al., 2018; Schroeders & Wilhelm, 2011).

The comparative analysis of students' academic achievement results after completion of the original and modified assignment, evidenced that students' level of information comprehension was higher after the task transformations. The results indicate that guiding the information processing, integrating information organizing tools, and clarifying and separating instructions significantly affect listening comprehension skills. It means that construct-irrelevant factors such as topic unawareness, narrow vocabulary, multitasking, and cognitive overload influence test performance and compromise the validity of tasks for comprehension assessment. The results of the study are in line with Rukthong's study (2016) which stated that the elimination of cognitive and perception barriers enhances the ability to use linguistic knowledge and inferencing skills while information comprehension. The study highlights the importance of considering these factors when designing construct-relevant assessments of reading and listening comprehension.

Students' answers to the reflective survey also allow us to conclude that accommodations of assignments (extra time, dictionaries, additional resources) provide equal access to information and assignment. Similar observations are found in the study of Young (2008) who stresses the importance of task modifications which may include adjusting the content or format of the assessment to better suit students' needs and abilities.

The existing strategies for assessing comprehension frequently place an increased focus on the student's capacity to reply to questions about a content instead of the more extensive run of capacities and information required for comprehension. My perceptions as well as experimental findings prove that this confined center may result in underestimation of cognitive differences, advancement of develop unimportance, inadequate and unjustifiable evaluations of reading or tuning in comprehension and students' inability to specify their accomplishments. To address these issues, I would propose a more comprehensive and all-inclusive technique to evaluate perusing and tuning in comprehension. This methodology includes construct-irrelevant variables investigation, application of a run of appraisal groups and planning of assignments for assessing an assortment of comprehension techniques so that understudies might illustrate the complete extend of their abilities, extended vocabulary, critical comprehension, infernal connections, integration of perceived and accomplished information, as well as metacognitive strategies to screen and direct the method of comprehension. In general, disposing of construct-irrelevant barriers in developmental evaluation contains a positive effect on learners' perusing and tuning in comprehension in higher instruction ESP courses, by permitting them to superior illustrate their genuine understanding of the course material, get focused on criticism and move forward in areas where they may be struggling.

4.2. Technology-enhanced formative assessment based on UDL principles

Over the past few decades, there has been a significant increase in the potential of digital technology to improve assessments, as noted by Bennett (2015). This has led to innovative assessment items that use multimedia and evaluate new constructs. Additionally, technology has allowed for the integration of assessment and instruction, enhanced item development, and the incorporation of universal test design principles. Technology-enhanced assessment involves variable technological features like media, interactivity, or response methods that surpass the conventional assessment techniques. Features of transformed assessment items functionality can encompass various aspects, including item format (such as drag-and-drop, ordering, and simulations), test taker response methods (such as voice recognition, and text-to-speech converting), and the stimuli that accompany the item (such as audio and video). Therefore, the primary objective of incorporating technology in an assessment is to overcome any potential underrepresentation of the construct by broadening the range of the test content or construct. An additional value of technology in an assessment is the enhancement of student involvement. Increased engagement can boost a student's drive and hard work, leading to more accurate test scores, which can positively impact the test's validity (Wise, 2015). The use of technology should also be evaluated to ensure that it does not introduce unexpected effects that can compromise the test results (Almond et al., 2010).

Therefore, it is necessary to perform an in-depth analysis of the construct, based on the academic standards, learning objectives, content blueprint, skills map, personal learners' profile and test specifications. The design of assignments should prioritize psychometrically sound assessment by avoiding the introduction of construct-irrelevant factors and maintaining test fairness without creating new barriers. However, it is important to ensure that tests are designed to meet the needs of diverse test-takers. To achieve this, UDL principles are to be embedded in the instructions description, assignment content development, and administration phases of assessment design. From the accessibility perspective, test administration can be broadly categorized into accessing content, interacting with content, response production, and interface navigation (Haynes, 2020).

Since the design of a technology-enhanced assessment is a part of the study, I incorporated technology into a construct-relevant assignment, which provided students with multiple opportunities for content representation, interaction and response production. It was the second modification of the task on listening and reading comprehension described above (Appendix J). My interventions were performed in an online learning environment that creates additional learning barriers to common reading and listening obstacles (decoding, comprehension, vocabulary). Among such barriers I observed less opportunities to ask questions, lack of assessment clarification, limited teacher's guidance, less scaffolding, insufficient or delayed feedback and students' inconsistency if they meet expectations. Among factors that affect motivation and persistence are indistinct boundaries between academic time and leisure time, which can lead to neglecting difficult tasks. Isolation caused by the lack of peer interaction can also be demotivating.

However, the results of the second assessment of technology-enhanced assignments indicated the improvement of reading and listening comprehension skills due to changes in the way students interacted with the assignment content and produced their responses. Students were suggested tools that supported their reading or listening skills. Text-to-speech tools, for example, built into devices and available through apps and extensions, are a great assistance for decoding and comprehension, allowing students to hear text aloud. The benefits of computer-based software, browser extensions, and mobile apps that enable literacy with digital text are confirmed by the finding of empirical research performed by Dawson et al. (2019) and Rao et al. (2021). Digital text enhancement integrates digital upgrades and literacy assistance technologies which offer a variety of alternatives for perception (UDL Guideline 1), vocabulary clarification (UDL Guideline 2), and comprehension support (UDL Guideline 3).

By incorporating hyperlinks to keywords definitions, I activated previous knowledge and allowed students to revise the meaning of specific terms. It was performed to stimulate neurological networks between the old and new information that makes information comprehension easier and adds

engagement. Visualizing some part of the content or definitions, I could support students who process and remember visual information better. Using personalized devices for listening, students benefit from having the ability to adjust the speed, volume, and pauses when processing information, as it can help them with the information perception to process, to revisit sections they may have missed or to skip sections they find easy. This can be especially beneficial for students who may require more time to process information, or who may struggle with specific types of questions. By helping students with their time, efforts and persistence management, technologies reduce stress and anxiety related to assessment, deadlines and cognitive workload.

Overall, findings demonstrate that students' performance of tasks on reading and listening comprehension increased due to technology integration. However, the improvements are not as significant as increased level of engagement, self-regulation and autonomy which is evident from students' answers to the reflective questionnaire. It means that construct-relevance influences language competence and technology contributes to the enhancement of motivation and commitment.

