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Incidental Teaching and Abstract Concept Formation in Deaf Children: An Analytical Review

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Abstract
This theoretical review examines the role of Incidental Teaching as a pedagogical approach in fostering the comprehension of abstract concepts among deaf children, with a focus on time, space, and causality. Building on Piaget's constructivism, Bruner's representational stages, and Vygotsky's socio-cultural theory, the paper highlights how language and social interaction are crucial in abstract thinking. However, the absence of auditory input places deaf children at a dual disadvantage—linguistic and cognitive. Through an analysis of recent literature (2010–2022) alongside classical works, this study argues that Incidental Teaching—by embedding learning in daily routines and natural contexts—offers a powerful alternative to traditional approaches. Evidence shows that when visual, experiential, and sign-based strategies are integrated into natural routines, children achieve deeper understanding and greater generalization of abstract concepts. The paper concludes with recommendations for integrating Incidental Teaching into formal curricula and future applied research.

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1. Introduction:

Abstract concepts are fundamental cognitive pillars upon which higher mental processes in humans are built, such as reasoning, problem solving, and symbolic thinking. These concepts enable children to perceive time, identify spatial relationships, and understand causal links between phenomena. However, these concepts are not acquired automatically. Rather, they require a rich educational environment and effective teaching methods that take into account individual differences, especially among groups with developmental disabilities, foremost among which is hearing impairment (*Shabab, 2008).*

Deaf children face specific challenges in constructing abstract concepts, given that these require internal linguistic processes that are often impaired or delayed due to the absence of normal auditory input *(Mohammed and Boualam, 2012)*. Language, especially oral language ( ), is the main medium for concept formation, and with the weakness of this medium, there is an urgent need to adopt pedagogical alternatives that take into account the cognitive and communicative characteristics of deaf children.

In this context, incidental education emerges as a flexible educational strategy based on investing in everyday situations and spontaneous activities within the child's environment and transforming them into meaningful learning opportunities, relying on visual and sensory media. This approach derives its effectiveness from the fact that it transfers learning from abstract models to real-life contexts, thereby enhancing the child's ability to construct and generalize understanding.

Based on the above, this study seeks to provide an analytical theoretical review to demonstrate the extent to which incidental education contributes to supporting the understanding of abstract concepts among deaf children, focusing on three key conceptual categories: time, place, and causality.

2. Problem Statement:

The acquisition of abstract concepts is one of the most sophisticated aspects of a child's cognitive development, as this process requires higher mental abilities such as abstraction, discrimination, symbolic representation, and causal thinking. These abilities do not develop in a vacuum, but are closely linked to language development, particularly spoken language, which is the primary tool for constructing meaning and organizing experience (*Algerian Ministry of National Education, 1990; Paul, 2009)*. However, deaf children, deprived of auditory input, face a double obstacle: linguistic and cognitive, as they lack the primary channel through which intangible concepts such as the idea of time, spatial relationships, or cause and effect are constructed (*Marschark & Knoors, 2020).*

Vygotsky's sociocultural theory (1978) confirmed that the development of abstract thought is dependent on rich social linguistic interaction, as higher mental functions, according to his conception, first arise at the external interactive level and then transfer to the internal subjective level. This explains why deaf children lag behind in forming complex concepts, due to the absence of natural verbal interaction in their early environment. *Hallahan & Kauffman* (2006) also pointed out that a deaf child's lack of oral language not only hinders communication but also limits the construction of the cognitive structures necessary for understanding symbolic and abstract concepts.

In the same context, a field study by *Marschark & Hauser* (2012) showed that deaf children suffer from a noticeable delay in understanding temporal, spatial, and causal concepts, which the researchers attributed to a lack of structured language mediation in early childhood. *Bruner* (1966) also emphasized that abstract concepts can only be understood if they are placed in vivid, tangible contexts, relying on action and observation before moving on to symbolic representation. This makes traditional education based on abstract explanation unsuitable for deaf children, who rely more heavily on visual and sensory channels (*Lieberman, Borovsky, & Mayberry, 2022).*

From this perspective, incidental education has emerged as an alternative pedagogical approach, based on investing in everyday moments and spontaneous situations to present concepts in meaningful contexts and in concrete ways, taking into account the child's interests and relying on visual and sensory media. Studies such as *Koegel, O'Dell & Koegel* (1987) and *Friedmann & Szterman* (2006) have demonstrated the effectiveness of this type of education in concept acquisition and functional language development in deaf children. *Paul* (2009) also showed that the use of visual media and embodied activities—which are at the heart of incidental education—effectively contributes to concept formation in this group.

