Research Article

Identifying Concepts of SOLO Taxonomy as Basis of Developing Events of Constructivist Instructional Design

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Abstract

The Structure of Observed Learning Outcomes (SOLO) Taxonomy provides a constructivist framework that positions learners as active architects of their own knowledge. Grounded in social interaction, experience, and reflection, it urges educators to articulate learning objectives in a specific sequence and to design multi-level assessments. Despite being a known framework, there is little clarity on how to structure a teaching method or instructional design using the SOLO Taxonomy. Thus the primary goal of this desk research is to synthesize key concepts of SOLO Taxonomy that can be considered in making an instructional design. Using the systematic review approach, relevant studies were thoroughly identified, gathered, and analyzed. All collected data underwent in-depth thematic analysis to generate the desired outcomes. The analysis identifies seven themes that constitute the core concepts of the SOLO Taxonomy: the Construction of Personal Meaning, Deep Meaningful Learning, a Theory Y Learning Climate, Cognitive Learning Strategies, Reflective Learning, Formative Feedback, and Sequential Learning based on Empirical Prerequisites. These findings have significant and direct implications for the development of instructional methods. Together, these themes establish a pedagogical framework that aligns with the taxonomy's hierarchy, facilitating a progression from unistructural comprehension to extended abstract synthesis. The application of these principles enables educators to construct learning experiences that go beyond factual recall to simultaneously achieve content mastery and develop essential skills in critical thinking, metacognition, and adaptive problem-solving.

Keywords: *SOLO Taxonomy, events of instruction, instructional design model, instructional and curriculum*

Introduction

Modern education requires tailored methods and practical to address students' diverse learning styles, abilities, and skills, thereby supporting their holistic development (Schott & Seel, 2012). Instructional design models are essential for achieving successful learning outcomes, as they translate broad educational principles into clear, practical, and student-focused concepts (Khalil & Elkhider, 2016).

Instructional design (ID) models are created to improve understanding of the design process, experiences, and practical applications in education (Lee & Jang, 2014). These models examine the entire development of educational

systems, including learning needs, goals, outcomes, and delivery methods. They ensure that instructional materials, activities, and assessments are designed, implemented, revised, and evaluated to meet academic standards (Briggs, 1977; Richey et al., 2004). As a result, grasping the core elements of teaching and learning is crucial for creating effective instructional design models.

Reigeluth and An (2009) highlighted that creating an instructional design (ID) model for teaching and learning is both strategic and highly beneficial. These models offer diverse approaches, contexts, and applications, allowing for more systematic and effective instruction (Gibbons & Rogers, 2009; Lee & Jang, 2014). The primary role of instruction is to organize and support learners' engagement, providing them with the knowledge and understanding necessary to apply higher-order thinking skills. This empowers learners to develop their own interpretations, analyses, reasoning, and ideas (Laurillard, 2008; Seel et al., 2017). Instruction consists of carefully planned activities where teachers, learners, materials, and the learning environment all play vital roles in the learning process. These elements must work together seamlessly to ensure successful academic outcomes (Dick & Carey, 1996).

Instructional design provides a systematic framework for enhancing pedagogical effectiveness and optimizing learning outcomes (Khalil & Elkhider, 2015). The process initiates with the articulation of clear learning objectives (Gagné et al., 1992) and the development of measurable outcomes (Mager, 1962; Dick & Carey, 1996; Ogbeiwi, 2017), followed by the alignment of instructional strategies, content, and materials with these objectives (Gustafson & Branch, 1997; Yokomoto & Bostwick, 1999; Diehm, 2017). Then, assessment mechanisms are then implemented to evaluate objective attainment (Mager, 1962), completing the instructional design cycle.

This structured approach achieves maximum efficacy when combined with learner-centered pedagogy (Dam, 1995; Jaiswal, 2019), which creates dynamic learning environments that simultaneously facilitate knowledge acquisition and cultivate learner autonomy (Jaiswal, 2019; Yan, 2012). Grounded in constructivist principles (Dam, 1995; Jaiswal, 2019), this framework represents the most effective approach for fostering comprehensive student development (Reigeluth et al., 2016). It emphasizes active learning through carefully designed curricula, engaging pedagogical activities, and performance-based assessments (Jaiswal, 2019), ultimately enabling students to achieve their full academic potential.

A widely recognized student-centered framework is the SOLO taxonomy, developed by Biggs and Collis (1982). It is fundamentally constructivist, grounded in the view that learners actively construct understanding rather than passively receive knowledge (Biggs & Collis, 1982). It maps a progression from surface to deep understanding through cognitive restructuring, aligning with radical constructivist views that knowledge develops through experience and reflection (von Glasersfeld, 1995). Teachers facilitate this process by designing social learning environments that introduce cognitive challenges through questioning, debate, and collaboration. These interactions provide crucial stimuli for learners to test and refine mental models, making the taxonomy a structured framework for active, self-directed knowledge building.

Biggs and Collis (1989) defined the SOLO taxonomy as "a framework for describing the level and quality of learning both within and across the curriculum." This taxonomy is a hierarchical framework that classifies learning outcomes based on increasing structural complexity, enabling its application across diverse subjects and educational levels. By emphasizing measurable and consistent criteria, the model facilitates the assessment of students' cognitive development (Biggs & Collis, 1989; Boulton-Lewis, 1992, 1995). Research further supports its utility in evaluating the depth and quality of learning, offering a systematic and reliable approach to understanding student progression (Chan et al., 2001, 2002; Hattie & Purdie, 1998).