The effectiveness of the technology integration is affirmed not only by scholarly accomplishments but by students' responses to the final reflection survey. Students communicated their agreement that technology had a positive effect on understanding the task content, instructions and complex concepts, finding solutions to the issue, illustrating the data comprehension. Moreover, technology empowers students to more viably arrange and organize their work on a task, improving efficiency and diminishing anxiety level. Students can also become more autonomous and contribute to their self-learning aptitudes development by utilizing technology. This enhanced autonomy empowers students to take charge of their learning and alter it to their particular needs and preferences. Concurring to students' answers, multimodality and diversity of options for expression increases students' cooperation in learning, making the learning process more engaging and stimulating. This may lead to increased wish to learn the English language, resulting in enhanced reading and listening comprehension abilities.

Technology offers various alternative assessment methods, such as multimedia presentations, online quizzes, and interactive simulations, that can provide a more comprehensive and authentic evaluation of students' learning outcomes. Additionally, technology provides immediate feedback, which can further support students' engagement and progress. Also, immediate feedback motivates students and promotes self-reflection, ultimately leading to better learning outcomes.

In order to achieve such results, educators should be aware of steps on how to integrate technology meaningfully and without creating additional barriers. The process of the assignment transformations was performed through the following steps:

- anticipatory set: the task begins by activating students' background knowledge of materials science;

- modality of the content: to enhance students' comprehension of the material, text was combined with a short video for the additional explanation of processes described in the text. The video served as a visual scaffolding tool to aid in students' understanding of the topic;

- modality of the response: it provided students with multiple ways of expressing their comprehension of the topic. To achieve this, students were given a choice to complete a test in a testing platform Classtime, Google Doc or the traditional paper-pen format. To answer the last question on students' personal opinion, I suggested multiple variants for self-expression: audio or video response, interactive poster or infographics, written text in Google doc.

By altering reading assignments, I have used three ways to improve reading comprehension training: Directed Reading-Thinking Activity (DRTA), Gist Statements, and Open Mind Diagrams. By monitoring reading and supporting UDL milestones, DRTA technique encourages metacognition and inferencing skills. Teachers advise their students to use the text features to form assumptions about the text before reading. Students alter their predictions depending on information from the text as they read by thinking back on what they have read and what they had predicted. Gist Statements condense the main idea of a text into a small number of words, enabling UDL checkpoints such as emphasizing important details, major concepts, relationships, and aiding in planning and strategy formulation. Students discuss their gist after reading the material, describe the information, and respond to the "Five W's and One H" addressing its substance (e.g. when, why, how). Open Mind Diagrams enable UDL checkpoints such as illustrating using multiple media, modifying the ways for response and navigation, and assisting planning and strategy formulation by adding symbols, words, quotes, or phrases to visually express information about a topic. Students can use online visual organizers and mind mapping applications like MIRO, Canva, Jamboard, and PictoChart, and the teacher establishes the guidelines and goals for the exercise. With Open Mind Diagrams, students can demonstrate their understanding of a subject by visually brainstorming representations, conducting additional research, and including images. This is an alternative to traditional exams or written responses. My suggestions on technology integration are described in Appendix K.

One of the more significant findings to emerge from this study is that technology integration to construct relevant assessment has several benefits for students, including enhanced reading and listening comprehension, more inclusive evaluation of learning outcomes, effective planning and organization, increased engagement and motivation as well as self-directed learning skills.

4.3. Effect of construct-relevant technology-enhanced formal assignments on students' motivation

Motivation is a crucial factor in designing learning materials and instructional strategies. Technology-based learning tools' effectiveness hinges on their use-friendliness and usability, which can impact motivation. If the system lacks pedagogically sound instructional design to enhance learning performance, it can lead to low motivation and engagement among learners (Refat et al., 2019) due to an imbalance and excessive increase of the cognitive load.

To verify the scope of motivational changes caused by UDL-related assessment, I employed Keller's ARCS model (2010) which focuses on motivation and consists of four major components: Attention, Relevance, Confidence, and Satisfaction. The model aims to facilitate effective instructional design by providing strategies to enhance motivation in learning and incorporating those strategies into formal curricular and teaching design. While other motivational models or theories also emphasize motivation in learning, such as learning performance or psychological aspects of learners, such as attitude, the ARCS model is significant in this study as it highlights the importance of motivation in the design and development of technology-enhanced instructional materials, in particular reading and listening comprehension assessment.

The ARCS model was applied in several studies on English language competency development. In Zhang's (2015) study on listening skills enhancement for second language learners, the model was used to evaluate the activities' impact on students' motivation. Another study found that the ARCS model was effective in enhancing motivation among Japanese students learning English and promoting cultural values. The model was also used in the study on cognitive load management focused on the development of smart communication networks for an e-grammar learning system (Refat et al., 2019) that included various audiovisual instructions. The study results demonstrate that the system has significantly increased learner motivation. These studies highlight the potential effectiveness of Keller's ARCS model in both measuring and improvement of motivation and language skills in diverse language learning contexts.

I used the UDL and ARCS models, which place a high priority on learner engagement and motivation, to create assessments that were engaging, pertinent, boosting students' confidence, and fulfilling for them. A survey's findings revealed that examinations that were UDL-adjusted, construct-relevant, and technologically improved had a favorable impact on students' motivation and confidence, encouraged their perseverance, and satisfied their interests. Students were able to pay attention and persevere because of the utilization of technologies and various media for content display. Having analyzed the findings of the study, I can claim that construct-relevant UDL -based technology-enhanced assessment has a significant influence on student motivation in several ways:

1. increased engagement: technology-enhanced assessments provide a more engaging and interactive experience for students compared to traditional paper-based assessments. For example, using multimedia tools, simulations, and media make the assessment more interactive and visually appealing, thus increasing students' engagement;
2. personalization and self-confidence enhancement: UDL-based technology-enhanced assessments promote personalization to meet the needs of individual students, including their learning style, preferences, and abilities. The personalization empowers students with more control of their learning and increase their motivation to do well;
3. timely feedback: technology-enhanced assessments provide immediate feedback to students, which can be motivating for students. They can see their progress in real-time and can identify areas where they need to improve;
4. authenticity: UDL-based technology-enhanced assessments suggest authentic and meaningful assessments that relate to real-world situations. It increases students' motivation as they can see the relevance of what they are learning to their future goals;
5. flexibility: UDL-based technology-enhanced assessments are flexible in terms of when, how long and where students can take the assessment. This can help reduce the stress and anxiety associated with traditional assessments and increase students' motivation.

