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The SOLO Taxonomy as a Tool for Assessing Key Competences: An Integrated Model

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Abstract: This paper proposes a theoretical–operational model for the qualitative assessment of key competences based on the integration of the SOLO Taxonomy, Piagetian cognitive development theory, and the competence-certification levels adopted in the Italian school system. The study addresses the need for assessment approaches capable of describing not only the correctness of students' responses but also the increasing structural complexity of their cognitive organization. A longitudinal rubric was developed to describe the progression of competence from ages 3 to 19 across early childhood, primary, lower secondary, and upper secondary education. The model combines the five structural levels of the SOLO Taxonomy with the four Italian certification levels—Initial, Basic, Intermediate, and Advanced—while introducing transitional configurations to represent progressive cognitive reorganization. The rubric was then applied exploratorily to the EntreComp indicator "Spotting Opportunities" to examine how increasing levels of cognitive organization can be translated into observable assessment descriptors. The application illustrates a progression from the identification of isolated elements to their integration, generalization, and transfer to new contexts. The model shows potential for supporting coherent vertical assessment of competences, but its practical validity, inter-rater reliability, discriminative capacity, and transferability across disciplinary domains require further empirical investigation.

Keywords: competence assessment; SOLO taxonomy; vertical curriculum; qualitative assessment; assessment rubrics.

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1. Introduction

Key competences have become central in European and national education policy, raising the need for assessment models coherent with the complex nature of competence. The 2018 European Recommendation defines competence as the combination of knowledge, skills and attitudes mobilized across contexts, rather than the simple mastery of content (European Commission, 2018). Accordingly, assessment should consider how students organize and mobilize information to address tasks and problems (Perrenoud, 1997; Weinert, 2001).

A further methodological issue concerns the relationship between competence and observable performance. Competence is not directly visible as an internal disposition; it becomes interpretable through the ways learners select, organize, connect and mobilize information in response to a task. For the reason, the

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proposed rubric does not evaluate competence through correctness alone. It considers the structural organization of the response as evidence of increasing cognitive complexity, while recognizing that performance may vary according to prior knowledge, task demands and disciplinary context. This perspective is particularly relevant to vertical assessment, where the same competence must be interpreted across different stages of schooling without assuming that age automatically determines the level reached.

The SOLO Taxonomy (Structure of the Observed Learning Outcomes), developed by Biggs and Collis (1982), describes learning through five levels of increasing structural complexity: prestructural, unistructural, multistructural, relational and extended abstract. Its focus on the quality of observable responses makes it relevant to competence assessment. The taxonomy is theoretically related to Piagetian accounts of cognitive development, in which learning involves qualitative transformations in cognitive structures through assimilation and accommodation (Piaget, 1967). Collis (1975) further differentiated developmental configurations during the school years.

Building on these premises, this contribution proposes a longitudinal rubric integrating SOLO levels, cognitive development and the four competence-certification levels used in the Italian school system—Initial, Basic, Intermediate and Advanced. The rubric is intended to describe qualitative progression from ages 3 to 19 while maintaining vertical continuity across school levels.

The model is illustrated through the EntreComp indicator "Spotting Opportunities" (Bacigalupo et al., 2016). This indicator was selected because it requires progressively more complex organization of information, from recognizing significant elements to identifying relationships among needs, resources and possible actions. The example is used to examine the operational coherence of the proposed model and to show how SOLO levels can be translated into observable competence descriptors.

2. Materials and Methods

The model was developed within research and instructional-design activities focused on competence assessment in the Italian education system. The aim was to construct a qualitative assessment tool coherent with the vertical curriculum from early childhood through secondary school.

The objectives were to: (1) integrate the SOLO Taxonomy with cognitive development theory; (2) define observable descriptors for the progressive development of key competences; (3) formalize structural criteria to reduce assessment arbitrariness; (4) propose a shared and theoretically grounded model consistent with Italian competence-certification levels; and (5) demonstrate its construction through an EntreComp indicator.

The rubric distributes the SOLO structural progression across ages 3–19 rather than reproducing all levels identically at every school stage. The four Italian competence levels are calibrated to the prevailing cognitive configuration of each educational segment. The resulting correspondence among school levels, competence-certification levels and SOLO structural levels is presented in Table 1.