However, there is a lack of studies using the SOLO taxonomy as a basis for designing instructional methods. While researchers have extensively employed this framework for developing learning objectives (Barandovska et al., 2020; Biggs, 1996, 2011; Brabrand & Dahl, 2009; Lueg et al., 2015; Rochana et al., 2021) and constructing assessment tools (Abdullah & Masran, 2021; Biggs & Collis, 1989; Chan et al., 2002; Hattie & Brown, 2004; Jones et al., 1997; Leung, 2000; Nor & Idris, 2009), its potential to inform teaching methodologies remains largely unexplored. The taxonomy's hierarchical structure, which effectively categorizes learning outcomes by increasing cognitive complexity (Biggs, 1996; Chubko et al., 2019), could theoretically provide valuable guidance for sequencing instructional activities and differentiating teaching approaches.

Biggs and Tang (2007) highlighted that the SOLO taxonomy is instrumental in defining, describing, and evaluating learning outcomes within the framework of constructive alignment. It offers a clear and structured understanding of learning outcomes, methods, and assessments, guiding both teachers and learners throughout the

process. Jaiswal (2019) asserted that the taxonomy specifies the expected outcomes of academic tasks, thereby facilitating the development of cognitive skills, collaboration, creativity, self-directed learning, assertiveness, and deep understanding. Originally formulated as a tool for identifying and categorizing teaching and learning activities, learning outcomes, and instructional methods, the SOLO taxonomy serves as a foundational component in the practical application of constructive alignment (Biggs & Collis, 1982; Easdown et al., 2018).

Moreover, SOLO taxonomy helps learners enhance their metacognitive skills, strategies, and techniques by enabling them to evaluate the complexity of their responses, performance, and answers based on their learning tasks and activities (Potter & Kustra, 2012; Hattie & Brown, 2004; Hook & Mills, 2011; Badr, 2020). According to Saputra et al. (2019), the SOLO taxonomy provides a practical framework for organizing and assessing learning responses, progressing from simpler to more advanced levels of difficulty. This progression is operationalized through the SOLO levels, which begin with pre-structural (the most basic), then advance through uni-structural, multi-structural, and relational levels, culminating in the abstract level, the highest level of cognitive complexity (Kaspersen et al., 2021; Brabrand & Dahl, 2009).

When planning and designing instruction, teachers apply the SOLO taxonomy to align their teaching strategies with students' levels of understanding, knowledge, and cognitive abilities (Yassine et al., 2017). The SOLO taxonomy serves as a framework for defining learning outcomes, designing engaging experiences, and creating assessments across all educational levels. It is a powerful tool for aligning teaching objectives with academic performance, fostering deep understanding and meaningful learning, and supporting students in achieving educational success.

Thus, this document aimed to synthesize key concepts of SOLO Taxonomy that can be considered in making a constructivist instructional design. Specifically, it sought to answer the following question:

1. What concepts of SOLO Taxonomy can be considered in developing events in an instructional design?

Materials and Methodologies

Research Design

This study used a systematic review method. Systematic reviews serve as a rigorous methodological approach for synthesizing existing research to inform evidence-based practices in instructional design. As defined by Green and Higgins (2008), a systematic review as a way to collect and analyze all available research that fits specific criteria to answer a straightforward question. This method is particularly valuable in educational research due to its structured, transparent, and replicable procedures, which minimize bias and enhance the reliability of findings (Gough et al., 2017). Unlike traditional literature reviews, systematic reviews employ explicit search strategies, inclusion/exclusion criteria, and quality assessment protocols to ensure methodological rigor (Petticrew & Roberts, 2006). This reduces selection bias and enhances the trustworthiness of conclusions, making them particularly suitable for proposing evidence-based instructional frameworks.
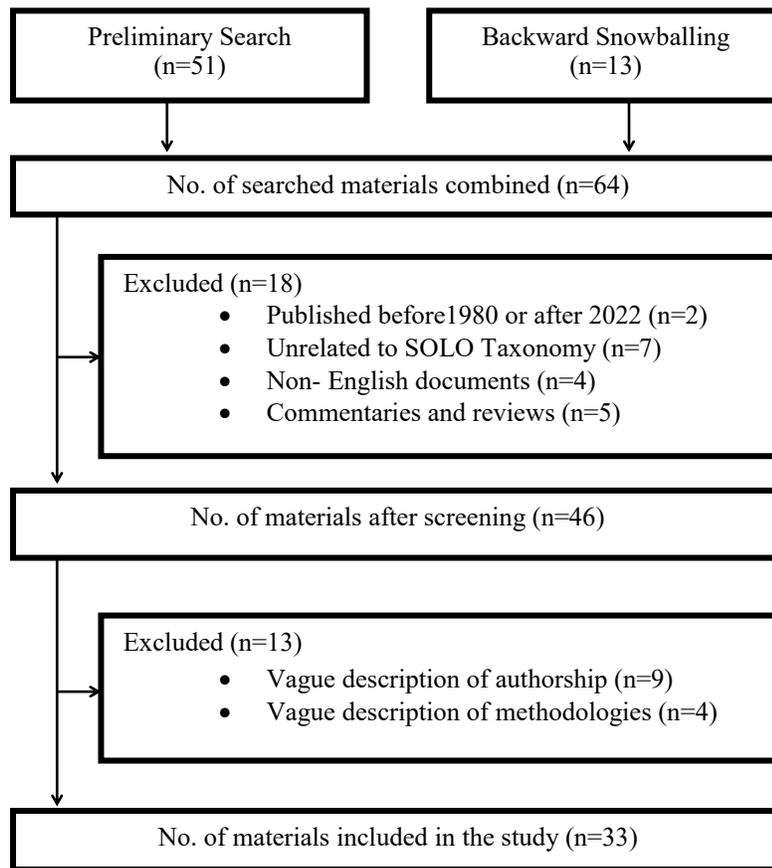
Sources and Materials