In the Algerian context, Ministerial Decision No. 6/15 (2016) stipulated the importance of integrating incidental education into official programs for Deaf Childrens. However, educational practice in the field still suffers from limited implementation of this approach, as most institutions rely on rigid traditional curricula that lack flexibility and do not take into account the cognitive and linguistic characteristics of deaf children.

Based on the above review of the theoretical and practical difficulties faced by deaf children in understanding abstract concepts, there is a clear need to adopt incidental education as an effective pedagogical approach to facilitate the acquisition of these concepts (time, place, causal relationships). This raises the central question of this study, which seeks to answer the following questions:

- What are the pedagogical principles on which incidental education is based?
- What are the cognitive and linguistic difficulties faced by deaf children in understanding abstract concepts (time, space, causality)?
- To what extent can Incidental Teaching, according to previous literature and studies, contribute to overcoming these difficulties?

3. Study objectives:

This study aims to provide a theoretical and analytical review of special education literature and contemporary cognitive theories in order to explore the extent to which incidental education contributes to supporting the understanding of abstract concepts in deaf children. This general objective is translated into a set of detailed objectives as follows:

- Analyze the nature of abstract concepts and their role in children's cognitive development.
- Diagnose the linguistic and cognitive challenges that hinder deaf children from acquiring these concepts.
- Review the theoretical and pedagogical foundations of Incidental Teaching.
- Discuss the ways in which Incidental Teaching contributes to bringing abstract concepts closer to deaf children.
- Highlighting the educational value of Incidental Teaching compared to traditional education in the context of teaching Deaf Childrens.
- Proposing future research avenues to expand the effectiveness of this pedagogical approach in Arab environments.

4. Importance of the study

1.4 Scientific importance:

This study provides a qualitative addition to the educational literature on the education of deaf children by linking abstract concepts with a flexible pedagogical approach. It is one of the rare theoretical studies that seeks to establish an integrated conceptual framework that combines constructivist and sociocultural theory and applies it to a group of learners with specific cognitive and linguistic characteristics.

2.4 Theoretical significance:

The study enhances the theoretical understanding of Incidental Teaching, not only as a teaching technique, but as an educational philosophy that transcends the boundaries of rote learning and reorganizes the relationship between learning, environment, and experience, especially for learners with special needs.

3.4 Applied educational significance:

The study provides educators and educational planners with an alternative vision that is more adapted to the reality of deaf children, by drawing attention to the need to integrate everyday situations and sensory and visual media into the design of classroom practices. It also provides a basis for the development of training programs that enable teachers to effectively employ incidental education.

4.4 Contextual relevance (Algeria/Arab world):

The study is consistent with recent trends in Algerian education policy, which stipulates the integration of incidental education into the education of persons with disabilities, but at the same time highlights the gap between theory and practice and proposes mechanisms to bridge it.

5. Study terminology

1.5 Incidental Teaching

Incidental teaching is a pedagogical approach that capitalizes on spontaneous and pre-planned everyday situations to transform them into meaningful learning opportunities, so that children learn through interaction with their natural environment rather than being limited to organized classroom activities. Incidental teaching is considered an effective teaching strategy for children with special needs, especially the deaf, because it integrates learning with direct sensory and visual experience (*McWilliam, 2010; Koegel et al., 1987).*

2.5 Abstract Concepts

These are higher mental constructs that do not rely on direct sensory perception but rather on symbols and language, such as the concepts of time, place, and causality. These concepts form the basis of reasoning and problem solving, and are acquired gradually through stages of mental development (Piaget) and through linguistic and social interaction (Vygotsky) (*Piaget, 1972; Vygotsky, 1978).*

35. Deaf Children

A child who suffers from total or partial hearing loss to a degree that affects their ability to acquire spoken language and communicate verbally in a natural way. Such children need alternative forms of language, such as sign language or visual media, in order to interact socially and learn academically *(Marschark & Hauser, 2012).*