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The construction of the rubric followed a qualitative alignment procedure. First, the structural progression of the SOLO Taxonomy was identified as the principal dimension for describing increasing complexity. Second, the four Italian certification levels were positioned within this progression according to the prevailing configuration expected at each educational stage. Third, descriptors were formulated in terms of observable characteristics of responses rather than presumed internal states. Finally, the descriptors were checked for vertical continuity and illustrated through a common competence indicator. This procedure was intended to make the interpretive criteria explicit and to reduce the risk that labels such as "basic" or "advanced" would be applied only as global judgments. The resulting model therefore links certification language to structural features that can be identified in students' responses.

The alignment process was designed to preserve the distinction between structural complexity and certification level. SOLO levels describe qualitative changes in the organization of observed responses, whereas the Italian certification categories provide a framework for communicating the degree of competence achieved. The proposed model therefore does not establish a one-to-one correspondence between the two systems. Rather, it identifies configurations in which the structural characteristics described by SOLO can provide a more explicit interpretive basis for the four certification levels. This distinction is particularly relevant in a longitudinal framework, since the same certification label may correspond to different structural configurations at different educational stages.

Table 1. Overview of the structural progression: correspondence among school levels, competence levels and SOLO levels

School level	Initial	Basic	Intermediate	Advanced
Early childhood (3–6)	Prestructural 0A	Prestructural	Prestructural 1A1	Prestructural 1A2
Primary (6–11)	Prestructural	Unistructural	Unistructural 2A	Multistructural
Lower secondary (11–14)	Unistructural	Multistructural	Multistructural 3A	Relational
Upper secondary (14–19)	Multistructural	Relational	Relational 4A	Extended abstract

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Two principles guide the construction: qualitative progression and vertical continuity. Progression refers to increasing organization, integration and transferability of information. Vertical continuity is ensured by using the Basic level of one school stage as the Initial level of the following stage, so that consolidated structures become the basis for subsequent differentiation and integration.

Transitional configurations are used between structural levels. They do not constitute independent levels but describe attempts to operate according to the logic of a higher level when integration is emerging but not yet stable. All descriptors are formulated positively and focus on the structural quality of the response rather than solely on correctness.

A further criterion concerns the interpretation of transitional configurations. These configurations are not intended to create additional SOLO levels or intermediate certification categories. They identify responses in which characteristics of a more complex structural organization are beginning to emerge but are not yet consistently integrated. Their function is therefore descriptive: they allow the rubric to represent qualitative changes that may occur between more clearly identifiable configurations without transforming the progression into a rigid sequence. This is particularly important when assessing competence across school stages, because students may demonstrate emerging forms of relational or abstract reasoning while still relying on less integrated forms of organization in other aspects of the same task.

2.1. Early Childhood Education (3–6 years)

Early childhood levels remain within the prestructural area. Initial and Basic describe emerging engagement and task relevance, while Intermediate and Advanced represent transitional attempts toward more differentiated responses.

The early-childhood configuration requires particular caution because responses are strongly influenced by immediate perception, affect and participation. The model therefore does not interpret the four certification levels as four fully differentiated SOLO stages. Instead, it uses them to describe increasing relevance and intentionality within predominantly prestructural responses. The distinction is useful because even when a child has not yet organized several elements relationally, differences can be observed in whether the child merely reacts, identifies something relevant, attempts a connection or provides an emerging justification.

As summarized in Table 2, the four competence levels are operationalized according to this structural progression. The emphasis is therefore placed on the quality and relevance of the emerging response rather than on the quantity of information mobilized. This allows the rubric to recognize meaningful differences in competence even when learners have not yet developed stable relational structures.

Table 2. Organization of competence levels in early childhood education

Level	Description
Initial	Expresses an initial idea, even if it is not relevant to the task

Basic	Partially or superficially connects the response to one element of the task
Intermediate	Justifies a response using an important element, although the connection is not logically grounded
Advanced	Argues for the response and connects it to the question through an element that is not relevant or that has been selected on a perceptual/emotional basis

2.2. Primary School (6–11 years)

Primary school begins from prestructural functioning and progresses through unistructural to multistructural organization. Pupils increasingly identify relevant elements and eventually manage several elements in an orderly but not yet integrated response.

