Re-conceptualizing the SIOP Model: Optimizing Academic Language Instruction for Mathematics with International Learners

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Abstract

This study addresses the lacuna in Persian language courses by proposing a model tailored for teaching semi-specialized Persian to engineering candidates in advanced contexts. The main aim is to augment comprehension of mathematical concepts while advancing Persian language proficiency. Central to this research is the assessment of the Sheltered Instruction Observation Protocol (SIOP) model's efficacy in instructing Persian learners from diverse backgrounds. The Re-conceptualized SIOP model was implemented across three mathematics instruction sessions in an experimental group, contrasting with a control group following the conventional language course at a Language Learning Center. Robust reliability and validity analyses were performed on the assessment tool used. Data collection involved pre- and post-treatment vocabulary assessments for both groups. ANCOVA analysis indicated a significant disparity ($p < 0.05$) between pre-test and post-test scores among 28 non-native Persian learners, highlighting the impact of the Revised SIOP model. The application of this model notably improved precise vocabulary usage among participants. These findings hold substantial implications for enhancing instruction in semi-specialized language for non-native speakers enrolled in mathematics courses. Additionally, they offer crucial guidance for educators teaching mathematics or other sciences to Persian language learners. Ultimately, the study underscores the efficacy of the

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Revised SIOP model in advancing Persian language learning and harmonizing language and content knowledge instruction.

1. Introduction

Teaching Language for Specific Purposes (LSP) involves thorough needs assessment to tailor courses for learners' language requirements in academic and professional realms. Language for Academic Purposes (LAP) has gained significance owing to the widespread use of foreign languages in education and professional contexts (Charles, 2013, p. 137). LAP addresses unique linguistic demands in academic settings, aiming to equip learners with language skills crucial for academic and career success (Hinkel, 2011, pp. 142-148).

Content-based education, part of the communicative approach framework for teaching second or foreign languages, aims to teach scientific disciplines using language as a medium (Lee, Quinn & Valdes, 2013, p. 6). Language serves as a tool to understand content, while content enhances language learning (Pessoa et al., 2007, p. 2). Utilizing language to teach scientific disciplines requires different cognitive processing, benefitting both linguistic and non-linguistic knowledge acquisition (Hofmannová, Novotná, & Pípalová, 2008, p. 3). The optimal outcome, Content Language Integrated Learning (CLIL), involves simultaneous instruction of academic subjects and language.

Acquiring a second language involves diverse linguistic and cognitive skills. Quality education, offering ample opportunities and activities, aids in acquiring language crucial for academic success (Kareva & Echevarria, 2013, p. 236). Removing linguistic barriers enhances comprehension, motivation, and the ability to grasp academic subjects. Teaching Persian to non-Persian speakers has grown notably, involving learners with varied cultural, scientific, and linguistic backgrounds. While aiming for university enrollment post-language course completion, learners often face obstacles due to unfamiliarity with semi-specialized and specialized Persian language, hindering academic progress across disciplines. This study focuses on Persian for academic purposes in mathematics, a prerequisite for basic sciences and engineering fields.

Despite mathematics being considered a "universal language," proficiency in mathematics doesn't guarantee effortless problem-solving across languages. Mastery of the language used in learning mathematics is essential for comprehension and

explanation of concepts (Kersaint, Thompson & Petkova, 2009, p. 72). In a multicultural teaching environment, mathematics educators must ensure all learners comprehend concepts in the target language equitably.

Non-Iranian Persian learners often encounter a deficiency in exposure to semi-specialized Persian language lexicon encompassing terms like function, exponent, vector, derivative, conjugate fractions, damped oscillations, acceptable uniformity, and more within their general Persian language education. The challenge arises notably for non-Iranian Persian students aspiring to enroll in and commence their university education, wherein advanced or supplementary level courses, predominantly instructed by mathematics specialists, face considerable difficulty in effectively imparting semi-specialized vocabulary using prevalent language teaching models and strategies. This linguistic disparity significantly contributes to academic hurdles encountered within basic sciences and engineering programs at universities, stemming from inadequate language proficiency. Notably, the increasing recognition of language diversity's pivotal role in mathematics education is underscored in scholarly discourse (Chronaki and Planas, 2018: 1101).

Beyond understanding and using mathematical language, students are expected to express ideas in writing and relate mathematical knowledge to daily experiences (Jourdain & Sharma, 2016: 44). Engaging in complex cognitive reasoning through mathematical discourse can be challenging due to interference from everyday language and specialized mathematical terms (Schleppegrell, 2011). Mastery of the "language of mathematics" is crucial for success, along with a solid grasp of "language in mathematics." The key question lies in how to effectively teach semi-specialized Persian and mathematical concepts to non-Persian speakers to mitigate language barriers in their initial year of study.

This study aims to enhance the proficiency of engineering candidates in semi-specialized Persian language, ultimately mitigating the incidence of university failure rates among this cohort. At present, a comprehensive program or framework for instructing semi-specialized Persian language within mathematical contexts remains absent. Elevating the performance of Persian learners in both scientific content comprehension and language acquisition necessitates the creation of a model facilitating concurrent instruction in Persian language and mathematics within supplementary educational courses. Consequently, this study endeavors to conceptualize an approach for teaching semi-specialized Persian in Persian language by adapting and localizing established pedagogical models from diverse languages, subsequently assessing their effectiveness within multilingual classroom settings.

The fundamental objectives guiding this inquiry precipitated the formulation of the central research question:

How does the re-conceptualized SIOP model impact the instruction of Persian language within mathematical contexts, particularly concerning the acquisition of semi-specialized vocabulary?