4.5 Time Concept

This is the child's ability to perceive the chronological sequence of events and understand the relationships between the past, present, and future. It is one of the most difficult abstract concepts for deaf children due to the absence of natural auditory reference, and it is built gradually through daily routines and pictorial schedules (*Friedmann & Szterman, 2006; Allen et al., 2021).*

5.5 Spatial Relations

This refers to a child's ability to perceive the locations, directions, and distances between objects in their surrounding environment. Deaf children rely heavily on visual cues to build this concept, making incidental education and visual media effective tools for supporting their understanding *(Emmorey, 2002).*

65. Causality

An abstract concept that refers to the perception of the relationship between cause and effect, i.e., understanding that a particular event or action leads to a specific result or effect. This concept forms the basis of logical thinking, and deaf children have difficulty understanding it due to their limited oral language input, so it is built through direct sensory experiences and practical representation (*Bruner, 1966; Paul, 2009).*

6. Study methodology

This study is based on a **theoretical and analytical review** of educational and psychological literature related to the acquisition of abstract concepts by deaf children and the role of Incidental Teaching in facilitating this acquisition.

References were selected based on the following criteria:

1. **Relevance**: Limited to literature dealing with the subject of abstract concepts, incidental education, or the education of deaf children.

2. **Recency**: Priority was given to literature and studies published between **2010 and** 2022, with the inclusion of some classic references (e.g., Piaget, Vygotsky, Bruner, Skinner) and important foundational sources (Koegel et al., 1987; Hallahan & Kauffman, 2006) to set the theoretical framework and strengthen the conceptual basis of the study.

3. **Diversity**: Integration of Arabic and foreign sources to ensure comprehensive coverage of the local and international contexts.

The literature review included literature extracted from peer-reviewed scientific databases such as *Scopus, Web of Science, and ERIC*, in addition to some educational studies specializing in the education of Deaf Childrens. The focus was on studies that addressed three central conceptual themes: **time, place, and causality**.

The study relied on **a critical comparative approach**, in which the following was done:

- Presenting the basic concepts as they appear in the literature.
- Analyzing the points of agreement and disagreement between theoretical approaches.
- Identifying strengths and weaknesses in educational applications.
- Highlighting the research gap that still exists in Arab and international research.

Thus, this study represents an effort to **compile and analyze the literature** to establish a coherent theoretical foundation that can contribute to guiding subsequent field research and testing the effectiveness of opportunity education in real classroom environments.

7. Theoretical framework:

1.7 Abstract Concepts: Cognitive Structure and Acquisition Difficulties in Deaf Children

Abstract concepts are considered to be among the highest levels of mental cognition, as they do not rely on direct sensory perceptions but are constructed through symbols, language, and classificatory thinking *(Piaget, 1972; Vygotsky, 1978)*. These concepts are characterized by generality and abstraction, as they can be generalized to multiple contexts and are essential for the development of children's abilities to plan, solve problems, and reason causally. However, children, especially those with hearing impairments, face significant difficulties in understanding these concepts due to their reliance on abstract symbolic language and their limited ability to connect the concept with its real-world manifestations (*Marschark & Spencer, 2010; Lieberman et al., 2022).*

Piaget explains that abstract concepts are not acquired all at once, but rather go through specific stages of cognitive development:

- **Sensory-motor stage (0–2 years):** The child's perception is limited to the tangible world, without symbols or abstract concepts.
- **Preoperational stage (2–7 years):** Children begin to use symbols, but their thinking remains limited to concrete images, and they have difficulty understanding time and causality.
- **Concrete operational stage (7–11 years):** Children acquire the ability to organize concrete concepts, such as temporal and spatial sequences.
- **Formal operational stage (11–15 years):** The ability to think abstractly, construct hypotheses, and reason symbolically emerges *(Piaget, 1972)*.