The researcher used a structured document review guide with five focused questions to extract SOLO Taxonomy concepts from each document systematically. This guide also identified specific resources to ensure only relevant data and information were included. Document selection and analysis followed predefined criteria to maintain rigor and align with the study's goals. Materials were systematically sourced from established academic databases, including Google Scholar, Elsevier, and Taylor & Francis Online. To ensure a comprehensive review, the scope of materials was not limited to journal articles but also extended to books, theses, and dissertations. This inclusive approach enhanced the depth and rigor of the analysis, providing a well-rounded understanding of the topic.

Data Collection

A framework designed for conducting systematic reviews, which was introduced by Moher et al., 2009 was employed in this study. This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring a structured, transparent, and methodologically rigorous process for data collection and reporting. The analysis incorporated publications from 1980 to 2022, a timeframe carefully selected to include foundational research on SOLO Taxonomy, track its theoretical evolution, and examine current applications. This comprehensive temporal scope allows for both historical perspective and contemporary relevance. Figure 1 shows the adapted framework used in the selection process.

For the initial analysis, relevant documents were gathered by searching online databases and journals, using "SOLO taxonomy" as the keyword

Figure 1.

The Review Framework Followed in this Study.

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│   Preliminary Search    │        │   Backward Snowballing  │
│        (n=51)           │        │         (n=13)          │
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┌──────────────────────────────────────────────────────────┐
│          No. of searched materials combined (n=64)        │
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    │        │ Excluded (n=18)                             │
    │        │   • Published before1980 or after 2022 (n=2)│
    ├───────▶│   • Unrelated to SOLO Taxonomy (n=7)        │
    │        │   • Non- English documents (n=4)            │
    │        │   • Commentaries and reviews (n=5)          │
    │        └─────────────────────────────────────────────┘
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│         No. of materials after screening (n=46)           │
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    │
    │        ┌─────────────────────────────────────────────┐
    │        │ Excluded (n=13)                             │
    ├───────▶│   • Vague description of authorship (n=9)   │
    │        │   • Vague description of methodologies (n=4)│
    │        └─────────────────────────────────────────────┘
    │
    ▼
┌──────────────────────────────────────────────────────────┐
│       No. of materials included in the study (n=33)       │
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to focus and structure the research. The initial search yielded a collection of relevant materials with a total of (n=51). By reviewing the references of the initially gathered materials through a backward snowballing approach, a second round of search identified additional (n=13) relevant sources, resulting in a combined total of (n=64).

The collected materials were screened for relevance by evaluating titles and abstracts against the exclusion criteria, which led to the removal of the following number of documents: published studies before1980 or after 2022 (n=2); unrelated to the SOLO Taxonomy (n=7); non- English documents (n=4); and commentaries and reviews (n=5), a total of 46 sources were selected for inclusion at this stage.

Two eligibility criteria, relevant to the primary focus of this research, were applied to the remaining 46 studies. A total of 13 studies were excluded – vague description of authorship (n=9) and vague description of methodologies (n=4). Only studies that clearly detailed their authorship details and methodologies were included, resulting

in 33 final selections. The 33 studies included in this review are summarized by title, author(s), publication year, and document type. These studies underwent rigorous analysis and evaluation. The results are presented.

Data Analysis

Thematic analysis was systematically employed in this study to examine the qualitative data, following the established methodological framework articulated by Braun and Clarke (2006). This approach facilitates the rigorous identification, encoding, and interpretation of recurrent patterns within the dataset, enabling the distillation of conceptually meaningful themes that align with the study's research objectives. The analytical process involved iterative cycles of data familiarization, initial code generation, theme development, and critical refinement, ensuring both methodological transparency and interpretive validity (Daly et al., 1997). Through this inductive yet structured process, seven themes that constitute the significant concepts of SOLO taxonomy were

Table 1.

Summary of Included Studies.