The use of UDL-adjusted evaluations that take into account students' needs and interests is supported by motivational theories like self-determination, attribution theory, and intrinsic/extrinsic motivation. Autonomy, competence, and relatedness are prioritized in UDL and self-determination theory because they raise learners' motivation and engagement. In an experiment, I gave students options for how to access and interact with content in text, audio, and video formats, encouraging autonomy and boosting engagement. The development of students' competence and their sense of autonomy are enhanced by construct-relevant evaluations that measure specific knowledge and abilities connected to learning objectives. The attribution hypothesis, which emphasizes that students attribute behavior to themselves and others and that these attributions affect motivation and accomplishment, is also consistent with technology-enhanced examinations. In general, UDL-adjusted examinations that incorporate motivational theories can improve students' motivation, engagement, and performance.

As it has already been mentioned, construct-relevant assessment is an approach to assessment that focuses on evaluating learners' understanding of key concepts and skills within a specific domain of knowledge. Educational technologies support construct-relevant assessment by providing learners with interactive and personalized learning experiences. Intrinsic and extrinsic motivation theories are relevant to construct-relevant assessment because they provide insight into the factors that influence

learners' engagement and motivation in the learning process. When designing construct-relevant assessments using educational technologies, educators use intrinsic and extrinsic motivation theories to create assessments that are engaging and motivating for learners. For example, real-life and authentic assessment tasks contribute to the increase of intrinsic motivation. By designing construct-relevant assessments using educational technologies that take into account intrinsic and extrinsic motivation theories, educators can create assessments that are effective for promoting learning, engagement, and motivation among learners.

The evidence from this study suggests that construct-relevant technology-enhanced assessment demonstrated positive influence on student learning and motivation. Providing students with assessments that are closely aligned with their learning goals, background, cognitive diversity and personal needs promotes positive attributions and motivation, thus, supporting students' academic success and well-being.

5. CONCLUSIONS

Based on the results of the study, it can be concluded that a technology-enhanced barrier-free formative assessment, designed using UDL principles, has a positive influence on learners' reading and listening comprehension skills in higher education. Eliminating construct-irrelevant barriers in formative assessments allows students to focus on the intended learning outcomes, leading to improved comprehension skills. The findings support the assumption that construct-relevant UDL-based assessment emphasizes individualizing of the learning process, identifying weaknesses and external barriers, and identifying strengths, challenges, and preferences. The process of designing construct-relevant assessments for reading and listening comprehension involves identifying the construct being assessed, evaluating the alignment between the construct and the assessment, recognizing learning barriers, analyzing the assessment format and structure, and reviewing students' performance on the assessment. By incorporating these insights into assessment transformations, I set up a more differentiated learning environment that contributed to the improvement of reading and listening comprehension.

However, not only construct-relevance contributed to the reading and listening comprehension improvement. Technology integration enhanced assessment items development and the incorporation of universal test design principles. Technology mostly increases student's motivation, self-regulation skills and self-learning skills. By providing learners with multiple means of representation, action and expression, education technologies support diversity in the learning environment and promote more equitable assessments.

Since the UDL approach is based on students' motivation, we consider motivation as a crucial factor in the design and development of learning materials and instructional strategies, especially those that utilize technology-based tools. The effectiveness of these tools depends on their usability, pedagogically sound instructional design, and their ability to enhance learning performance without overloading cognitive functions. Therefore, the ARCS model (Keller,...) is a significant tool for enhancing motivation in the design and development of technology-enhanced instructional materials, particularly reading and listening comprehension assessment. The UDL framework and ARCS model share the priority of learner engagement and motivation in the learning process. The findings of this study demonstrate that construct-relevant UDL-based technology-enhanced assessment positively impacts student motivation by increasing engagement, personalization and self-confidence enhancement, timely feedback, authenticity, and flexibility. The study findings also align with motivational theories, which emphasize the need to design assessments that support learners' ongoing learning and growth by promoting autonomy, competence, and relatedness. Therefore, it is reasonable to consider the UDL principles and ARCS model when designing technology-enhanced assessments to improve learner motivation and engagement. Based on the results of the study, it can be concluded that a technology-enhanced barrier-free formative assessment, designed using UDL principles, has a positive influence on students' reading and listening comprehension skills in higher education.

5.1 Limitations

There are a number of sample-related restrictions on the study. First, there are only 38 participants in the sample, which is rather small. Although a convenience non-probability sampling methodology was used to choose the sample, which is appropriate for action research, it restricts how widely the results can be applied to other situations or populations. Additionally, the sample was limited to engineering majors in 3–4 courses who were also studying ESP, who had a language proficiency level of B1 (CEFR), and had prior experience taking standardized tests. This may restrict the findings' applicability to other fields, degrees of language, or student demographics. The results could have been biased and affected because the researcher was also the course's instructor. Self-reported questionnaire data may be influenced by social desirability bias because respondents may give information that they think is required of them.

5.2. Future research

The current study focused on promoting UDL principles through the use of technologically enhanced barrier-free assessments of reading and listening comprehension. Future studies should look into how

technology-enhanced UDL principles of representation and engagement might affect students' academic outcomes. Additional areas of research could deal with improvement of productive language skills such as writing and speaking through technology-enhanced UDL.

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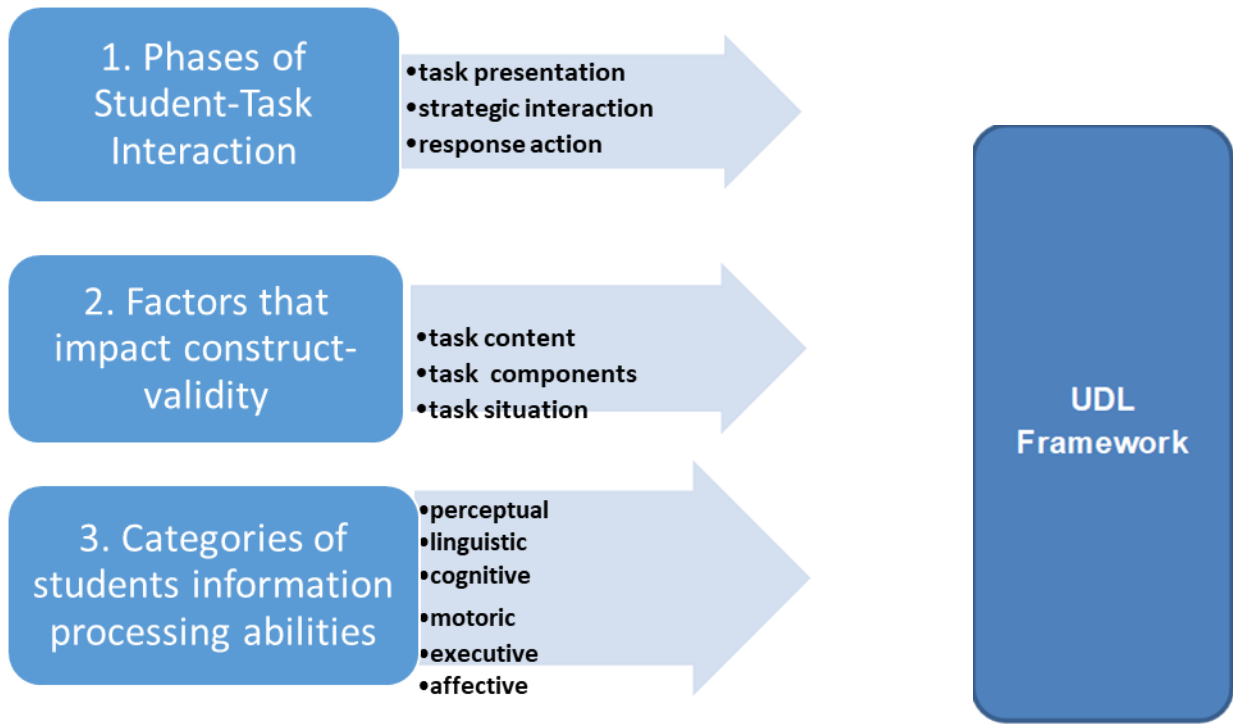
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Appendices