At the core of this research lies the evaluation of the effectiveness of the Sheltered Instruction Observation Protocol (SIOP) model in guiding and instructing Persian learners, considering their diverse backgrounds and motivations. This research introduces two novelties: firstly, the novel use of SIOP for teaching semi-specialized Persian vocabulary, a groundbreaking application in this context; secondly, the enhancement of the SIOP model itself, a pioneering effort tailored to this instructional framework. These unique contributions highlight our research's pioneering role in reshaping both the application and improvement of the SIOP model in Persian language education.

Based on the aforementioned research question, the principal hypothesis is proposed as follows: The utilization of the re-conceptualized SIOP model influence significantly the instruction of Persian language for mathematical contexts, particularly in the acquisition of semi-specialized vocabulary. The outcomes of this research are anticipated to equip educators with a repertoire of teaching strategies and methodologies within the revised framework.

1.1 Backgrounds

Within the Iranian context, a dearth of research specifically investigates the teaching of semi-specialized Persian language through the adaptation and localization of established pedagogical models from other languages, evaluating their effectiveness within multilingual classroom settings. However, international studies examining analogous educational methodologies, notably the Sheltered Instruction Observation Protocol (SIOP) and Specially Designed Academic Instruction in English (SDAIE), present pertinent insights. The forthcoming section delves into an examination of these studies, aligning with the framework of SIOP and SDAIE, to glean valuable perspectives in this domain.

In the domain of Sheltered Instruction Observation Protocol (SIOP) research, In Boughoulidi's quasi-experimental study (2020), the efficacy of the Sheltered Instruction Observation Protocol (SIOP) Model within an urban school setting in Morocco, catering to students from diverse backgrounds, was investigated. The study's primary objective was to assess and compare the academic advancement and performance of 9th-grade English language learners (ELLs) enrolled in either a mainstream classroom or a SIOP-implemented class. The SIOP Model, acknowledged for its

facilitation of content comprehension and language acquisition among ELLs, was administered exclusively to the latter group. Findings unveiled the marked superiority of the SIOP class in terms of both content assimilation and language proficiency, particularly evidenced by the learners' adeptness in furnishing accurate responses to wh-questions within notably shorter time spans. The consistent outperformance of the SIOP group over the mainstream class was evident, with the fourth SIOP class displaying an 81.40% correct response rate, a substantial 10.82% improvement from the initial 70.58%. In contrast, the mainstream class showcased a more modest increase from 35.29% to 40.74%.

Furthermore, an in-depth analysis of response duration shed light on significant disparities between the SIOP and mainstream classes. Learners enrolled in the SIOP classes exhibited swifter response times, with a considerable portion of correct answers provided within seconds. Notably, in the initial SIOP class, 32.35% of responses were delivered in under two seconds, whereas the equivalent mainstream class only yielded 14.70% within this temporal threshold. A comparative examination between the fourth SIOP and mainstream classes underscored the pronounced advantage of the SIOP class, with a greater frequency of accurate answers by SIOP learners and a markedly lower rate of incorrect responses—29.41% false answers as opposed to the learners in the initial mainstream class scoring 73.52% of the false answers. The discernible contrast between the two classes transcends a substantial margin of 44.11%.

Azure (2014) conducted a study examining the implementation of SIOP in an elementary school in North Dakota and its implications for language learners. Data collection spanned four weeks, and subsequent evaluation revealed improved performance among language learners. The study concluded that the SIOP model effectively enhanced reading levels among language learners, elevating academic vocabulary and language skills not only for learners in the classroom but also for a majority of language learners.

Short, Fidelman, and Legwitt (2012) delineated a study examining the impact of Sheltered Instruction Observation Protocol (SIOP) on the academic performance of middle and high school language learners. The treatment group comprised 10,000 participants, while the comparison group consisted of 6,000 participants. The assessment focused on language proficiency tests evaluating writing, reading, and oral reproduction skills. Overall findings indicated that SIOP presents a promising avenue for professional development and reflects positively on the quality of education provided to language learners, showcasing their academic advancements within the

participating school districts. Although the impact ranged from low to moderate, the outcomes were positive.

Genzuk (2011) investigated an approach wherein learners with limited English proficiency can achieve successful English acquisition and higher subject matter competence at the university level through a well-structured and implemented program. This approach encompasses all facets of education, encompassing planning, classroom management, curricular activities, and assessment. It is particularly suitable for language learners who have attained a certain level of English proficiency and basic literacy skills in their native language. The study underscores the necessity for more precise curriculum design for learners engaged in long-term language courses. Such learners benefit from a challenging, meticulously designed curriculum integrated with instructional guidelines, targeted support, scaffolding, and personalized assessment, fostering effective performance within a classroom setting through careful planning and execution.

Driscoll's (2011) research delved into the potential of sheltered instruction to enhance the language proficiency of individuals with insufficient linguistic skills. The research inquiry arose due to the absence of appropriate curricula, disparities among language learners in higher education, and inadequacies in evaluating English language learners. Participants in this study were drawn from secondary education levels, encompassing diverse cultural and educational backgrounds from various countries. The study's findings emphasize the pivotal role of sheltered instruction, not only in fostering English language development among secondary level learners but also in supporting individuals with limited language proficiency. Moreover, this instructional approach was noted to not only enhance classroom teaching but also contribute significantly to the cognitive development of language learners.