In contrast, *Vygotsky* offers another classification of concepts:

- **Everyday concepts**, which develop spontaneously through interaction with the environment;

- **and scientific concepts**, which are acquired through formal education in a school setting. He emphasizes that language is the central mediator in the transition from the sensory to the abstract level, and that social interaction ( ) within the "zone of proximal development" helps children acquire concepts that exceed their current level of development *(Vygotsky, 1978; Mayer & Trezek, 2021).*

For deaf children, the path to acquiring abstract concepts is fundamentally different. Due to the absence of auditory input, these children rely on visual and motor channels, which requires the redesign of learning environments to compensate for hearing loss. Research indicates that the difficulties deaf children have with abstraction are not due to low intelligence, but rather to the absence of appropriate linguistic mediation, especially in the early years of life (*Lieberman et al., 2022; Marschark & Knoors, 2020).*

Therefore, sign language and visual media become essential tools for supporting concept building in this group. Sensory-experiential strategies gain importance as a preliminary bridge to abstraction, as motor activities, pictorial presentations, and visual stories help transform symbolic concepts into experiences that can be perceived and understood. In order to be constructed properly, a concept must be "touched and experienced" before it can be abstracted, especially in the case of deaf children (*Emmorey, 2002; Lieberman et al., 2022).*

2.7 Incidental education: theoretical foundations and its role in constructing abstract concepts

1.2.7 Definition and Theoretical Foundations of Incidental Teaching

Incidental teaching emerged as a contemporary pedagogical model that aims to integrate learning into everyday contexts by investing every spontaneous life situation as an opportunity to build knowledge and skills *(McWilliam, 2010).* It is defined as an educational approach that turns every situation in a child's life into a learning moment by linking personal experiences to targeted concepts and skills in an environment that is not separated from the real context.

This approach is based on three complementary theoretical pillars:

- **The behavioral approach (Skinner, 1953):** where learning is based on reinforcement and repetition within natural situations.
- **The constructivist approach (Piaget, 1972):** where concepts are built gradually through interaction with the environment and solving sensory problems.
- **The sociocultural approach (Vygotsky, 1978):** where linguistic and social interaction is the primary driver of abstract thinking development, especially within the "zone of proximal development."

2.2.7 Characteristics of Incidental Teaching compared to traditional education

Dimension	Incidental Teaching	Traditional education
Learning centrality	The child	Educator
Environment	Natural living environment	Closed classroom
Interaction	Interactive and active	Limited
Content	Derived from the moment and context	Pre-structured
Language	Multimodal (visual, kinesthetic, symbolic)	Directly verbal

Evolution of concepts	Gradual, circular From the concrete to the abstract	Transitional, linear
Responsive to individual differences	High	Weak

Recent studies show that Incidental Teaching supports the development of children's comprehensive competencies: cognitive, linguistic, social, and emotional, in a more integrated and effective way than traditional models *(Hume et al., 2014; McWilliam, 2020)*.

32..7 Opportunity education and the understanding of abstract concepts in deaf children

Incidental education is one of the most effective educational approaches for deaf children, as it provides a visual, interactive, and experiential learning environment. This approach helps kids gradually build concepts, starting with the tangible and ending with the abstract, by connecting concepts to everyday life, rather than relying on abstract verbal explanations (*Friedmann & Szterman, 2006; Paul, 2009).*

Incidental Teaching is consistent with:

- The gradual construction of concepts (Piaget)
- Social and linguistic mediation (Vygotsky)
- It provides a tangible visual input that is suitable for deaf children who rely on non-auditory channels.

42..7 Conceptual applications of incidental education:

1.4.2.7 Acquiring the concept of time

Time is one of the most difficult abstract concepts to grasp, given the absence of a direct sensory reference for it. Incidental Teaching emerges as an effective educational medium through:

- **Daily routine:** Using the order of activities (waking up, breakfast, school, etc.) to reinforce the concepts of "before" and "after."
- **Visual cues:** Pictorial schedules and educational clocks illustrate the sequence of time.
- **Linking to recurring events:** e.g., Friday = prayer, summer = hot, linking the concept to a sensory experience.

Lieberman et al. (2022) demonstrated that deaf children develop more accurate representations of time when presented with visual temporal content within a life context.

24..2.7 Building spatial understanding

Spatial perception is relatively easier for deaf children due to the development of visual processing. Incidental education contributes to the development of this concept through:

- **Organization activities:** arranging objects, identifying locations (right/left, above/below).
- **Classroom environment:** Using movement within the classroom to teach directions.
- **Visual media:** Pictorial maps and models facilitate mental representation of spatial relationships.

Emmorey (2002) showed that sign language enhances visual-spatial representation in deaf people more than verbal education.

34..2.7 Understanding causal relationships

Causal understanding requires the ability to connect cause and effect, which deaf children struggle with due to limited linguistic interaction. Incidental education provides opportunities for:

- **Direct sensory experiences:** e.g., pressing the button→ turns on the light.
- **Dramatic simulation:** to represent the sequence of events in a tangible way.
- **Directed questions:** "Why did the cup break?" "What made you late?"
- **Relate to personal experience:** e.g., feeling cold without a coat.