Appendix A. Framework for UDL-based assessment (Dolan et al., 2013, p. 14)



Appendix B. Personal Learning Profile Questionnaire (Bray & McClaskey, 2016)

I would like to invite you to participate in a research project by completing the following questionnaire/ The purpose of this questionnaire aims to create your personal learning profile and to make classes more personalized. The information you provide will be used to enhance and improve assessment assignments. Completing the survey will take 10 minutes of your time.

By continuing with the questionnaire, you agree with the following statements:

1. *I have been given information about this research project.*
2. *I understand that my answers will not be released to anyone and my identity will remain anonymous. When the results of the study are reported, I will not be identified by name or any other information that could be used to infer my identity. Only researchers will have access to view any data collected during this research.*
3. *I understand that I may withdraw from this research any time I wish and that I have the right to skip any question I don't want to answer.*
4. *I understand that my refusal to participate will not result in any penalty or loss of benefits to which I otherwise am entitled to.*
5. *I understand that if I have any additional questions, I can ask the research team listed below.*
6. *I have read and understood all statements on this form.*
7. *I voluntarily agree to take part in this research project by completing the following questionnaire.*

-Agree

-Disagree

Instructions: Please rate the following statements according to how strongly you agree or disagree with them, using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree). There are no right or wrong answers - we simply want to understand your individual learning style and needs.

I. Access

1.1 Strengths

1. I connect what I'm learning to what I know (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree)
2. I can visualize what I hear or read
3. I enjoy learning autonomously

1.2 Challenge

4. I have troubles focusing in a classroom
5. I understand foreign language written information better than auditory format of information
6. I do not understand original text on my specialty in English

1.3 Preferences

7. I prefer learning through visual aids such as diagrams, pictures, or videos.
8. I learn best when I have clear, step-by-step instructions to follow.
9. I appreciate when learning materials are presented in multiple formats, such as text and audio.

II. Engagement

2.1. Strengths

10. I enjoy learning through interactive activities and discussions with others.
11. I enjoy being a leader
12. I feel motivated to learn when I have choices and can make decisions about my own learning.

2.2 Challenges

13. I have troubles and problems organizing my work on assignment in classroom
14. I feel confused when I am doing multiple tasks
15. I am not comfortable asking for help or clarification when I am unsure about something.

2.3. Preferences

16. I prefer tasks to be broken down into smaller tasks.
17. I feel confident in my learning when I have access to supportive resources such as dictionaries or glossaries.
18. I feel more engaged in learning when I have opportunities to connect what I am learning to real-world situations.

III. Express

3.1. Strengths

19. I am good at speaking in English or presenting
20. I often express my thought visually
21. I feel comfortable when learning under time limit

3.2. Challenges

22. I find notes taking and summarizing difficult
23. I have troubles putting thoughts to paper
24. I find it difficult to monitor the progress of my learning

3.3 Preferences

25. I prefer to express my learning through creative or open-ended projects rather than standardized assessments.

26. I prefer to express my understanding orally

27. I prefer to use multiple media for communication

Appendix C. Final reflective questionnaire results (number of respondents = 38)

Statements	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
I feel safe and accepted in the	8	21	6	3	0
My teacher knows my interests and background	7	19	7	5	0
I am provided with choices, clues and tools to show what I have learned	8	21	7	2	0
A teacher helps me to believe in myself to meet higher expectations	5	16	13	4	0
I am taught how to organize my work and	4	14	13	7	0
I clearly understand what I have to do to	15	19	4	0	0
I am provided with resources and explanations to get additional	12	19	7	0	0
I understand why teacher suggest specific topics and texts for the	6	11	13	6	2
Teacher offers adjustable level of assignment	5	18	13	2	0
The assignment match my level of specialism	8	17	7	4	2

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Technology assists me in the assignment to understand and find solution	8	21	5	4	0
Alternative resources and technology allow me to demonstrate what I have learned	7	26	0	5	0
Due to technology I can plan and organize my work on an assignment	7	18	9	2	2
I feel more engaged in the learning activities with technology application than without	8	17	7	6	0
Technologies help me to become more independent and contribute to my self-learning skills	7	20	8	3	0

Appendix D. Personal Learning Profile Questionnaire Results

Statements	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Access					
Strength					
I connect what I'm learning to what I know	7	13	9	5	4
I can visualize what I hear or read	12	18	6	2	0
I enjoy learning autonomously	8	17	7	6	0
Challenge					
I have troubles focusing in a classroom	5	21	9	3	0
I understand foreign language written information better than auditory format of information	14	17	3	4	0
I do not understand original text on my specialty in English	6	19	4	9	0
Preference					
I prefer learning through visual aids such as diagrams, pictures, or videos.	12	19	7	0	0
I learn best when I have clear, step-by-step instructions to follow.	15	19	4	0	0
I appreciate when learning materials are presented in multiple formats, such as text and audio.	13	18	5	2	0

Engagement					
Strength					
I enjoy learning through interactive activities and discussions with others.	4	13	8	10	3
I enjoy being a leader	2	5	17	9	5
I feel motivated to learn when I have choices and can make decisions about my own learning.	11	20	5	2	0
Challenge					
I have troubles organizing my work on assignment in classroom	10	15	8	5	0
I feel confused when I am doing multiple tasks	11	13	5	7	2
I am not comfortable asking for help or clarification when I am unsure about something.	3	9	6	17	3
Preference					
I prefer tasks to be broken down into smaller tasks.	11	24	3	0	0
I feel confident in my learning when I have access to supportive resources such as dictionaries or encyclopedias.	9	18	6	3	2
I feel more engaged in learning when I have opportunities to connect what I am learning to real-world situations.	12	17	5	4	0
Express					
Strength					
I am good at speaking or presenting in English	6	18	9	4	0