In primary school, the progression becomes more differentiated. The learner moves from focusing attention on a single relevant element toward identifying and organizing several elements. At the multistructural level, however, the elements may remain juxtaposed rather than integrated into a coherent whole. The rubric therefore distinguishes between the accumulation of relevant information and the establishment of relationships within that information. This distinction is central to the proposed model because it allows assessment to recognize meaningful progress before fully relational reasoning is achieved. The distinction between multistructural and relational organization is particularly relevant at this stage. A learner may identify several correct elements and even organize them in an orderly way without explaining how those elements influence or depend on one another. The rubric therefore treats the establishment of explicit relationships as a qualitative change rather than as a simple increase in the amount of information included in the response.

As summarized in Table 3, the four competence levels are operationalized according to this structural progression.

Table 3. Organization of competence levels in primary school

Level	**Description**
Initial	Partially connects the response to one element of the task.
Basic	Responds on the basis of one correct aspect on which attention is focused.
Intermediate	Explains or clarifies the response on the basis of a single relevant element.

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Advanced	Expands and enriches the response by identifying several relevant aspects.

2.3. Lower Secondary School (11–14 years)

Lower secondary school begins with unistructural functioning and consolidates multistructural processing. The Intermediate level represents the transition toward relational integration, while Advanced corresponds to a coherent relational structure.

Lower secondary education represents a significant transition because learners are increasingly able to coordinate several elements within an explicit structure. The rubric therefore places particular emphasis on the move from multistructural organization toward relational reasoning. At the Intermediate level, relationships may be emerging or only partially justified; at the Advanced level, the response is expected to integrate relevant elements and formulate a coherent explanation. The descriptors consequently focus not simply on the number of elements identified, but on the quality of the connections established among them. This transition is particularly relevant for competence assessment because relational performance requires more than the simultaneous presence of several correct elements. The learner must make the relationship among those elements explicit and use it to construct an explanation. Consequently, the distinction between Intermediate and Advanced is based on the stability and coherence of the relationships established rather than on the number of elements identified.

As summarized in Table 4, the four competence levels are operationalized according to this structural progression.

Table 4. Organization of competence levels in lower secondary school

Level	**Description**
Initial	Responds on the basis of one correct aspect on which attention is focused.
Basic	Responds on the basis of two or more relevant elements without connecting them.
Intermediate	Responds on the basis of two or more relevant elements organized in an orderly way but not related to one another.
Advanced	Integrates several relevant elements through explicit connections and formulates a coherent explanation.

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2.4. Upper Secondary School (14–19 years)

Upper secondary school begins with multistructural functioning and progresses through relational to extended abstract organization. Students increasingly integrate information through principles, formulate deductions and generalize reasoning beyond the immediate context.

In upper secondary education, the model extends the progression toward relational and extended-abstract organization. Students are expected not only to connect information but also to identify principles, formulate deductions, delimit the validity of an explanation and transfer reasoning beyond the immediate task. The Advanced configuration therefore represents a qualitative shift from contextual integration toward generalization and transfer. At this stage, transfer represents a further qualitative dimension of competence. The learner is no longer limited to organizing information within the immediate task but can use an underlying principle to interpret a different situation. Transfer is therefore considered evidence of extended structural organization when the learner is able to justify why the principle remains applicable beyond the original context. This does not imply that every learner at this age will consistently produce extended-abstract responses; rather, the descriptors specify increasingly complex forms of performance that educational tasks can elicit and support.

As summarized in Table 5, the four competence levels are operationalized according to this structural progression.

Table 5. Organization of competence levels in upper secondary school

Level	Description
Initial	Responds on the basis of two or more relevant elements without connecting them.
Basic	Organizes the response by placing data within a coherent structure and connecting them through explanation.
Intermediate	Organizes the response by systematically connecting data on the basis of an explicit criterion and delimiting its validity within the context.
Advanced	Integrates deductions, transfers and generalizations into the response on the basis of data from a conceptual system.

3. Results

The rubric was applied exploratorily to examples of students' work related to identifying opportunities in learning activities. The purpose of this application was not to validate the instrument empirically, but to examine whether its descriptors could represent increasing levels of structural complexity in observable responses.