3.7. How does incidental education facilitate understanding of spatial relationships?

Spatial awareness is one of the abstract concepts in which deaf children can make relative progress, given their heavy reliance on visual processing, which is one of their strongest cognitive strengths *(Emmorey, 2002; Marschark & Hauser, 2012)*. Opportunity education utilizes this visual advantage by integrating children into daily spatial activities that are kinetic and representational in nature, helping them move from spontaneous cognitive understanding of space to organized conceptual representation.

Among the strategies used are:

- **Routine activities at home or in the classroom:** for example, when arranging toys or tableware, concepts such as "above/below," "right/left," and "inside/outside" can be taught through practical repetition and visual explanations.
- **Using the classroom environment for spatial orientation:** For example, when moving between activities or locations, visual and verbal cues can be used to reinforce directions: "Go to the right," "Sit behind the table," which reinforces the mental representation of spatial relationships.
- **Use of models and pictorial maps:** These media are effective teaching tools for representing abstract spatial relationships, especially when linked to the child's experiences within the school or neighborhood.

Studies such as *Allen, Hwang & Stiles (2021)* have shown that visual-spatial training linked to real-world content enhances abstract understanding of place in deaf children to a greater extent than traditional verbal instruction.

It can be said that incidental education transforms "place" from raw visual perception into **a cognitive structure** that can be used to understand maps, estimate distances, and organize roles, paving the way for expanding the child's conceptual abilities in later stages.

4.7 How does incidental education help build causal understanding in a sensory and representational way?

Causal understanding is one of the most complex abstract concepts, given that it requires mental reasoning and linking two variables on a temporal and sequential level: cause→ effect. Studies show that deaf children suffer from a clear deficiency in causal thinking as a result of the weakness of the oral language channel, which is a key mediator in interpreting phenomena and sequences of events (*Paul, 2009; Marschark & Knoors, 2020).*

Incidental Teaching helps overcome this difficulty by presenting causal ideas **through** direct **sensory experiences** and embodying them in visual and representational language that matches the child's cognitive characteristics. This includes:

- **Direct experimentation:** such as observing that pressing a button turns on a light, or that pouring water on the floor causes wetness. These simple activities reinforce the cause-and-effect relationship through repetition and observation.

- **Visual and dramatic representation:** Role-playing or visual simulations (such as silent educational videos or illustrated scenes) are used to represent the relationship between an event and its consequences, compensating for the lack of verbal causal description.

- **Guiding questions:** Questions such as "Why did the cup break?" or "What caused the door to open?" allow the child to reflect on the sequence of events and build simple causal links at first.

- **Linking to personal experience:** Example: The child feels cold because he went outside without a coat. This type of connection is one of the most powerful tools for establishing causality, as it stems from **a personal experience with direct significance**.

Research by *Lieberman et al. (2022)* indicates that deaf children who are exposed to visible and embodied causal experiences demonstrate a greater ability to transfer these concepts to new learning situations.

5.7 The educational value of incidental education in abstract concepts:

The educational value of incidental education is not limited to simplifying abstract concepts for deaf children, but goes beyond that to make these concepts closer to their daily experiences and more firmly rooted in their cognitive structure. It is an educational approach **that integrates the tangible and the symbolic**, transforming individual experience into shared social experience, allowing deaf children to transcend the limitations of the auditory channel and rely on **visual and motor channels** to construct more solid mental representations of complex concepts (*Lieberman et al., 2022; Marschark & Knoors, 2020).*

Incidental Teaching also provides a flexible learning environment that enables educators to **tailor the teaching process** to each child's characteristics, moving away from rigid traditional models. This represents a qualitative shift towards more **inclusive** and equitable education, where every life situation—such as play, shopping, or family interaction—becomes **a rich learning opportunity** that contributes to the consolidation of concepts through practical application and direct sensory interaction (*McWilliam, 2020).*

Recent educational studies confirm that this type of learning not only enhances cognitive **abilities** but also contributes to **the linguistic, social, and emotional development** of deaf children by making abstract concepts part of an integrated network of meaningful life experiences *(Allen et al., 2021; Mayer & Trezek, 2021).*

Thus, incidental education can be considered an integrated pedagogical framework that promotes **alignment between theory** and practice and provides deaf children with a gradual path from direct sensory perception to symbolic and abstract thinking, in line with their cognitive and linguistic particularities.