Title	Author/s & Year of Publication	Type of Document
Constructive Alignment and the SOLO Taxonomy: A Comparative Study of University Competences in Computer Science vs. Mathematics	Brabrand, C. & Dahl, B. 2008	Published Journal
The Effectiveness of Inquiry-Based Learning to train Students' Thinking Skill based on SOLO Taxonomy	Damopolii, I., Nunaki, J.H., Nusantari, E., & Kandowangko, N. Y. 2020	Published Journal
An Application of the SOLO Taxonomy to Classify Strategies used by Pre-Service Teachers to Solve "One Question Problems"	Caniglia,J. C. & Meadows, M. 2018	Published Journal
Analysis of Asynchronous Online Discussion using the SOLO Taxonomy	Holmes, K. 2005	Published Journal
The SOLO Taxonomy: Classify Students' Responses in Solving Linear Program Problems	Claudia, L. F., Kusmayadi, T. A., & Fitriana, L. 2020	Published Journal
Assessing the Structure of Learning Outcomes from Counselling using the SOLO Taxonomy: An Exploratory Study	Burnett, P. C. 2007	Published Journal
Designing a Multi-Faceted SOLO Taxonomy to Track Program Design Skills Through an Entire Course	Castro, F.E.V. & Fisler, K. 2017	Published Journal
An Identification of Students' Responses based on SOLO Taxonomy in Mathematics Learning toward Learning Activities and Learning Outcomes	Kaharuddin, A. & Hajeniati, N. 2020	Published Journal
Assessing the Complexity in Learning Outcomes - A Comparison between the SOLO Taxonomy and the Model of Hierarchical Complexity	Stålne, K., Kjellström, S., & Utriainen, J. 2015	Published Journal
Exploring the Use of Cognitive Science Approaches alongside SOLO Taxonomy as a Pedagogical Framework to Build Deeper Knowledge in Science and Foundation Subjects at Primary Schools in UK	Davies, O. & Mansour, N. 2022	Published Journal
Student Perceptions regarding the Usefulness of Explicit Discussion of "Structure of the Observed Learning Outcome" Taxonomy	Prakash, E.S., Narayan, KA, & Raman, S.K. 2010	Published Journal
Back to the Chalkboard: Lessons in Scaffolding using SOLO Taxonomy from School Teachers for University Educators	Sprecher, E. A. 2019	Published Journal
Using SOLO Taxonomy to Explore Students' Mental Models of the Programming Variable and the Assignment Statement	Jimoyiannis, A. 2011	Published Journal
The Application of SOLO Taxonomy in Writing Module based on Self and Peer Assessment for Primary Level in Malaysia: A Pilot Study	Abdullah, N. & Masran, Md. N 2021	Published Journal
SOLO Taxonomy for Assessing Novices' Algorithmic Design	Ginat, D. & Menashe, E. 2015	Published Journal
Assessing Students' Informal Inferential Reasoning using SOLO Taxonomy based Framework	Nor, N. M. & Idris, N. 2010	Published Journal
Cognitive Processes in asTTle: The SOLO Taxonomy	Hattie, J. & Brown, G. 2004	Published Journal
Cognition in the Formal Modes: Research Mathematics and the SOLO Taxonomy	Chick, H. 1998	Published Journal
Analysis of the Ability in Mathematical Problem-Solving based on SOLO Taxonomy and Cognitive Style	Mulbar, U., Rahman, A., & Ahmar, A. S. 2017	Published Journal
The Development of SOLO Taxonomy Based Assessment Tool on Text of Observation Reports of X Grade Students of Senior High School 1 NA. IX-X	Mindayani, N., Hadi, W., & Ambarita, B. 2019	Published Journal
Analysis of Attainments and Evaluation Questions in Sociology Curriculum according to the SOLO Taxonomy	Korkmaz, F. & Unsal, S. 2017	Published Journal
The Structure of the Observed Learning Outcome (SOLO) Taxonomy: A Model to Promote Dental Students' Learning	Lucander, H., Bondemark, L., Brown, G., & Knutsson, K. 2009	Published Journal
The Challenge of Assessing Creative Problem Solving in Client-Based Marketing Development Projects: A SOLO Taxonomy Approach	Jaskari, M. M. 2013	Published Journal
Evaluation of Student Learning in Organic Chemistry using the SOLO Taxonomy	Hodges, L. C. & Harvey, L. C. 2003	Published Journal
How to Analyze the Students' Thinking Levels based on SOLO Taxonomy	Putri, U. H., Mardiyana, M., & Saputro, D. R. S. 2017	Published Journal
The Contribution of Metacognitive in the Inquiry-based Learning to Students' Thinking Skill based on SOLO Taxonomy	Nunaki, J. K., Damopilii, I., Nusantari, E., & Kandowangko, N. Y. 2019	Published Journal
Aligning Seminars with Bologna Requirements: Reciprocal Peer Tutoring, The SOLO Taxonomy, and Deep Learning	Lueg, R., Lueg, K., & Lauridsen, O. 2015	Published Journal
Students' Ability of Mathematical Problem-Solving based on SOLO Taxonomy	Saputra, D. C., Nurjanah, A., & Retnawati, H. 2019	Published Journal
Enhancing Teaching through Constructive Alignment	Biggs, J. 1996	Published Journal
Teaching for Quality Learning at University, 3rd Edition	Biggs, J. & Tang, C. 2007	Published Book
SOLO Taxonomy in a Visible Learning School:A Quasi-Experimental Design to Study the Effect of SOLO Taxonomy on Student Metacognitive Ability	Badr, S. K. I. 2020	Published Doctoral Dissertation
SOLO Taxonomy as a Framework of Designing Comprehension Strategies The Application of The SOLO Taxonomy in Evaluating the Level of Introductory Financial Accounting Assessments	Benecke, G. V. 2021	Published Doctoral Dissertation
Evaluating the Quality of Learning: The SOLO Taxonomy	Biggs, J. & Collis, K. 1982	Published Book

found, each representing a foundational conceptual component.