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The exploratory application highlights a progressive change in the structural organization of competence-related responses across school stages. At the Initial level, responses are mainly characterized by recognition or immediate participation. At the Basic level, learners identify more than one relevant element, although these elements may remain separate. The Intermediate level introduces an increasingly explicit organization of relationships, while the Advanced level is characterized by integration, explanation and, where appropriate, transfer to a different context. The progression is therefore not based on the accumulation of additional content, but on changes in how available information is selected, organized and connected. This distinction is particularly relevant for competence assessment because two responses may contain a similar amount of information while differing substantially in their structural organization.

The application focused on the EntreComp indicator 1.1, "Spotting Opportunities," from Area 1, Ideas and Opportunities (Bacigalupo et al., 2016). The indicator was selected because it involves recognizing significant situations and transforming relevant elements into possible starting points for action or innovation. Its cognitive progression can therefore be represented through increasing organization of information.

As shown in Table 6, the descriptors maintain the same structural logic across the educational pathway while increasing in complexity. In early childhood, competence is expressed through emerging engagement, attention to relevant cues and initial attempts to make a response meaningful. In primary school, pupils progressively identify and organize several relevant elements. In lower secondary school, they begin to establish explicit relationships among elements and construct coherent explanations. In upper secondary school, responses integrate information through principles, deductions, generalizations and transfer to other contexts.

The results also highlight the value of maintaining a common structural language across school stages. Although the concrete descriptors change with age and educational context, the underlying progression remains recognizable: attention to a relevant element, organization of several elements, establishment of relationships, coherent explanation, and eventual generalization or transfer. This continuity makes it possible to interpret ~~competence~~ development of competence without treating each school stage as an isolated assessment system. It also provides a basis for comparing the structure of responses produced in different contexts while retaining sensitivity to developmental and task-related differences. In this sense, the EntreComp example functions as a test of conceptual coherence: the same indicator can be described through increasingly complex forms of cognitive organization.

The exploratory application therefore illustrates how SOLO levels can be translated into observable competence descriptors while preserving continuity among the four competence-certification levels. It provides an operational example of the model rather than empirical evidence of its reliability or effectiveness.

Table 6. SOLO levels for the EntreComp indicator "Spotting Opportunities"

School level	Initial	Basic	Intermediate	Advanced

Early childhood	Sometimes says "I don't know" or tries to participate, following whatever catches their attention	Shows an initial willingness to enter the activity. "I don't know what to do… but I'll try anyway."	Approaches the new activity and tries to participate by connecting with an element they recognize or like. "I'll do it because I like this part."	Participates with interest in the new activity and explains the choice by referring to an aspect considered important, even if the connection is not completely clear. "I like it because we build something… even if it's not exactly like that."
Primary school	Approaches the new activity and tries to participate by connecting with an element they recognize. "I'll do it because I like this part."	Participates in the new activity by connecting with a simple element they recognize. "I'll do it because it reminds me of a game I know."	Participates in the new activity and justifies the choice with a relevant element of the task. "I like it because I can build something and understand how it works."	Participates with interest in the new activity, recognizing several elements that engage them, even though these are not yet integrated. "I like it because I can build, use different materials and work with others."
Lower secondary	Participates in the new activity by connecting with an element they recognize. "I'll do it because it reminds me of a game I know."	Participates in the new activity by identifying several elements that interest them, although they are considered separately. "I like it because I can use the computer and also work with my classmates."	Participates by recognizing several relevant aspects and beginning to identify possible connections among them. "I like it because we work in groups and use the computer, so we can help each other and do the work better."	Participates consciously by connecting different aspects of the activity and explaining how they contribute to engagement and the outcome. "I'm engaged because it combines group work and digital tools: this lets us compare ideas, improve them and produce more effective work."

Upper secondary	Participates in the new activity by identifying several elements that interest them, even if considered separately. "I like it because I can use the computer and also work with my classmates."	Participates in the new activity by identifying several elements that interest them, even if considered separately. "I like it because I can use the computer and also work with my classmates."	Participates consciously by relating aspects of the activity to personal goals or learning strategies, beginning to reflect on effectiveness. "I'm engaged because working in groups with digital tools helps me understand better and organize my ideas, even though I still need to improve my time management."	Participates by integrating different aspects of the activity into a broader view, connecting them to general principles such as collaboration, learning effectiveness and innovation, and recognizing transferability to other contexts. "Working in groups with digital tools improves learning because it enables comparison and shared construction of knowledge; this approach can also be effective in other contexts, such as work or interdisciplinary projects."