6.7 Previous experiences and studies confirm the effectiveness of incidental teaching:

Incidental teaching has received increasing attention in the fields of special education and educational psychology, especially in the education of children with special needs, such as deaf children or children with autism spectrum disorder. The literature indicates that this strategy is an effective pedagogical approach to facilitating language acquisition and abstract concepts, as it integrates learning into natural situations and creates a meaningful learning environment (*McWilliam, 2010; Hume et al., 2014).*

1.6.7 Studies by Koegel and colleagues

Robert Koegel and his colleagues were among the first researchers to establish incidental teaching within the framework of naturalistic behavioral interventions. In an applied study of children with autism spectrum disorder, the results showed that the use of incidental teaching led to **an increase in communicative initiatives** and enhanced the ability to **use language in everyday situations** (*Koegel, O'Dell, & Koegel, 1987).* Subsequent studies have shown that this strategy not only supports language development but also contributes to the development of higher cognitive skills such as classification and discrimination, which are the basis for building abstract concepts (*Koegel et al., 1999).*

26..7 Contributions McWilliam :

McWilliam (2010, 2020) emphasizes that the effectiveness of incidental education lies in its ability to integrate learning into children's daily routines, whether at home or in kindergarten. His research indicates that this method supports **generalization**, whereby children are able to transfer what they have learned to new situations, which forms the basis for understanding abstract concepts such as time and causality. He also explained that the role of the educator is central in monitoring the "teachable moment" and investing in it to enhance learning, rather than limiting themselves to structured lessons alone.

36..7 Paul's studies on the language of deaf children:

Paul (2009) pointed out that incidental education is an effective tool for promoting the language of deaf children, as it compensates for the lack of natural language experiences through **guided visual dialogue activities**. He showed that children who benefited from Incidental Teaching practices showed **significant progress in understanding temporal and causal concepts** compared to their peers who received traditional rote-based education.

46..7 Contributions by Marschark and colleagues:

Marschark & Hauser (2012) argue that deaf children suffer from a knowledge gap in abstract concepts due to auditory deprivation, but Incidental teaching is an effective pedagogical approach to reduce this gap, as it allows educators to use real-life situations (such as rain falling or a light bulb turning on) to explain causal relationships, facilitating the transition from sensory experience to abstract concept. Subsequent research by *Marschark & Knoors (2020)* has also shown that incorporating **sign language** into incidental teaching strategies increases their effectiveness, as it provides the child with a symbolic means of expressing abstract meanings.

56..7 General conclusions from previous studies

By reviewing these studies, the following conclusions can be drawn:

1. Incidental Teaching is not just a teaching technique, but **a comprehensive approach** that roots learning in the child's natural context.

2. Its effectiveness is evident in the areas **of language and communication** (Koegel, Paul), but it also extends to **higher cognitive concepts** such as time, place, and causality.

3. Its success depends on the educator's ability to **identify educational moments** and use them effectively.

4. It represents a means of compensating for the developmental gap in deaf children by relying on **sensory experience** and **visual interaction** as supports for abstraction.

Therefore, it can be said that incidental education is one of the most adaptable educational approaches to the specificities of deaf children, as it addresses both language and knowledge dimensions simultaneously and links direct sensory experience with abstract mental representation.

8. General conclusion:

The theoretical review confirms that the deaf child's understanding of abstract concepts, especially those of time, space, and causality, is based on **organized linguistic and social mediation** and requires educational bridges that transfer experience from the tangible to the symbolic. In this context, Incidental Teaching emerges as a pedagogical approach capable of transforming everyday situations into meaningful learning units, in line with *Piaget's* constructivist conception, *Bruner's* logic of graduated representations, and *Vygotsky's* principle of social mediation and zone of proximal development. This theoretical convergence, supported by applied literature, reinforces the validity of considering incidental education as a fundamental educational option rather than a secondary alternative in the education of deaf children.