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I often express my thought visually	8	16	5	6	3
I feel comfortable when learning under time limit	0	5	8	18	7
Challenges					
I find notes taking and summarizing difficult	5	17	10	6	0
I have troubles putting thoughts to paper	11	18	9	0	0
I find it difficult to monitor the progress of my learning	3	15	9	8	3
Preferences					
I prefer to express my learning through creative projects rather than standardized assessments.	9	17	5	7	0
I prefer to express my understanding orally	12	15	4	7	0
I prefer to use multiple media for communication	8	19	7	4	0

Appendix E. Post-test questionnaire (Adapted from: Post-test Self-Assessment, University of Calgary, Student Success Centre, 2014)

Instruction

The purpose of a post-test survey is to help you analyze the test situation.

If you did poorly, analyzing can help you recognize strategies and behaviors that need changing so you can have greater success with future testing situations. If you did well, analyzing can help you understand that it wasn't luck but the way you prepared and the way you approached the test.

1. To what extent was the assignment easy for you? (Extremely difficult -1; Moderately difficult-2; Neither difficult nor easy-3; Moderately easy -4; Extremely easy -5)
2. To what extent was the assignment difficult for you? (Extremely difficult -1; Moderately difficult-2; Neither difficult nor easy-3; Moderately easy -4; Extremely easy -5)
3. Where the instructions clear? Did you understand what you had to do? (Yes/No)
4. Was the text connected with your specialism? (Yes/No)
5. Did you revise vocabulary before the task completion? (Yes/No)
6. Why did you lose points? (Choose as many as you feel necessary)
 - Illegible writing
 - Factual errors
 - Small grammar/vocabulary error
 - Misunderstood the instruction
 - Struggled with question format
 - Difficulty expressing myself in English
 - Ran out of time and did not complete all questions
 - Complicated terminology in the text
 - Too much information to memorize
7. Do you experience the same problems when you take a test or complete assessment tasks?
(Yes/No)

Appendix F. Identified learning barriers and recommendations on their elimination

Barriers	Explanation	Recommendations based on UDL Guidelines and Checkpoints
Cognitive:	Limited working memory; lack of background knowledge activation; multiplicity of listening strategies (micro and macro listening).	Optimize relevance, value, and authenticity (checkpoint7.2) Activate supply background knowledge (checkpoint3.1) Guide information processing and visualization (checkpoint3.3) Facilitate managing information and resources (checkpoint6.3)
Self- regulation:	Multi-modality of the goal, lack of possibility for progress monitoring	Heighten salience of goals and objectives (checkpoint8.1) Facilitate personal coping skills and strategies (checkpoint9.2) Develop self-assessment and reflection (checkpoint9.3) Guide appropriate goal-setting (checkpoint6.1) Enhance capacity for monitoring progress (checkpoint6.4)
Perceptive	Multimodality of visual clues for one task, accent and pace of speech	Minimize threats and distractions (checkpoint7.3) Offer alternatives for visual information (checkpoint1.3)
Linguistic	too specified terminology, abbreviation, length of the text, distracting phrases	Clarify vocabulary and symbols (checkpoint2.1) Clarify syntax and structure (checkpoint2.2) Support decoding of text, mathematical notation, and symbols (checkpoint2.3)

Appendix G

Statistical results for Listening comprehension assessment (Task 1)

	M (SD)	ΣX	ΣX^2	<i>f-ratio</i>	<i>p-value</i>
Attempt 2 (N=38)	20,039 (3,9)	1523	31673	33,35	0,00001
Attempt 3 (N=38)	24,23 (3,3)	1841	45407	42,29	0,00001

Statistical results for Listening comprehension assessment (Task 2)

	M (SD)	ΣX	ΣX^2	<i>f-ratio</i>	<i>p-value</i>
Attempt 2 (N=38)	17,51(3,05)	1331	24009	55,64	0,00001
Attempt 3 (N=38)	21,44 (2,8)	1630	3554	71,91	0,00001

Statistical results for Reading comprehension assessment (Task 1)

	M (SD)	ΣX	ΣX^2	<i>f-ratio</i>	<i>p-value</i>
Attempt 2 (N=38)	18,27 (3,9)	1389	26559	47,74	0,00001
Attempt 3 (N=38)	22,30(4,3)	1695	39175	11,63	0,001005

Statistical results for Reading comprehension assessment (Task 2)

	M (SD)	ΣX	ΣX^2	<i>f-ratio</i>	<i>p-value</i>
Attempt 2 (N=38)	13,82(2,4)	1050	14944	106,3	0,001001
Attempt 3 (N=38)	18,03(2,8)	1370	25312	166,36	0,001003

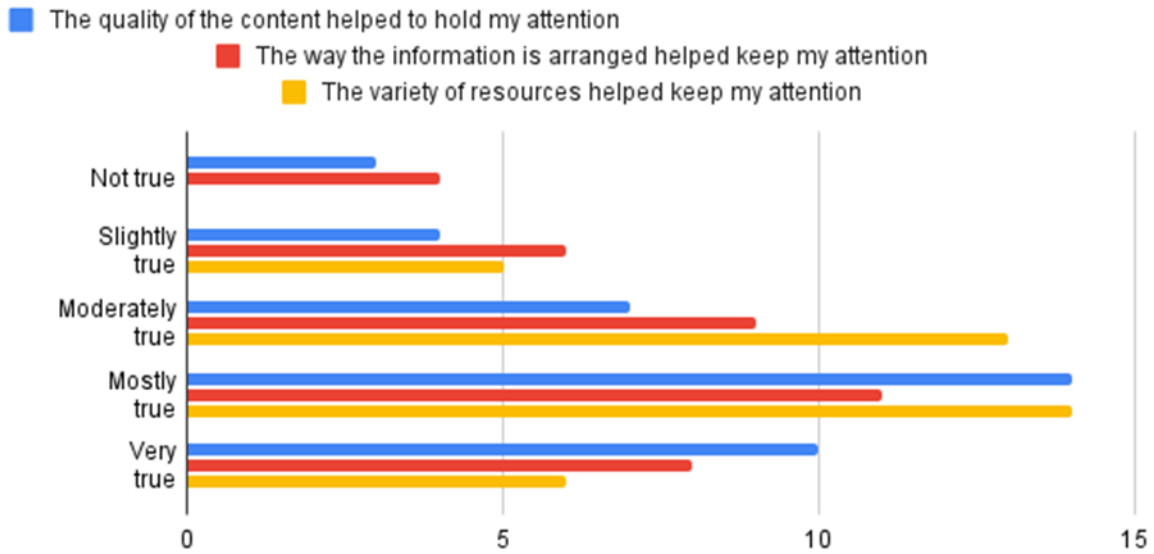
Appendix H. Results of ARCS questionnaire on motivation