Echevarria, Short, and Powers (2006) investigated the efficacy of SIOP on the academic language development of language learners. This study spanned from 1998 to 2000, conducted in a west coast public school and two east coast districts. The research encompassed 346 language learners in grades 6-8 within the intervention group, engaging in tailored programs focused on social sciences, mathematics, and science. Findings highlighted the enhanced educational benefit experienced by the intervention group, showcasing a statistically significant disparity between the intervention and comparison groups. These outcomes suggest potential avenues for enhancing approaches in aiding language learners' development of academic literacy skills.

1. 2 Theoretical Foundations

Daily interactions often employ general language, while academic settings demand proficiency in specialized discourse and technical lexical items (Fernández-Silva et al., 2014, p. 184). Academic language, essential for deepening subject understanding and communicating knowledge, necessitates adeptness in intricate discourses. For instance, in mathematics, unique linguistic structures like logical connectors ('consequently,' 'however') signify relationships different from everyday language (Slavit and Ernst-Slavit, 2007:7). In scientific and engineering contexts, educators must grasp how language constructs and conveys meaning to aid learners (Lee, Quinn, & Valdes, 2013, p. 4). Bridging not just native and target languages but also academic and social language, educators must facilitate language learners' participation in math class interactions (Slavit & Ernst-Slavit, 2007, p. 3).

Language for Academic Purposes (LAP): Examines text structure, meanings, and content across academic disciplines (Hyland, 2007, p. 1). LAP comprises General (LGAP) and Specific (LSAP) branches—LGAP focuses on universal language skills, while LSAP delves into field-specific terminology (Jordan, 2010, p. 109), emphasizing curriculum layers, learning-based methods, and content authenticity for effective teaching.

Content Language Integrated Learning (CLIL): Merges subject learning with a foreign language, utilizing language as an educational medium. This method aims to address language learners' communication deficiencies while fostering intercultural learning (Haagen-Schützenhöfer & Hopf, 2010, p. 2). Integrated language and content teaching methods involve teacher collaboration, distinct in its approach, aiming to align curriculum and teaching programs with linguistic and content objectives. The focus lies in achieving learning goals to enhance learners' knowledge base (Richards & Rodgers, 2014, p. 128).

The Lesson Objectives in Teaching Mathematics to Non-Persian Speakers: The objectives delineated in the instruction of mathematics to non-Persian speakers encompass both language and content goals. Content objectives center around the acquisition of mathematical subject matter, while language objectives focus on enabling learners to articulate mathematical knowledge, apply newfound information, and complete academic tasks proficiently. An additional layer of complexity arises from the inherent nature of mathematics itself, as it operates as a distinct language system. Within the realm of mathematical knowledge, the linguistic dimension encompasses distinct vocabulary, syntactical structures, semantic features dictating truth

conditions, and discourse components (Kersaint, Thompson & Petkova, 2009, pp. 46-51).

The process of learning mathematics inherently involves the negotiation of meaning, a mechanism vital for grasping concepts and ideas across various domains. In language acquisition, this meaning negotiation is an internalized process, transcending proficiency levels, and occurs universally among languages and cultures (Trumbull & Solano Flores, 2011, p. 219). Slavit and Ernst-Slavit (2007:5) categorize mathematical language into four types of lexical items (Table 1): high-frequency words prevalent in daily discourse, general words chiefly acquired in formal educational settings, and specialized vocabulary tailored for mathematical contexts, all of which demand attention in the teaching curriculum.

Table 1: Vocabulary Types Common in Mathematics Classrooms

Type	Description	Examples
High-frequency vocabulary	Mostly social language; Terms used regularly in everyday situations	small, orange, clock
General vocabulary	Mostly academic language; Terms used in school but not directly associated with mathematics	combine, consequently, describe
Specialized vocabulary	Academic language; Terms broadly associated with mathematics	vector, mean, arc, angle
Technical vocabulary	Academic language; Terms associated with a specific mathematical topic	quadratic equation, acute angle, absolute value

The emphasis within language objectives centers on cultivating lexical comprehension, aiding learners in deciphering the meanings of new words by exploring their construction. Nonetheless, certain instances underscore the teaching of language functions. These functions entail instructing learners on how to solicit information, draw comparisons between ideas, validate opinions, and compile thematic details.

Mathematical Teaching Models for Second and Foreign Language Learners:

The teaching of mathematics to language learners has prompted extensive study and discussion regarding suitable pedagogical approaches. Educators seek a teaching model conducive to enhancing the academic literacy and language proficiency of Persian learners while effectively delivering mathematical content. Notable examples of such models, observed in other languages, include Specially Designed Academic Instruction in English (SDAIE) and Sheltered Instruction Observation Protocol (SIOP), which will be elucidated further in the subsequent section.

Specially Designed Academic Instruction in English (SDAIE):

Specially Designed Academic Instruction in English (SDAIE) stands as a pedagogical method tailored to grant learners comprehensive access to core curriculum concepts while acknowledging their limited language proficiency. SDAIE aims to ensure equitable access to standard curriculum content for language learners. The fundamental distinction lies in its facilitation for teachers to convey essential curriculum concepts without necessitating an exhaustive grasp of the language.

Sheltered Instruction Observation Protocol (SIOP):

The Sheltered Instruction Observation Protocol (SIOP) addresses the common challenge faced by second or foreign language learners who engage with academic material in a language distinct from their native tongue. These learners continuously strive to advance their language proficiency while grappling with the complexities of course concepts, new information, and the skills demanded by academic disciplines. For these individuals to succeed in comprehending intricate lessons, a modified and sheltered educational approach becomes imperative, rendering lessons meaningful and accessible. The focus of sheltered instruction aims distinctly at fostering the ongoing development of language skills, especially in scientific and academic contexts (Fritzen, 2011, p. 1).