Results and Discussion

Summary of Included Studies

Table 1 summarizes the collection of documents systematically selected and analyzed to identify and categorize SOLO taxonomy concepts. The document selection process adhered a rigorous, multi-phase methodology designed to ensure scholarly validity, relevance, and methodological integrity. Inclusion criteria were established to maintain consistency and academic rigor: (1) studies published between 1980 and 2022, ensuring a comprehensive historical perspective on the SOLO taxonomy's evolution; (2) studies published with clearly documented authorship and methodological transparency, guaranteeing academic credibility; (3) studies explicitly addressing the SOLO taxonomy's theoretical foundations, applications, or empirical validations; and (4) studies published in English to facilitate accurate interpretation and synthesis.

Following an exhaustive database search and systematic screening process – which involved

Table 2.

Themes identified from the concepts of SOLO taxonomy.

Construct	Concept	Theme
Recognition & Retention of Prior Learning	Conceptualizing of Knowledge	Construction of Personal Meaning
Construction of Knowledge	Building of the Unknown Knowledge	
Identification of Misconception	Restructuring of Knowledge	
Debate, Case Study & Essay Writing	Critical Thinking	Deep Meaningful Learning
Programming Activities, Laboratory Experiments		
Capstone Projects		
Reviews & Critiques of Relevant Articles	Problem Solving	
Reasoning and Proving		
Problem-based Teaching & Learning		
Immersion	Creative Thinking	Theory Y Learning Climate
Service Innovation, Project Proposal & Development		
Cause and Effect Chain		
Workplace Learning	Engagement and Sharing	
Interactive Lecture and Discussion		
Inquiry-based Teaching and Learning		
Reciprocal Peer Tutoring		
Communication and Collaboration	Active Learning	
Brainstorming		
Group Investigation Activity		
Differentiated Instructions/Activities	Self-Motivation	
Self-Efficacy		
Self-Directed Learning		
Linking Diagrams	Knowledge Structuring	Cognitive Learning Strategies
Guided Example Strategy		
Think Aloud, Concept Map, and Number Pattern Diagram		
Reflective Diary and Journals	Self Reflection	Reflective Learning
Self Address Questions		
Self Monitoring		
Note Taking	Self Review	
Learning from Error		
Shared Toolkit for Response and Portfolio Assessment	Student-Student Feedback	Formative Feedback
SOLO Rubric	Teacher-Student Feedback	
SOLO Levels of Understanding	Knowledge Structuring	Empirical Prerequisites
Prestructural, Unistructural, and Multistructural Level	Surface Level of Understanding	Sequential Learning
Relational and Extended Abstract Level	Deep Level of Understanding	

title/abstract review, full-text assessment, and critical appraisal – 33 documents met all eligibility criteria and were retained for qualitative synthesis. This structured methodology guaranteed a reliable and in-depth extraction of SOLO concepts, establishing a robust foundation for discussing their pedagogical implications

Themes of the Concepts of SOLO Taxonomy

The identified themes are summarized in Table 2 and discussed in detail in the following sections.

Theme 1: Construction of Personal Meaning

One of the central and most significant concepts of SOLO Taxonomy is the construction of personal meaning, in which emerged as theme number one. This is crucial for effective instructional design that emphasizes learners' active engagement in synthesizing knowledge. This process is anchored in three interdependent aspects: (1) conceptualizing knowledge, where learners interpret and categorize information within their cognitive frameworks; (2) building unknown knowledge, which involves generating new insights through inquiry and problem-solving; and (3) restructuring knowledge, where prior understanding is revised or expanded in response to new evidence.

Central to this framework is learner autonomy, as students independently create, interpret, and refine ideas by drawing on prior learning while addressing guided misconceptions (Kaharuddin & Hajeniati, 2020; Burnett, 2007). Such self-directed meaning-making fosters higher-order cognitive outcomes, including hypothesis generation, reflective analysis, and evidence-based generalizations (Davies & Mansour, 2022; Hattie & Brown, 2004; Claudia et al., 2020). These dynamics align with SOLO Taxonomy's hierarchical learning cycle (Biggs & Collis, 1982, 1989), which presents five progressive levels of understanding from unstructured (prestructural) to abstractly integrated (extended abstract). At each stage, learners organize and structure responses to demonstrate deepening mastery (Nor & Idris, 2010), a process that hinges on their ability to decode new knowledge and assimilate it into existing mental models (Biggs, 1971).

Through emphasizing iterative knowledge construction, SOLO Taxonomy serves as both a framework for mapping cognitive development and a tool for designing instruction that fosters critical thinking, self-regulation, and intellectual autonomy. This focus on personal meaning-making highlights its dual function: it acts as a measurable learning outcome while simultaneously driving transformative educational experiences that empower learners to engage deeply with content and cultivate lifelong intellectual growth.

Theme 2: Deep Meaningful Learning

Essential to the SOLO Taxonomy's application in education is the concept of deep meaningful learning, which has appeared as the theme two. This is basis for effective instructional design that transcends surface-level knowledge acquisition. This principle emphasizes fostering higher-order cognitive engagement, enabling learners to synthesize, evaluate, and apply knowledge through intellectually challenging tasks such as critical analysis, problem-solving, and creative reasoning (Brabrand & Dahl, 2008; Chick, 1998).