4. Discussion and conclusions

The proposed model offers a theoretically coherent way to connect cognitive structure, competence assessment and vertical curriculum. Its main contribution is the operational translation of SOLO structural progression into descriptors that can be read across school stages while retaining the competence-certification framework used in the Italian system.

An important implication is that the model can support assessment transparency without claiming to eliminate professional judgment. When teachers identify whether a learner selects relevant information, organizes several elements, establishes relationships, explains a criterion or transfers a principle, the basis of the assessment becomes more explicit and potentially more shareable. The rubric may therefore serve not only as an assessment framework but also as a design reference for learning activities. Tasks can be constructed to create opportunities for movement from recognition toward organization, connection, explanation and transfer. In this perspective, assessment and instructional design are connected: the structural level expected from a task should be compatible with the type of cognitive organization that the learning activity is intended to develop.

This perspective also has implications for formative assessment. If descriptors are expressed through observable characteristics of performance, they can be used not only to assign a level but also to provide learners with information about the next qualitative step in their development. A learner whose response remains at a

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multistructural configuration, for example, may be supported in moving toward relational organization by being asked to explain how the identified elements influence one another. Similarly, a learner who already establishes coherent relationships may be challenged to examine whether the same principle can be applied beyond the original context. The rubric can therefore function as a bridge between assessment and feedback, making the progression visible and potentially supporting more intentional instructional planning.

The correspondence with the Italian certification levels should be interpreted as a calibration rather than an equivalence. The categories Initial, Basic, Intermediate and Advanced belong to the certification framework, whereas prestructural, unistructural, multistructural, relational and extended abstract describe structural characteristics of observed learning outcomes. Bringing the two frameworks into dialogue can support vertical continuity, but it does not make them conceptually identical. It provides a practical bridge between certification language and a taxonomy that makes qualitative differences in responses explicit.

The same caution applies to Piagetian theory. The model draws on the idea that cognitive development involves qualitative transformations, but it does not assign a fixed SOLO level to an age or developmental stage. A learner may produce responses at different structural levels depending on prior knowledge, task demands, scaffolding and disciplinary conventions. The progression should therefore be read as a framework for interpreting evidence and designing assessment opportunities, not as a deterministic sequence.

From a methodological perspective, the exploratory application suggests that the model can provide a consistent structure for describing qualitative differences in competence-related performance. However, consistency at the conceptual level cannot be considered evidence of measurement validity. The present study does not test whether different assessors would assign the same level to the same response, nor does it establish whether adjacent levels can be reliably distinguished in authentic assessment situations. These questions require empirical investigation and should be addressed before the rubric is used as a standardized assessment instrument. The model should nevertheless be considered a theoretical and methodological proposal rather than a validated assessment instrument. Its descriptors require empirical testing in authentic educational settings. Future studies should examine practical applicability, inter-rater reliability and the discriminative capacity of adjacent levels, particularly where transitional configurations may overlap.

The relationship between the SOLO Taxonomy and cognitive development theory should be interpreted as a structural analogy, not as a direct or deterministic correspondence. The rubric levels describe prevailing configurations of students' responses and are not intended to represent fixed developmental stages. This distinction is important because individual variability and disciplinary differences may affect the structure of an observed response.

Transferability across disciplinary domains also requires investigation. Different competences and tasks may mobilize different cognitive processes and forms of knowledge representation; consequently, SOLO-based descriptors may require domain-specific calibration. The application to EntreComp should therefore be

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understood as a methodological example of how the instrument can be constructed, not as evidence of universal applicability.

An additional issue concerns teacher interpretation. Because the rubric describes structural qualities rather than fixed categories of learners, its effective use depends on the ability to distinguish between the characteristics of a response and assumptions about the learner. Professional development should therefore focus not only on learning the terminology of SOLO, but also on analysing evidence, comparing examples and discussing borderline or transitional cases. Shared calibration activities may be particularly useful for increasing interpretive consistency among teachers while preserving the professional judgment required by competence assessment.

Finally, implementation in school practice would require teacher familiarity with the interpretive logic of the SOLO Taxonomy and, potentially, shared assessment protocols and professional development. Further studies applying the rubric to other competence domains, school contexts and task types are needed to establish its scope and conditions of use.

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