The creation and evaluation of the Sheltered Instruction Observation Protocol (SIOP) stemmed from a desire to aid teachers in meticulously planning and consistently delivering high-quality lessons that explicitly address both academic content and language acquisition for second language learners (Kareva & Echevarria, 2013, pp. 240-241). Originally conceived as a measurement tool for researchers to monitor teachers' implementation of sheltered education techniques, the SIOP evolved into an approach encompassing eight components for lesson planning and presentation. This model provides a structured framework for educators to render subject matter, such as social studies or mathematics, comprehensible to language learners by employing strategies that cater to their linguistic needs while simultaneously enhancing their academic language skills in reading, writing, listening, and speaking (Echevarria, Power & Short, 2006, p. 2).

Comprising 30 teaching strategies categorized within eight distinct components—lesson preparation, background creation, comprehensible input, strategies, interaction, practice and implementation, lesson presentation, and review and assessment—the SIOP model offers a comprehensive framework for educators (Echevarria, Vogt & Short, 2017). These components serve as a structured guide in fostering an inclusive and effective instructional environment for language learners.

Lesson Preparation: Lesson Preparation involves crafting a tailored plan specifically intended for a distinct cohort of language learners within a particular course. It necessitates establishing meaningful connections between the existing knowledge and experiences of language learners and new information being presented. A crucial aspect of each lesson, framed within the Sheltered Instruction Observation Protocol (SIOP), involves the clear delineation, demonstration, and oral review of both general and specific teaching objectives encompassing content and language objectives (Kareva & Echevarria, 2013, p. 240). These objectives align with the prescribed curriculum of the relevant academic discipline and encompass the lexical nuances and academic language imperative for the success of language learners.

Well-structured lesson plans foster heightened learner engagement, leading to a more profound grasp of the lesson's content (Goldenberg, 2008, p. 17). Within this domain, teachers can engage in various activities such as utilizing graphic organizers before, during, and after the lesson, adapting content, incorporating supplementary notes, employing text highlighting techniques, and deploying strategic questions to facilitate comprehension and retention.

Building Background: In the realm of language learning, activating prior knowledge proves pivotal for effective comprehension and assimilation of new content (Zashchitina & Moysyak, 2017, p. 5). Learners lacking the ability to access their background information may struggle to establish connections between novel and familiar concepts, hindering their grasp of key ideas within the text. Engaging in simple activities, such as prompting students to recall information and apply their previous learning, serves as an essential strategy (Stahl & Nagy, 2005, p. 116). A crucial element within this process involves linking the new lesson to the existing knowledge of language learners, validating their cultural background and experiences to a certain extent. In practice, it becomes imperative for educators to consider both the cultural context and the diverse experiences brought by language learners into the classroom setting.

In scenarios involving learners from varied cultural backgrounds, teachers must exert additional effort to provide supplementary experiences, especially for those lacking the requisite background knowledge in specific mathematical lessons. (Echevarria, Vogt & Short, 2017) Employing diverse practical activities proves beneficial in facilitating learning, including contextualizing new vocabulary, enabling learners to self-select essential words, constructing personalized dictionaries centered on mathematical concepts, and involving learners in the display of mathematical words on classroom walls. Furthermore, employing strategies like conceptual mapping for

intricate concepts and integrating various games featuring mathematical vocabulary can greatly aid in reinforcing comprehension and engagement.

Comprehensible Input: Within the SIOP model, the third component is Comprehensible Input, rooted in the Comprehensible Input hypothesis formulated by renowned linguist Stephen Krashen. This hypothesis advocates for learners' exposure to reading and listening materials slightly beyond their current language proficiency or interlanguage level (Figure 1).
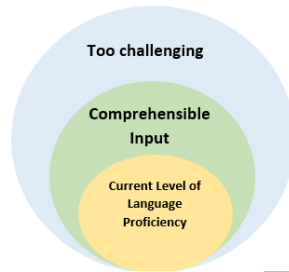

Figure 1: Comprehensible input

Krashen's input hypothesis is encapsulated by "i+1," where "i" signifies the learner's existing interlanguage or proficiency level, and "+1" represents language material slightly above their current competence. As per this hypothesis, learners advance when teachers, mindful of their current content and language grasp, introduce material that offers just a slight level of challenge, analogous to ascending one step of a ladder. In this context, teachers can provide verbal and procedural scaffolding, foster discussions, contextualize abstract concepts, clarify key ideas using the learner's first language, and integrate language skills—listening, speaking, reading, and writing—with mathematical content.

Strategies:

Strategies encompass mental processes aimed at augmenting comprehension and retention of information. In the realm of mathematics education, the utilization of teaching strategies holds paramount importance. Teachers play a pivotal role in explicating the rationale behind these strategies, elucidating how, when, and where to apply them, and subsequently reinforcing their efficacy through reflection and reasoning processes (Enríquez, Oliveira, Valencia, 2017, p. 2).

Learning strategies encompass cognitive, metacognitive, and social/affective domains. Examples of these strategies include expressing thoughts verbally, making predictions, summarizing information, among others. The effective implementation,

modeling, and explicit instruction of such strategies are integral facets of effective mathematics instruction. (Vakilifard and Khaleghizadeh, 2014)

Interaction: Positioned as the pivotal ninth component within this instructional model, interaction represents an indispensable facet in the continuum of learning. As language learners engage in reciprocal communication during the learning trajectory, acknowledging the nuanced and multifaceted nature of interaction becomes imperative. Notably, educators are active participants in interactions, engaging not only with learners but also with parents and administrators. This engagement assumes significance, enabling educators to navigate challenges and address the distinctive needs of language learners effectively. The efficacy of educators significantly hinges upon their comprehensive grasp of diverse learning domains, their adeptness in reflective teaching practices, and their proficiency in employing astute problem-solving strategies (Hurst, Wallace & Nixon, 2013, p. 4).