Statements	Not true	Slightly true	Moderately true	Mostly true	Very true
Attention					
The quality of the content helped to hold my attention	3	4	7	14	10
The way the information is arranged helped keep my attention	4	6	9	11	8
The variety of resources helped keep my attention	0	5	13	14	6
Relevance					
It is clear to me how the content of assignment is related to things I already know	0	2	11	17	8
The content and instructions of assignment convey the impression that being able to work with the technology is worth it	0	4	8	15	11
The content and instructions are useful to me	6	6	12	10	4

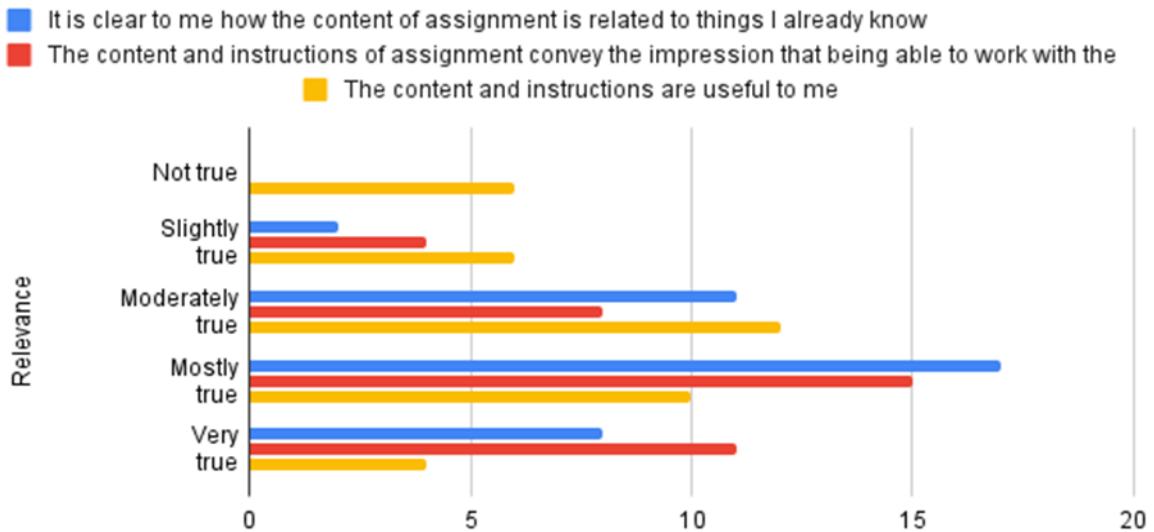
Confidence					
As I worked with the assignment, I was confident that I could learn how to understand the information well	3	6	9	14	6
After studying the given instructions, I was confident that I would be able to complete exercises	0	0	13	17	8
The good organization of the content and instructions helped me be confident that I would learn how to complete the task	0	3	10	14	11
Satisfaction					
I enjoyed working with these instructions and they stimulated me to keep on working	0	4	14	12	8
I really enjoyed working with the assignment instructions	0	2	11	15	10
It was a pleasure to work with such well-designed instructions	0	2	17	13	6

Appendix I. Charts of Likert Scale results for ARCS questionnaire

Attention:

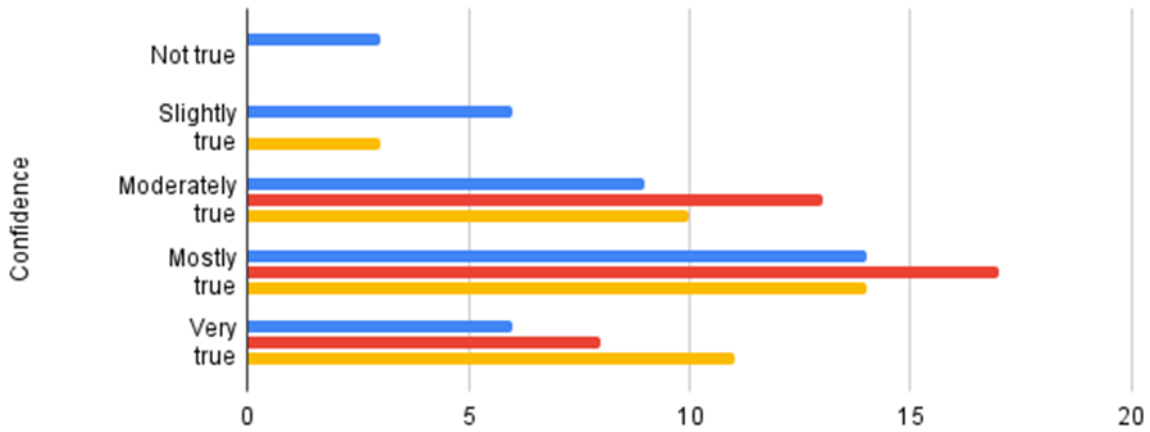


Relevance:



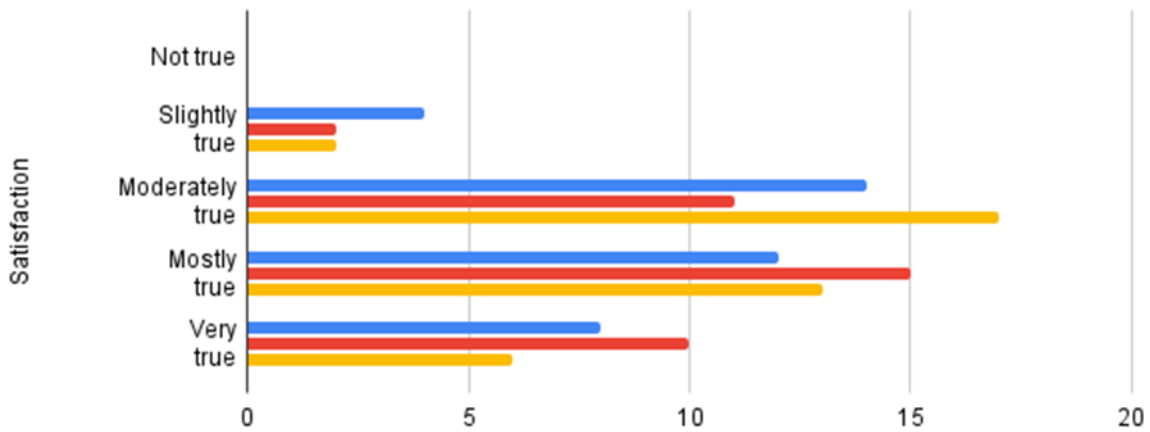
Confidence:

- As I worked with the assignment, I was confident that I could learn how to understand the
- After studying the given instructions, I was confident that I would be able to complete exercises
- The good organization of the content and instructions helped me be confident that I would learn



Satisfaction:

- I enjoyed working with these instructions and they stimulated me to keep on working
- I really enjoyed working with the assignment instructions
- It was a pleasure to work with such well-designed instructions



Appendix J

Listening comprehension. Task 1

Original task:

1. Listen to a talk about the properties of graphene. Choose the correct options and complete the notes in the table. Write about the graphene application (50 words). (Lytovchenko et al., 2021, p.23)

Modified assessment task

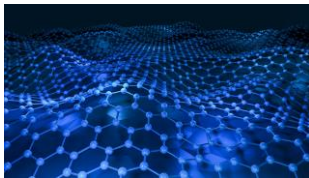
Options for the task completion:

- you can complete the task in a Google doc;
- you can complete the task on [Classtime](#) platform

1. Listen to a lecture (*identifying type of listening to focus attention*) about the properties and application (*functional focus*) of graphene (*Graphene (γραφην) is the name for a single layer sheet of carbon atoms that are bonded together in a repeating pattern of hexagons - activation of background knowledge*). While listening you can use [MIndMap](#) as an organizer to make notes.

Order the pictures in the sequence with the speaker's description, which picture he mentions the first, the second and the third.

A



B



C



- 1)
- 2)
- 3)

2. Listen to the first part of the text and underline the correct alternatives in the table (*limitation of listening goal to one to lessen the cognitive overload, decrease the level forced persistence and selective attention*):

General properties	<i>thick/thin; strong/weak; rigid/flexible; stretchable/malleable; conductor/resistor</i>
--------------------	---

Thermal conductivity	<i>high/low</i>
Conductivity	<i>high/low</i>
<u>Fabrication</u>	now possible to fabricate sheets of 7/17mm/ 17cm /70 cm <i>width</i>
Optical <u>transparency</u>	<i>coloured/non-coloured</i> <i>totally/almost transparent</i>

3. Listen to the second part of the lecture and complete the notes in the table (*limitation of listening goal to one, to lessen the cognitive overload, decrease the level forced persistence and selective attention*):

Structure of graphite	sheet of carbon with a..... structure
Current applicationscreens,panels,cells
Potential applicationelectronics,sensors, composite materials for..... and.....
Strength	breaking strength:.....;.....
Optical transparency	absorbs.....of light intensity
<u>Conductivity</u>	higher conductivity than.....
Thermal conductivity	conducts heat.....

4. Note 2 ideas on possible [graphene](#) application in your specialism (*integration of new information into existing knowledge*).

Options for the task:

- write in the Google doc;
- record your audio/video message in [Flipgrid](#)
- post your ideas on [Jamboard](#)

Listening comprehension. Task 2

Original task

1. Listen to the text about braking systems and note what braking systems are mentioned.

Complete the table.

	Type of brakes	Parts of brakes	Advantages
Bicycles			
Aircraft			
Electric cars			

2. Listen again and correct the statements about the braking systems and justify your idea.

- Coaster brakes are used on the rear wheel of multispeed bikes, which do not have shiftable gears.
- Hand levers and cables are used to operate the gear mechanism.
- When the pull cable is released brakes are released too.
- Regenerative braking recaptures some of the vehicle's momentum as a magnetic field.
- The extra electricity can be dissipated into the air.

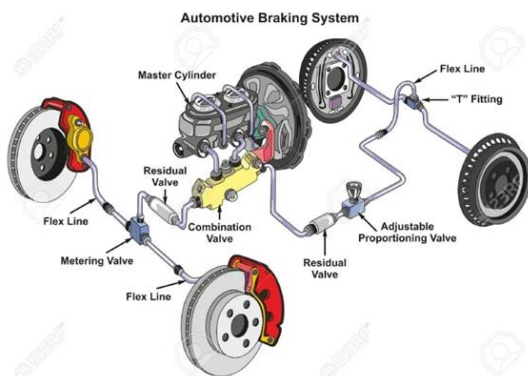
(Lytovchenko et al., 2021, p. 47)

Modified assessment task

Options for the task completion:

- you can complete the task in Google doc;
- you can complete the task on Classtime platform

1. Listen to the lecture about braking systems (гальмівна система)



<https://studentlesson.com/automotive-braking-system-definition-functions-working/>

1. Underline which vehicles and their corresponding braking systems are mentioned:

- trains
- buses
- bikes
- airplanes
- trams
- cars

2. Listen to the text again and complete the table:

	<u>Type of brakes</u>	<u>Parts of brakes</u>
<i>Bicycles</i>		
<i>Aircraft</i>		
<i>Electric cars</i>		

3. Listen to the lecture again and find a mistake in sentences, type a correct version:

1. [Coaster brakes](#) are used on the rear wheel of multi speed bikes, which do not have shiftable [gears](#).
2. Hand [levers](#) and cables are used to operate the gear mechanism.
3. When the [pull cable](#) is released brakes are released too.
4. [Regenerative braking](#) recatures some of the vehicle's momentum as a magnetic field.
5. The extra electricity can be dissipated into the air.

4. Explain the advantages of the two braking systems you have listened about.

Options for the task completion:

- write in the Google doc;
- record your audio/video message in [Flipgrid](#)
- post your ideas on [Jamboard](#)

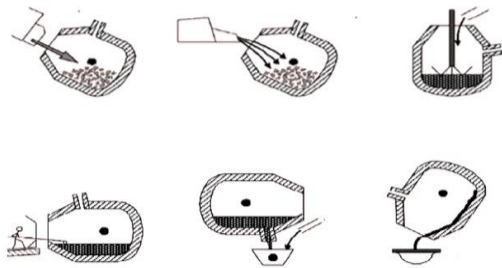
Reading comprehension task 1

Initial version

1. Read the draft of a brochure on the BOS process. Answer the questions:

- What are the raw materials and the end product of the process?
- What is the other waste by-product of the process?
- Why do you think the seal at the top has to be movable?