Evidence shows that **embedding learning in daily routines**, using visual media, practical representation, and sign language promotes the formation of conceptual structures and facilitates generalization across situations. In the concept of time, daily routines and pictorial schedules allow for the consolidation of the concepts of sequence and

duration. In space, the visual strength of deaf children is transformed into clearer representations when taught within familiar spaces. Causality is built through sensory experiences and guided representations that reinforce the relationship between cause and effect. In this way, Incidental Teaching not only compensates for the auditory channel, but also reshapes the cognitive path in line with the specificities of this group.

These findings have **clear practical implications**, as the generalization of Incidental Teaching requires its integration into official curricula and individual education plans, the creation of visually rich learning environments, the training of educators to identify and capitalize on "teachable moments," and the involvement of families to ensure continuity of practice at home and at school. In the Algerian context, the existing regulatory framework provides an opportunity, but the transition from text to application requires clear procedural tools and assessment indicators based on pictorial performance tasks and valid sign language tests to measure conceptual development.

Despite the strength of the theoretical arguments, the study remains fundamental in nature and does not test hypotheses in the field. Hence, there is a need for **quasi-experimental and longitudinal research** comparing the effectiveness of Incidental Teaching and traditional education in constructing concepts of time, space, and causality, while analyzing the impact of control variables such as age, degree of hearing loss, primary language pattern, time of intervention, and family involvement. It also seems urgent to develop supporting **digital visual materials** and prepare rigorous **Arabic-sign language assessment standards** that ensure measurement validity in classroom settings.

In conclusion, it can be said that Incidental Teaching provides an integrated framework that combines theoretical requirements with practical needs, and reframes the teaching of abstract concepts to deaf children in a functional and generalizable manner, based on motivation and meaning. Adopting this framework is not a methodological luxury, but rather an educational necessity to achieve greater **cognitive justice** and provide meaningful learning opportunities that lead to greater independence and more effective integration into school and society.

Based on the above, we conclude with the following recommendations:

1. **Conduct quasi-experimental and longitudinal studies** to compare the effectiveness of Incidental Teaching with traditional teaching in constructing concepts of time, space, and causality.

2. **Analyze control variables** (age, degree of hearing loss, sign language as first or second language, time of early intervention) to understand their impact on the understanding of abstract concepts.

3. **Develop interactive digital programs** (apps, visual educational games, sign language communication platforms) to integrate technology into Incidental Teaching.

4. **Developing** rigorous **Arabic-sign language assessment standards** that ensure measurement validity in both classroom and home environments.

5. **Conduct cultural comparisons** between Arab and Western contexts in the application of Incidental Teaching to reveal differences related to culture and institutional structure.

6. **Integrating Incidental Teaching with other strategies** (collaborative learning, multisensory teaching) to test its potential in an integrative framework.

Findings

1. Incidental Learning Contexts and Conceptual Growth

Deaf children exposed to structured incidental teaching in natural routines (e.g., meal preparation, classroom transitions, social play) demonstrated stronger abilities to generalize abstract concepts such as “before–after,” “cause–effect,” and “near–far” than peers exposed only to traditional instruction.

2. Integration of Multimodal Communication

The use of sign language, visual symbols, and experiential cues proved highly effective in compensating for auditory limitations. Evidence from multiple studies suggests that when teachers model abstract concepts through embodied and visual strategies, comprehension levels significantly improve.

3. Role of Social Interaction

Findings support Vygotsky's claim that learning is mediated by interaction. Peer-to-peer incidental learning contexts (e.g., collaborative games) enhanced children's acquisition of abstract categories more than teacher-only interventions.

4. Bridging Cognitive Delays

Incidental Teaching was shown to mitigate developmental delays by aligning abstract concept acquisition in deaf children with developmental milestones of hearing peers. This was particularly observed in the domains of temporal sequencing (yesterday, today, tomorrow) and causal reasoning.

5. Policy and Curriculum Implications

A consistent theme was the underutilization of Incidental Teaching in formal deaf education curricula. Findings suggest that integration of incidental strategies could transform educational outcomes, reduce dependency on rote memorization, and foster more meaningful cognitive engagement.

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Ethical Considerations

As this paper is a theoretical and literature-based review, it did not involve direct experimentation with human participants or animals. Nevertheless, all referenced studies were selected from reputable journals and databases, ensuring adherence to established ethical research standards. The authors emphasize the importance of informed consent, respect for deaf children's dignity, and the ethical integration of culturally appropriate teaching strategies in applied future research.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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