Furthermore, this segment emphasizes the preparation of activities aimed at fostering peer dialogue. Teachers can facilitate such interactions by encouraging detailed questioning and responses, organizing learners into flexible, homogeneous, or heterogeneous groups based on language proficiency, employing cooperative learning methodologies, incorporating information gap tasks, segmenting reading assignments for group analysis, conducting multi-stage interviews, elucidating key concepts and lexical items, encouraging written responses, and orchestrating roundtable discussions. These activities are designed to cultivate a balanced and dynamic interactional environment encompassing both teacher-learner exchanges and peer-to-peer engagements.

Practice & Application: Within the instructional framework, lessons should offer abundant opportunities for non-Iranian learners to apply their grasp of mathematical concepts and Persian language skills. Practical activities play a pivotal role in bridging the gap between abstract mathematical concepts and concrete application. The synergy between these realms is most effectively realized when learners engage in activities that encompass all four language skills. These activities include segmenting content into meaningful segments, formulating test questions or mathematical problems for peers, teaching concepts to fellow learners, employing and creating graphic organizers, collaborating in mathematical problem-solving endeavors, participating in group discussions, and engaging in collaborative projects (Hofmannová, Novotná, & Pípalová, 2008, p. 3). These engagements provide robust avenues for learners to connect theoretical knowledge with practical application in a language-learning context.

Lesson Delivery: Lesson delivery, synonymous with the presentation of a lesson, encompasses the teacher's assessment of the successful integration of content and language objectives, the level of student participation, and the synchronization of the lesson pace with the learners' capabilities. Teachers must gauge the effectiveness of their teaching strategies in capturing students' attention and actively involving them in the learning process. Achieving these goals requires explicit delineation of content and language objectives, comprehensive structuring of lesson implementation procedures, and a presentation pace tailored to the lesson's complexity and students' comprehension abilities. Monitoring and optimizing student engagement, exhibiting adept multicultural and multilingual class management skills, and judiciously allocating time for exercises further contribute to the effectiveness of lesson delivery (Hurst, Wallace & Nixon, 2013, p. 4).

Review & Assessment: Review and assessment are integral components of the learning process. Evaluation involves identifying the needs of language learners, documenting their progress, and determining how syllabus designers, planners, and teachers can improve their work. Ideally, assessment serves as a tool to assist teachers in guiding learners throughout their learning journey (Frank, 2012, p. 32). As part of each SIOP lesson, teachers allocate time to review and evaluate the comprehension of key language and content concepts and assess the achievement of learning objectives during the lesson to determine if additional explanation or re-teaching is necessary. The assessment data collected during the training course is utilized to plan subsequent lessons.

2. Methodology:

The methodology employed in this research extends the established Sheltered Instruction Observation Protocol (SIOP) Model, renowned for its efficacy in catering to the educational requirements of English learners across other countries. The SIOP Model, comprising eight interconnected components, has been instrumental in shaping instructional practices (Lesson Preparation, Building Background, Comprehensible Input, Strategies Interaction, Practice/Application, Lesson Delivery, Review & Assessment). In our study, we introduce three pivotal components derived from previous research in second language didactics. These components, focusing on the learning climate, motivation, and cultural nuances within language teaching and learning, serve to enhance the Revised SIOP Model. Their incorporation aims to empower educators in addressing the academic and linguistic necessities specific to Persian learners. This innovative expansion of the

instructional intervention underscores its distinctiveness and significance in optimizing language and content instruction.

2. 1 Revising the Sheltered Instruction Observation Protocol (SIOP):

The Learning Climate: Second language educators emphasize the pivotal role of the learning environment in the success or failure of second language acquisition. This climate significantly influences both the physical and psychological aspects of language learners (Kiatkheeree, 2018, p. 391). A conducive learning climate hinges on three key components: the teacher, the language learner, and the educational setting. Each of these elements contributes distinct conditions and attributes that foster a positive and productive learning atmosphere. Deficiencies in any of these elements can impede the learning climate and hinder the achievement of educational objectives.

In multicultural classrooms, learners benefit from comprehensible input within a low-anxiety learning environment. Access to a classroom climate aligned with their background knowledge further enhances their learning experiences (Kersaint, Thompson & Petkova, 2009, p. 57). Brown (2007, p. 515) emphasizes the responsibility of second language educators in creating a climate that respects diverse opinions, beliefs, and cultural identities. The power dynamics within educational environments differ, with some learners accustomed to teacher-centered systems while others emerge from cooperative learning contexts. Teachers in multicultural classrooms can gradually balance power dynamics through various activities, fostering an environment where learners both understand and accept the distribution of authority (Wintergerst & McVeigh, 2011, p. 180).

Motivation: Motivation significantly shapes the dedication of language learners to their language acquisition endeavors. Crookes and Schmidt (1991, p. 501) delineate four motivational domains in second language acquisition: the cognitive level, micro level, classroom level, curriculum level, and extra-classroom level. The cognitive level involves the processing of second language input, while the micro level reflects the learner's attention to this input. Classroom activities and the learner's anticipation of success and control over tasks impact motivation at the classroom level. The choice of presented content, constituting the curriculum level, influences curiosity and interest in learners. External factors, such as informal interaction and prolonged influences, encompass the extra-classroom level.