By challenging students to apply their cognitive capacities, creativity, and analytical skills, deep meaningful learning fosters the dual outcome of content mastery and metacognitive awareness, both of which are critical for success in academic and real-world contexts (Sprecher, 2019; Mulbar et al., 2017; Jaskari, 2013). Importantly, the SOLO Taxonomy not only guides instructional strategies but also serves as a robust assessment framework, as articulated by Biggs and Collis (1982). The taxonomy's hierarchical structure, which ranges from unistructural to extended abstract responses, provides educators with a systematic tool for evaluating the depth and quality of student work in inquiry-based and problem-solving contexts (Caniglia & Meadows, 2018; Jimoyiannis, 2011). This dual role highlights its utility as both a scaffold for designing cognitively rigorous activities and a framework with clear criteria for assessing intellectual development.

By embedding these principles into their pedagogy, educators can create learning environments that prioritize enduring understanding over rote memorization, thereby equipping students with the adaptive skills needed to navigate complex challenges. The integration of deep, meaningful learning with SOLO's theoretical and practical dimensions thus represents a holistic approach to education, aligning instructional design with cognitive development and assessment efficacy.

Theme 3: Theory Y Learning Climate

The Theory Y learning climate, a transformative concept within the SOLO Taxonomy, redefines pedagogy by positioning learner autonomy, intrinsic motivation, and collaborative engagement as central catalysts for deeper cognitive growth. This concept emerged as the study's third key theme. Rooted in principles of creative thinking, engagement and sharing, active learning, and self-motivation, this framework

empowers educators to cultivate classrooms where students take ownership of their intellectual journeys. Theory Y highlights that when learners are granted autonomy over their educational processes, including setting personal goals, selecting inquiry pathways, and participating in peer dialogue, their motivation and academic performance improve (Biggs, 1996; Sprecher, 2019; Brabrand & Dahl, 2008).

Fostering environments rich in interactive discussions and cooperative problem-solving, students not only refine their conceptual understanding but also develop metacognitive skills, as evidenced in studies linking Theory Y practices to improved critical thinking and creativity (Davies & Mansour, 2022; Kaharuddin & Hajeniati, 2020; Von Benecke, 2021). Collaborative learning emerges as the foundation of this approach: Holmes (2005) underscores the value of open-ended tasks that invite diverse perspectives, while structured peer activities such as brainstorming sessions, small-group template development (Sprecher, 2019), and learning partnerships (Biggs, 1996) enable students to synthesize ideas dynamically. Aligned with the SOLO Taxonomy's hierarchical progression, these strategies embody advancing cognitive complexity through iterative knowledge restructuring (Nunaki et al., 2019) and creative application (Castro & Fisler, 2017).

Ultimately, Theory Y shifts the educator's role from authority to facilitator, designing scaffolded yet flexible opportunities for students to connect laboratory reports, debates, or projects to broader conceptual frameworks (Lueg et al., 2015; Ginat & Menashe, 2015). By embedding autonomy, collaboration, and reflective practice into instructional design, Theory Y not only amplifies engagement but also aligns with SOLO's vision of learning as a scaffolded journey toward higher-order thinking and self-regulated mastery.

Theme 4: Cognitive Learning Strategies

Integral to the SOLO Taxonomy's pedagogical framework is the concept of cognitive learning strategies, which developed as theme four. This empowers learners to develop intellectual competencies through structured knowledge organization systematically. Grounded in the taxonomy's emphasis on knowledge structuring, these strategies engage learners in metacognitive processes such as information synthesis, critical analysis, and schema development to optimize memory retention and conceptual understanding (Chick, 1998; Lucander et al., 2009; Prakash et al., 2010).

Scaffolding activities, such as having students create flowcharts to map conceptual relationships (Abdullah & Masran, 2021), enable them to visualize and internalize complex ideas. This process fosters a shift from surface-level memorization toward deep, self-regulated learning. This approach not only reveals academic success as a product of strategic effort rather than innate ability but also cultivates metacognitive awareness, as learners reflect on their problem-solving approaches (Hodges & Harvey, 2003; Holmes, 2005). Practical applications include using flowcharts to visually map relationships between lecture concepts or guided exercises as learning activities that challenge students to weigh contradictory arguments before forming conclusions (Sprecher, 2019). Such activities provide a dual function by scaffolding the progression from unistructural (facts) to extended abstract (insights) within the SOLO framework and simultaneously diagnosing the depth of student learning (Holmes, 2005). For instance, structured peer discussions and reflective prompts encourage learners to articulate their reasoning, revealing gaps in understanding while fostering self-regulated learning habits (Hodges & Harvey, 2003).

This alignment of cognitive strategies with SOLO's hierarchical structure underscores their dual role: they enhance intellectual rigor while cultivating a growth mindset, equipping students to approach challenges with analytical confidence and adaptability. Ultimately, integrating these strategies into pedagogy bridges the gap between theoretical knowledge and actionable skills, ensuring that learning transcends rote memorization to achieve enduring, transferable mastery.

Theme 5: Reflective Learning

Reflective learning emerges as a fundamental concept within the SOLO Taxonomy. As theme number five, it is integral to designing instructional models that foster metacognitive growth and self-regulated learning. Central to this approach is the emphasis on activities that prompt learners to critically evaluate their own learning processes, aligning with the taxonomy's higher-order levels, relational and extended abstract thinking.