2. Match the parts of diagrams with the stages in the draft. One part matches with 5 stages. Write a caption for each diagram (Lytovchenko et al., 2021, p.68)



Modified assessment task

Options for the task completion:

- you can complete the task in Google doc;
- you can complete the task on Classtime platform

1. Read the text of the [draft](#) and notes. A technical writer is halfway through writing the draft on stages (*focus of the text function*) of a brochure on the Basic Oxygen Steelmaking process ([Basic oxygen steelmaking](#) is a multistep **process** that involves the use of pure oxygen to produce steel from molten iron - *background knowledge activation*). The draft includes 5 of 11 stages of the process. Six remaining stages are in the notes (*focusing on the text structure*). Find synonyms to the following words in the draft or notes (*start with the low order reading skills- word meaning*):

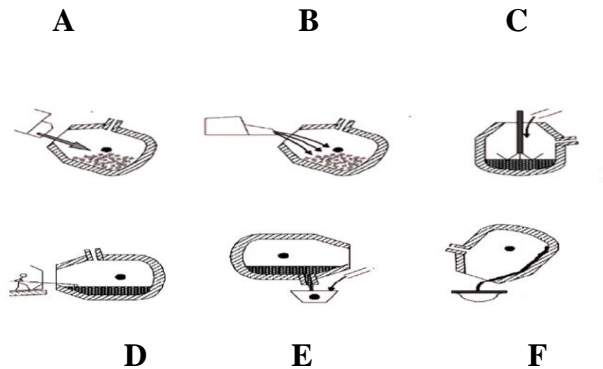
- [converter](#) -
- to charge -
- [lance](#)-
- to tap -
- to adjust -

2. Read texts and find the definitions (explanation) of the following words (*terminology meaning for better information processing*):

- scrap steel

- the blow
- flux
- slag
- sub-lance

3. The diagram illustrates stages of the BOS process (*connection of the diagram with the information in the text to stay focused with the topic*). Match each diagram A-F with the number of stages from the draft and the notes:



- | | |
|----|----|
| 1) | 4) |
| 2) | 5) |
| 3) | 6) |

4. Read through the questions, then read text once more and write the answers to the questions.

While reading you can use MIndMap to make notes.

1. What are the raw materials of the process?
2. What are the end products of the process?
3. What is the byproduct of the process?
4. How is it removed?
5. Why is the seal at the top movable?
6. What is the function of the inert gas pipes?
7. What is the function of the sub-lance?

Options for the task completion:

- write in the Google doc;
- record your audio/video message in Flipgrid
- post your ideas on Jamboard

Reading comprehension task 2**Initial version**

Read the text “Creation of Steam Engine”, define key historical events that led to the invention of the Steam engine and evaluate its economic advantages. (Lytovchenko et al., 2021, p.12)

Modified assessment task**Options for the task completion:**

- you can complete the task in Google doc;
- you can complete the task on Classtime platform

1. Scan the text “Creation of Steam Engine” and complete a table about the historical events either mentioned or not in the text:

Event	Mentioned	Not mentioned
Papin's invention		
Aeolipile invention		
Newcomen steam engine		
Industrial revolution 1700		

2. Read the text in detail. While reading you can use MindMap to make notes. Find words or collocations which mean:

- a) hot mist that water produces when it is boiled;
- b) an engine or motor in which the pressure of a liquid or gas moves a special wheel around;
- c) a space that is completely empty of all gas, especially one from which all the air has been taken away;
- d) warmth or the quality of being hot;
- e) a part of an engine consisting of a short solid piece of metal inside a tube which moves up and down to make the other parts of the engine move.

THE CREATION OF STEAM ENGINE (Abstract from the text)

Any engine that uses the energy of expanding steam is known as a steam engine. Steam can be utilized to push [piston](#) or spin a turbine to power an engine. Electric generators and massive ships are propelled by enormous turbines. Large [piledrivers](#) are powered by steam engines. Trains are still pulled by locomotives powered by piston steam engines in various nations. Most trains in the US are pulled by diesel engines.

Modern industry as well as Industrial revolution is a result of the steam engine's development in the 1700s. People had to rely on their own strength or that of animals, the wind, and water up until that point. Numerous horses could be replaced by a single steam engine. It could provide the energy required to run each machine in a factory. A steam locomotive could haul heavy loads of great distances in a single day. Steamships provided safe, fast, dependable water transportation.

3. Read the text carefully and consider the information presented in the text. Give a clear and concise statement expressing your opinion on the question, using the information from the text to support your position: What are the economic consequences of the Steam Engine invention?

Options for the task completion:

- write in the Google doc;
- record your audio/video message in Flipgrid
- post your ideas on Jamboard

Appendix K. Technology integration recommendations

Assignment part	Tool	UDL checkpoints
Pre-assignment task: identify false and real graphene properties	Jamboard	Recruiting interest: Optimize relevance, value, and authenticity (7.2); Sustaining efforts: Heighten salience of goals and objectives (8.1) Comprehension: Activate or supply background knowledge (3.1) Expression and Communication: Use multiple media for communication (5.1)
Listening task: Listen to a lecture about the properties and application of graphene. Order the pictures in the sequence with the speaker's description which picture he mentions the first, the second and the third;	In-text hyperlinks to online dictionary for "graphene", "malleability", "osmosis" link to a short video of "graphene" definition; interactive online testing tool for online ordering pictures and immediate feedback (Wordwall)	Executive functions: Facilitate managing information and resources (6.3) Language & Symbols: Clarify vocabulary and symbols (2.1) Expression and Communication: Use multiple tools for construction and composition (5.2) Perception: Offer alternatives for auditory information (1.2) Comprehension: Maximize transfer and generalization (3.4)
Listen to the text once more and underline the correct alternatives in the table	Interactive online format of the table and options selection (Classtime platform)	Recruiting Interest: Optimize individual choice and autonomy (7.1) Sustaining persistence: Vary demands and resources to optimize challenge (8.2) Physical Action: Vary the methods for response and navigation (4.1)
Listen to the description of the diagram and label its parts	Interactive online format of the diagram (Classtime platform)	Recruiting Interest: Optimize individual choice and autonomy (7.1) Sustaining persistence: Vary demands and resources to optimize challenge (8.2) Physical Action: Vary the methods for response and navigation (4.1)
Note 2 ideas on possible graphene application in your specialism	video and audio sharing: FlipGrid; collaborative board: Padlet; audio sharing: Vocaroo	Physical Action: Vary the methods for response and navigation (4.1) Expression and Communication: Use multiple tools for construction and composition (5.2) Language and Symbols: Illustrate through multiple media (2.5) Self-regulation: Facilitate personal coping skills and strategies (9.2)