In language education, particularly concerning mathematical content, motivation proves crucial for learning mathematical vocabulary and concepts. While various methods exist to make learning engaging for language learners, it is imperative for them to grasp lexical items and concepts, emphasizing the significance of word selection for

effective communication in both spoken and written discourse (Stahl & Nagy, 2005, p. 123).

Culture: The relationship between language and culture is intrinsic and complex, intertwining in communicative contexts within the target language culture (Genc & Bada, 2005, p. 2). Culturally enriched language learning aids in bridging abstract language constructs with real-life contexts, aiding learners in understanding cultural aspects. Teachers instructing second or foreign languages acknowledge the pivotal role of culture in learners' adaptation and success in the target society. Thus, enhancing learners' cultural and intercultural competencies remains a fundamental goal in language education.

Within classrooms, language learners bring unique linguistic and socio-linguistic behaviors reflective of their cultural background. Conflicting behaviors with the host culture can disrupt communication between teachers and learners, creating challenges in student-student interactions (Wintergerst & McVeigh, 2011, p. 149). Managing these cultural disparities involves respecting diverse communication styles, recognizing signs of culture shock, understanding cultural expectations in verbal and non-verbal communication, and acknowledging differences in educational approaches among cultures. The integration of these elements—learning climate, motivation, and culture—forms the basis of the proposed Revised SIOP model for language and content teaching (Figure 2).
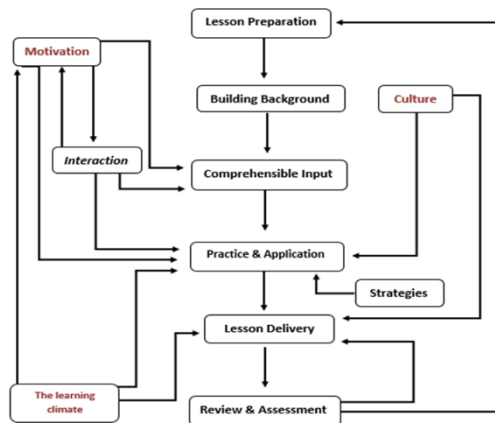

Figure 2: Revised SIOP Model for Language and Content Instruction

The Implementation of the Revised Model in Classroom Setting: The revised model was introduced in a math class at the Persian Language Center, International University in Qazvin, spanning three sessions as the experimental group. The teacher leading

this experimental group received prior or concurrent training on the revised model during data collection. A separate class operated as the control group, following standard direct teaching methods for mathematical concepts. Initially, integrating all components of the revised SIOP model in each lesson posed challenges in the experimental group despite teacher training. However, over time, the implementation became more feasible, with some components being applied individually or in conjunction with others based on class dynamics.

2.1 Participants

Participants in this study were drawn from the Persian language teaching center at the International University in Qazvin, enrolled in humanities, medical sciences, engineering sciences, and social sciences complementary courses. Specifically, the research focused on Persian learners within the engineering sciences group undertaking semi-specialized language courses. The study involved two classes of semi-specialized math language, randomly assigned into experimental and control groups. The participants, volunteers aiming to pursue studies in basic science and engineering fields in local universities, comprised 28 Persian learners (14 in the experimental group - 11 males and 3 females, and 14 in the control group - 12 males and 2 females) from diverse countries, aged between 20 and 23 years old.

2. 2 Development and Validation of Written Vocabulary Assessment Tool

Instrument Development: The meticulous development of the written vocabulary assessment tool aimed to ensure its appropriateness in evaluating lexical comprehension within the context of the revised SIOP model and educational interventions. The tool's development underwent rigorous scrutiny to align with the requirements and objectives of the SIOP model revision.

Initial Evaluation of Lexical Items: Before implementation, a comprehensive evaluation of lexical items within the assessment tool was conducted. This evaluation focused on determining the relevance, clarity, and alignment of vocabulary terms with the curriculum objectives and the revised components of the SIOP model, ensuring their suitability for assessment purposes.

Reliability Assessment and Validity Analysis: Several measures were employed to ascertain the reliability and validity of the written vocabulary assessment tool. Internal consistency, evaluated through Cronbach's alpha coefficient and test-retest reliability, ensured stability in measuring students' understanding of vocabulary terms over time. The initial sample revealed a Cronbach's alpha of 0.769, falling within an acceptable range for reliability.

Validity checks were executed to confirm the assessment tool's efficacy in measuring its intended objectives. Content validity was ensured through expert evaluation, validating the relevance of vocabulary items to the components of the SIOP model. Concurrent validity was assessed by comparing assessment results with established measures of vocabulary comprehension, affirming the tool's effectiveness in measuring targeted aspects of vocabulary understanding.

Pre-test Implementation and Post-test Assessment: Before the educational interventions, a pre-test utilizing the developed written vocabulary assessment was administered in multiple sessions. This pre-test served as a baseline measure to gauge students' initial understanding of the vocabulary terms associated with the revised SIOP model. Following the implementation of educational interventions, a post-test was conducted in three sessions. The post-test aimed to evaluate the impact of the interventions on students' comprehension and retention of vocabulary terms integrated into the revised SIOP model.

Data Collection and Analysis: The written vocabulary assessment tool served as the primary data collection instrument, capturing students' understanding of vocabulary terms. Comparative analysis between pre-test and post-test data was conducted to evaluate the effectiveness of educational interventions in enhancing students' lexical comprehension within the SIOP framework. The choice of a written vocabulary assessment was deliberate, considering its capacity to gauge students' depth of understanding regarding vocabulary terms incorporated within the revised SIOP model. This choice aimed to capture nuanced insights into students' comprehension and utilization of these terms in context.