Students actively engage in self-reflection and self-review to transform their learning process. By systematically identifying academic gaps and refining their understanding, they take ownership of their educational development (Biggs, 1996; Biggs & Tang, 2007; Burnett, 2007). This introspective practice not only enhances academic performance but also cultivates personal growth, as learners develop the ability to connect theoretical principles to practical decisions, iteratively improving their problem-solving strategies (Jimoyiannis, 2011; Putri et al., 2017).

The integration of reflective learning within SOLO Taxonomy is operationalized through structured pedagogical tools. For instance, simplifying the taxonomy's framework enables students to self-monitor their progress, aligning their efforts with teacher expectations and fostering autonomy (Sprecher, 2019). Additionally, teaching learners to navigate SOLO's hierarchical structure empowers them to craft nuanced responses and prompts, advancing from foundational knowledge (unistructural) to sophisticated synthesis (extended abstract) (Jimoyiannis, 2011). Practical strategies such as guided self-assessment, peer feedback, and metacognitive exercises such as summarization and reflective journaling, anchor this process, enabling students to extract more profound meaning from content and internalize learning as a dynamic, iterative process (Biggs, 1996; Lucander et al., 2009). These methodologies are aligned with formative feedback and cognitive strategies, creating a cohesive instructional ecosystem that prioritizes critical thinking over rote memorization.

Ultimately, reflective learning underscores SOLO Taxonomy's transformative potential in education. By embedding reflection into pedagogy, educators equip students with the skills to independently navigate complex concepts, bridging the gap between theoretical knowledge and real-world application. This alignment not only elevates academic rigor but also nurtures lifelong learners capable of adaptive, self-regulated growth, cornerstones of a holistic educational paradigm.

Theme 6: Formative Feedback

Formative feedback stands as a foundation of the SOLO Taxonomy's pedagogical framework. As theme number six, it bridges the collaborative learning and metacognitive development through two interdependent strategies: student-student feedback and teacher-student feedback. Rooted in the taxonomy's hierarchical structure, formative feedback fosters iterative learning by enabling students to identify knowledge gaps, refine understanding, and progress from surface-level (unistructural) to deep, relational thinking. Peer interactions, for instance, create dynamic opportunities for learners to exchange perspectives, critique reasoning, and collaboratively problem-solve, thereby internalizing diverse approaches to complex tasks (Biggs, 1996; Saputra et al., 2019).

Effective feedback serves as a crucial scaffold in the SOLO (Structure of Observed Learning Outcomes) taxonomy, supporting learners' progression from basic comprehension (multistructural) to advanced conceptual synthesis (extended abstract) (Abdullah & Masran, 2021; Stålne et al., 2015). Teachers facilitate this development by providing targeted feedback that

helps students integrate fragmented knowledge into coherent frameworks. Structured reflection activities, including self-assessment and peer review, further reinforce this process by encouraging students to critically examine their understanding and apply theoretical knowledge in practical contexts (Burnett, 2007).

For example, peer feedback using SOLO-aligned rubrics helps students assess the logical consistency of arguments (relational stage), while instructor feedback promotes higher-order thinking by challenging assumptions and introducing new perspectives (Prakash et al., 2010). This dual approach not only corrects misunderstandings but also enhances metacognitive skills, enabling students to monitor their progress and adapt their learning strategies.

When integrated with SOLO-based tasks such as iterative writing revisions or rubric-guided peer assessments, formative feedback moves beyond simple error correction. Instead, it becomes a powerful tool for intellectual growth, fostering both academic resilience and self-regulated learning (Abdullah & Masran, 2021). By aligning feedback with SOLO's developmental stages, educators promote active, reflective learning that equips students with adaptable skills for academic and real-world challenges.

Theme 7: Empirical Prerequisites Sequential Learning

The SOLO Taxonomy, developed by Biggs and Collis (1982), provides a robust framework for understanding how learners' cognitive complexity evolves as they engage with academic tasks. Central to this taxonomy is the concept of empirical prerequisites for sequential learning, which emerged as theme seven. This highlights the hierarchical and scaffolded nature of knowledge acquisition. The hierarchical progression of learning necessitates that learners first acquire surface-level knowledge, which characterized by fragmented facts and basic comprehension at the multistructural level before advancing toward deeper, more integrated understanding at the relational and extended abstract levels. This sequential development ensures a systematic transition from the accumulation of discrete ideas (quantitative learning) to their synthesis and abstraction (qualitative learning), a principle reinforced by Caniglia and Meadows (2018) in their application of SOLO Taxonomy to problem-solving strategies. Empirical studies across disciplines confirm this progression: Brabrand and Dahl (2008) demonstrate its efficacy in structuring university-level competences, while Damopolii et al. (2020) highlight its role in fostering critical thinking through inquiry-based learning. The

foundational prestructural and unistructural levels, where learners exhibit no understanding or grasp isolated aspects, respectively, must precede multistructural competence, as working memory requires mastery of basic elements before managing complex schemas (Jimoyiannis, 2011; Castro & Fisler, 2017). The relational level, where knowledge is integrated into coherent frameworks, depends on this prior accumulation, as evidenced by studies in mathematics (Claudia et al., 2020) and science (Davies & Mansour, 2022). Finally, the extended abstract level, marked by generalization and transfer, is achievable only after relational mastery (Nunaki et al., 2019).