In this section, we present descriptive statistics pertaining to the principal variable under study, specifically the test scores observed within the two tests and control groups across the pre-test and post-test phases.

2.3. Descriptive Statistics of Test Scores in Pre-test and Post-test Phases

Overview of Test Scores: Table 1 displays the mean scores and standard deviations for both the experimental and control groups across the pre-test and post-test assessments. The pre-test mean score for the experimental group was 12.800, while the control group scored 17.750. In the post-test, the experimental group obtained a mean score of 15.500, and the control group scored 17.468.

Table 2: Descriptive Statistics for the Primary Research Variable

variable	Test	Group	Mean scores	Standard
	Pre-test	Experimental	12.80	2.859
		Control	17.750	2.434
Test score	Post-test	Experimental	15.500	4.281
		Control	17.468	2.041

2.4. Analysis of Covariance (ANCOVA) Assumptions

Normality of Post-Test Scores: Assessing Normality using Kolmogorov-Smirnov Test The normality assumption for the distribution of post-test scores was examined using the Kolmogorov-Smirnov test. The test aimed to ascertain if the post-test score distributions adhered to a normal distribution.

Results of Normality Test: Table 2 presents the Kolmogorov-Smirnov test results for post-test scores in both control and test groups. The significance levels for these scores were found to be above 0.05, confirming the assumption of a normal distribution in the post-test scores.

Table 3: Kolmogorov-Smirnov Test Findings for Post-Test Score Distributions

Scores	Test statistics	Significant level	Result
post-test scores in control groups	0.246	0.086	Normal
post-test scores in test groups	0.246	0.200	Normal

Linearity of Pre-test and Post-test Correlation: Testing Linearity of Correlation between Pre-test and Post-test Scores The linearity of the correlation between pre-test and post-test scores was evaluated to ensure the correlation assumption.

Linearity Test Results: Table 3 displays the test results for the linearity of correlation between pre-test and post-test scores. The significant F-values at the 0.001 level affirm the existence of a significant correlation between the pre-test and post-test scores.

Table 4: Results of the Linearity Test for Pre-test and Post-test Score Correlation

variables	Test statistics	Significant level
Score	30.938	0.001

Homogeneity of Variances: Examination of Variances Homogeneity via Levene's Test Levene's test was utilized to verify the homogeneity assumption in the variances of pre-test and post-test scores.

Results of Variances Homogeneity Test: Table 4 presents the outcomes of Levene's test for both pre-test and post-test scores. The significance levels exceeding 0.05 indicate support for the hypothesis, affirming the equivalence of variances in the pre-test and post-test scores.

Table 5: Homogeneity Test Results for Score Variances

variables	Test	Test statistics	Degrees of freedom1	Degrees of freedom2	Significant level
Scores	Pre-test	1.721	1	16	0.208
	Post-test	3.732	1	16	0.071

These sections delve into the descriptive statistics of test scores, the evaluation of assumptions for ANCOVA, including normality, linearity of correlation, and homogeneity of variances, providing an analytical framework for the subsequent ANCOVA analysis.

3. Discussion

The findings delineated in this research align notably with analogous outcomes observed in various studies pertaining to the efficacy of the Sheltered Instruction Observation Protocol (SIOP) model. Echevarria, Short, and Powers (2006) investigated SIOP's impact on language learners' academic language development, demonstrating augmented educational benefits within intervention groups, corroborating our research's assertion of the SIOP model's affirmative impact on the acquisition of mathematical language among Persian learners. Similarly, Boughoulidi (2020), Short, Fidelman, and Legwitt (2012) and Azure (2014) underscored SIOP's favorable influence on academic performance and language skills, akin to the discernible progress in mean scores observed in our research's experimental group, accentuating the model's effectiveness in enhancing vocabulary acquisition within specific academic realms.

In contrast, Genzuk's (2011) emphasis on structured language acquisition programs resonates with our research's focus on the restructured SIOP model's influence on enriching specialized vocabulary acquisition within mathematical contexts. Driscoll's (2011) exploration of sheltered instruction parallels the observed positive influence of the SIOP model on cognitive development and proficiency enhancement among

language learners, akin to this research's findings of heightened proficiency in specialized Persian vocabulary acquisition within the experimental group. While these previous studies encompass diverse educational contexts and subject areas, collectively they underscore SIOP's effectiveness in augmenting language acquisition and academic performance. Notably, these aligning outcomes echo the positive influence observed in this research, particularly concerning Persian learners' proficiency in grappling with the acquisition of mathematical language.

The research hypothesis posits the paramount importance of the revised paradigm in refining the proficient utilization of reading vocabulary among Persian learners, implying that conventional pedagogical methodologies applied in teaching mathematics to Iranian Persian learners might lack direct transferability to their non-Iranian counterparts. The revamped SIOP model, meticulously crafted upon empirical foundations, is perceived as an extensive framework aimed at amplifying instructors' effectiveness and fostering student advancement. It is observed that while the model's immediate efficacy might appear modest, its optimal performance necessitates protracted implementation, signifying promising prospects for prospective investigations in this domain.

Furthermore, the empirical findings evince that the implementation of this revised approach distinctly augments the comprehension of academic language and vocabulary among language learners. It underscores the imperative for educators to seamlessly integrate this model into their instructional schemata, notably within content-oriented teaching for non-native language learners, contingent upon their familiarity with the model's structural underpinnings and procedural deployment.

Moreover, it is pertinent to highlight that the proposed conceptual framework serves as a conduit for language learners across diverse academic backgrounds, facilitating their assimilation into comprehensive educational programs. The analytical scrutiny via covariance analysis accentuates the statistical significance, affirming the hypothesis and validating the efficacy of the prescribed training.

Additionally, in the absence of a structured amalgamation of language and content education, this re-conceptualized model proffers itself as a foundational framework or initial stepping stone for such pedagogy, contingent upon requisite refinements and empirical scrutiny. Acknowledging the inherent challenges in reforming educators' pedagogical approaches, it advocates for a continuous regimen of workshops, supportive mechanisms, and meticulous planning to ensure efficacious implementation.

In essence, the study underscores the affirmative ramifications of the restructured SIOP model, accentuating its potential in fostering linguistic acquisition, fostering a fertile ground for subsequent scholarly inquiries, and accentuating the imperative for an ongoing professional development framework to enable educators to adeptly assimilate these pedagogical paradigms.

4. Conclusion:

In summary, the didactics of language instruction tailored for mathematical contexts holds significant importance within second language education, particularly for foreign student cohorts. The efficacy of the Revised SIOP Model in elevating the academic language proficiency of foreign students within mathematics classrooms is well-documented. This model centers on delivering explicit language guidance and scaffolded support while integrating purposeful activities that afford students opportunities to employ academic language in meaningful contexts. Consequently, students benefit from an enhanced grasp of mathematical concepts, leading to discernible advancements in their academic performance.

The applicability of this model extends beyond Persian learners engaged in mathematical studies; it notably proves efficacious even for those with limited language proficiency. Its implementation has demonstrated transformative impacts on classroom dynamics, fostering cognitive advancements among language learners and bolstering their self-assurance. By prioritizing language acquisition within mathematical domains and leveraging robust instructional models like the Revised SIOP Model, foreign students stand to substantially augment their academic language skills, thereby achieving heightened success in their mathematical education.

Educational Implications and Further Research:

However, further research endeavors remain imperative to delve into the model's effectiveness across diverse student demographics and its enduring influence on long-term language competencies. Moreover, while the model serves as a valuable framework for teaching language within mathematical contexts, the individualized needs of students necessitate adaptable instructional approaches. Given the paucity of research in this realm, there exists a pressing need to conduct comprehensive studies encompassing the pedagogy of diverse subjects—ranging from social sciences to physics—tailored for international students. These research findings should inform classroom strategies at varied academic tiers.

The recommendation stands to widen the implementation of this educational model, extending its application to other disciplines such as geometry, numerical analysis, and mathematics across Iranian classrooms, catering to children and adolescents alike. Its utilization in regular classrooms, notably in bilingual regions of the country, holds promise in accelerating content assimilation and fostering superior quality learning compared to non-utilization scenarios.

In essence, the evident success observed in students, especially in bilingual settings, underscores the significant promise of the Revised SIOP Model as an educational cornerstone. Its broader integration, coupled with tailored adaptations addressing diverse student needs, holds the potential to foster accelerated and enriched learning experiences across varied academic terrains. This approach heralds a paradigm shift in second language didactics, offering a systematic framework that not only aids in content assimilation but also stands as a pivotal catalyst in propelling academic excellence across multicultural educational landscapes.

مفهوم‌سازی دوباره الگوی شپاپ برای اهداف ریاضی: بهینه‌سازی آموزش زبان فارسی دانشگاهی به دانشجویان خارجی

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چکیده :

تمرکز این پژوهش ارائه الگویی برای آموزش زبان فارسی نیمه‌تخصصی به داوطلبان رشتهٔ مهندسی است که به یادگیری زبان‌های نیمه‌تخصصی در دوره‌های پیشرفته زبان فارسی می‌پردازند. هدف اصلی این پژوهش افزایش درک مفاهیم ریاضی و بهبود مهارت زبان فارسی است. در این پژوهش اثربخشی الگوی شپاپ در آموزش زبان به زبان‌آموزان با زمینه‌ها و انگیزه‌های مختلف ارزیابی می‌شود. بدین منظور، الگوی شپاپ که بازنگریسته و دوباره مفهوم‌سازی شده بود، در سه جلسه آموزشی ریاضی در مرکز آموزش زبان فارسی دانشگاه بین‌المللی قزوین اجرا شد. از نظر پایایی و روایی ابزار ارزیابی اعتباری‌سنجی شد. برای گردآوری داده‌ها و نیز واکاوی آماری، ارزیابی یادگیری واژه‌ها پیش و پس از آزمون انجام شد. نتایج به‌دست‌آمده از ۲۸ فارسی‌آموز غیرایرانی نشان‌دهنده تفاوت آماری معناداری میان نمرات پیش‌آزمون و پس‌آزمون بود ($p<0/05$). اجرای الگوی شپاپ بازنگریسته منجر به بهبود در استفاده دقیق از واژه‌ها در میان فارسی‌آموزان غیرایرانی شد. این یافته‌ها پیامدهای مهمی برای تقویت آموزش زبان نیمه‌تخصصی و دانشگاهی به غیرایرانیان داوطلب تحصیل در دانشگاه دارد. علاوه بر این، نتایج می‌تواند به عنوان یک راهنمای ارزشمند آموزشی برای مدرسانی باشد که ریاضیات و علوم دیگر را به زبان‌آموزان ایرانی آموزش می‌دهند. این مطالعه اثربخشی الگوی شپاپ بازنگریسته را در افزایش یادگیری یکپارچهٔ زبان و محتوای دانش‌های گوناگون برجسته می‌کند.

کلیدواژه‌ها :زبان فارسی، شپاپ بازنگریسته، زبان دانشگاهی، ریاضی، آموزشکاوی

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