The taxonomy's distinction between surface knowledge (multistructural) and deep knowledge (relational/extended abstract) has profound pedagogical implications. Surface knowledge, while necessary for initial competency, focuses on isolated details and memorization, whereas deep knowledge prioritizes contextual connections, critical analysis, and creative application (Biggs, 1996; Hattie & Brown, 2004; Badr, 2020). Consequently, this distinction necessitates instructional frameworks that are explicitly designed to scaffold the progression between levels, ensuring students advance beyond superficial recall to achieve sophisticated, higher-order thought. For instance, Brabrand and Dahl (2008) and Davies and Mansour (2022) demonstrate how educators can use SOLO to structure assessments that align with cognitive milestones, fostering metacognition and self-regulated learning.

Moreover, SOLO's demonstrated applicability across a wide spectrum, spanning K–12 schooling, higher education, and professional training, underscores its significant utility in contemporary educational practice. As Leung (2000) noted that the taxonomy serves not only as an assessment tool but also as a cognitive enhancer, guiding learners from incompetence to expertise through structured, incremental challenges. Its integration with competency-based curricula (Mulbar et al., 2017) and digital learning tools further illustrates its relevance in addressing contemporary educational demands. While critiques of SOLO often cite potential biases toward Western educational paradigms, its emphasis on measurable cognitive progression offers a universal scaffold for designing equitable, outcome-aligned teaching strategies.

By prioritizing knowledge structuring and cognitive depth, SOLO Taxonomy transcends theoretical abstraction, providing educators with actionable insights to cultivate expertise, critical thinking, and lifelong learning in diverse learner cohorts.

Conclusion

This study aimed to synthesize the key concepts synthesize key concepts of SOLO Taxonomy that can be considered in making an instructional design. The findings of this study reveal seven interconnected themes derived from SOLO Taxonomy that hold critical implications for instructional design: Construction of Personal Meaning, Deep Meaningful Learning, Theory Y Learning Climate, Cognitive Learning Strategies, Reflective Learning, Formative Feedback, and Empirical Prerequisites Sequential Learning. Together, these themes form a cohesive pedagogical framework that aligns with the hierarchical progression of cognitive development—from foundational unistructural comprehension to advanced extended abstract synthesis. By integrating these principles, educators can design learning experiences that transcend rote memorization, fostering not only mastery of content but also the cultivation of critical thinking, metacognitive awareness, and adaptive problem-solving skills.

Construction of Personal Meaning highlights how students must construct their own personal meaning in order to form knowledge. This directly informs the selection of learning activities that guide students to conceptualize, generate, and restructure knowledge, thereby achieving desired learning outcomes. Formative Feedback aids in the identification of knowledge gaps, areas for growth, potential resources for support, and potential modifications or adaptations of learning strategies to achieve course objectives for students. Reflective Learning emphasizes the value of introspection. The act of constructing and interpreting personal experiences facilitates critical self-reflection, enabling students to derive meaning, acknowledge deficiencies, and pinpoint opportunities for personal growth. Deep Meaningful Learning refers to the development of higher-order thinking skills through a variety of active intellectual activities with the goal of creating meaning by the identification of patterns and associations between concepts. Key skills developed include inquiry, problem-solving, and critical, creative, and metacognitive thinking. This well-established theory can meet the demands of high standards for instruction at all educational levels. Empirical Prerequisites Sequential Learning allows a hierarchical learning progression based on the relationships and interconnections between ideas, response, or skills. Before moving on to more difficult and complex topics, it makes sure that students have the necessary foundational knowledge or abilities. The taxonomy's hierarchical levels provide students with a framework to

consciously develop their thinking from simple recall (unistructural) to complex abstraction (extended abstract), leading to more effective and self-directed learning. The Theory Y Learning Climate asserts that students are inherently motivated to learn; educators who embrace this mindset cultivate more engaged learning (Markwell, 2006). When given the motivation, autonomy, and room to make their own decisions, students perform at their highest level. The cognitive learning approach employs specific strategies designed to enhance students' mental processes and metacognitive skills. This form of instruction facilitates learning, thinking, and recall by requiring students' active participation in the process. Among these are the following: employing imagery to help with memorization, summarizing meaning, organizing new language, and repeating and interpreting context. Deliberate manipulation of language is a key component of all these learning processes.

These themes form a cohesive pedagogical framework where structured knowledge progression (Empirical Prerequisites) enables cognitive strategy development, while a supportive learning environment (Theory Y Climate) fosters reflective practice and formative feedback cycles - ultimately facilitating the construction of personal meaning and deep learning (Biggs & Collis, 1982; Caniglia & Meadows, 2018). However, the model's universal applicability is not absolute; cultural factors can present significant constraints. For example, SOLO's individualistic and hierarchical structure may not align with educational systems that prioritize rote memorization or collective knowledge traditions (Biggs, 1996). The framework's effectiveness further depends on institutional capacity to provide sustained formative feedback and metacognitive support (Kahruddin & Hajeniati, 2020). Through strategic adaptations like localized reflection and technology-enhanced scaffolding, this integrated model provides a versatile framework for achieving meaningful, transferable learning in any educational setting.

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