IntechOpen

Teacher Training and Practice

Edited by Filippo Gomez Paloma

Teacher Training and Practice

Edited by Filippo Gomez Paloma

Published in London, United Kingdom

Teacher Training and Practice
http://dx.doi.org/10.5772/intechopen.109058
Edited by Filippo Gomez Paloma

Contributors
Farida Huseynova, Kenneth Adu-Gyamfi, Isaiah Atewini Asaki, Benjamin Anim-Eduful, Francesca Granone, Elin Kirsti Lie Reikerås, Enrico Pollarolo, Monika Kamola, Chiara Gentilozzi, Filippo Gomez Paloma, Antonio Cuccaro

First published in London, United Kingdom, 2023 by IntechOpen
IntechOpen is the global imprint of INTECHOPEN LIMITED, registered in England and Wales, registration number: 11086078, 5 Princes Gate Court, London, SW7 2QJ, United Kingdom

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Additional hard and PDF copies can be obtained from orders@intechopen.com

Teacher Training and Practice
Edited by Filippo Gomez Paloma
p. cm.
Print ISBN 978-1-80356-908-6
Online ISBN 978-1-80356-909-3
eBook (PDF) ISBN 978-1-80356-910-9

Meet the editor

Filippo Gomez Paloma is a Full Professor of Didactics and Special Pedagogy in the Department of Education, University of Macerata, Italy. He holds a master's degree in psychology, two degrees (Italian and French) in Motor and Sports Sciences, three specializations in special education, a master's on International Qualification of "High Education Level," and a Ph.D. in Pedagogy. He is a member of many international scientific societies and a member of the board of directors of the Società Italiana di Ricerca Didattica (SIRD), whose research is on training and education in schools. He was previously the director of the Special Education School European University of Rome, Italy, and a senior expert pedagogical consultant for the National Institute for the Evaluation of the Education and Training System (INVALSI), Italy.

Contents

Preface

In recent years, research on teacher training and teaching practices has been increasingly enriched by scientific contributions from disciplines other than pedagogy. If we think about the didactic conduct that teachers must put into practice, we realize that interdisciplinary studies in areas ranging from psychology to philosophy, from neuroscience to anthropology, and from sociology to linguistics are necessary to understand and refine teachers' efficiency and effectiveness. This interconnected scientific network reflects the complexity of our society and invites researchers to reflect on a very delicate question: How is it possible to respect the methodological rigor of investigation and/or experimentation procedures while at the same time being open to interdisciplinary innovations characterized by a plurality of approaches to research? This question was, for me, the interpretative key with which I tried to examine the valuable contributions proposed by the authors of this volume, aware that in order to understand the fertile heuristic potential of the world of education and of teaching practices, it is necessary for scholars to "dare with awareness."

In recognizing the scientific value and the future implementation of the research within this volume, I would like to present this preface as a connecting thread that intersects the contributions through the Embodied Cognitive Science (ECS) paradigm (Gomez Paloma, 2017).

At the basis of the ECS paradigm, there are a series of scientific constructs that span several disciplines but that univocally respond to the value of the Body–mind–environment relationship, according to a holistic and interconnected vision of the three entities. All the chapters, while having as their object a specific research model, investigate their field of study recognizing, albeit indirectly, the anthropological framing of the person as a complex unit. It is therefore evident that the authors' vision is to frame teaching and teacher practices by enhancing didactic interaction and aware of the interdependent variables that come into play in training processes.

In my, "Introductory Chapter: Teacher Education between Science and Consciousness", I emphasize this dialogue between disciplines, without which teacher training risks failing.

Chapter 2, "A Comparative Study of Groups of Teachers on the Perceived Nature of Effective Teaching and Learning Science" by Kenneth Adu-Gyamfi, Isaiah Atewini Asaki, and Benjamin Anim-Eduful, clearly illustrates how teaching cannot fail to consider the complex plurality of the capabilities to be developed in students, valuing the principles of active participation and qualitative circularity between the teaching and learning process.

Chapter 3, "Assessment of Students' Reading Comprehension Skills in Teaching English" by Farida Huseynova, confirms the need for an interactive role of the student. Naturally, this didactic interaction, which is necessary for the student to build knowledge and develop talents, goes hand in hand with the personality of the teacher, specifically with the teacher's perception of his or her own professional identity.

The teacher's professionalism understood as the ability to interact empathically with and among students, acquires increasing value for a teaching practice to be effective and meaningful. This is also confirmed by Norway's national education system, which, through its institutional documents, calls for the acquisition of methodological skills to stimulate new abilities already in preschool children. Chapter 4, "Critical Thinking, Problem-Solving and Computational Thinking: Related but Distinct? An Analysis of Similarities and Differences Based on an Example of a Play Situation in an Early Childhood Education Setting" by Francesca Granone, Elin Kirsti Lie Reikerås, Enrico Pollarolo, and Monika Kamola, in addition to examining the differences and similarities of the constructs of the three cognitive abilities, shows how useful it is to assume specific ways of didactic conduct, also through technology, to solicit one or the other ability, aware of how incisive the relational attitude of the teacher is as well as his or her verbal cues.

This professionalism, in order to be translated into valid, effective, and satisfactory teaching practices, requires training that shifts the focus away from the content to be learned, directing the focus towards the transformation of the teacher's forma mentis as a person. Chapter 5, "Physical Education in the Academy – Learning Takes Body" by Filippo Gomez Paloma, Chiara Gentilozzi, and Antonio Cuccaro, focuses on the didactic approach used to teach Motor Education in the five-year degree course that trains future teachers in Italy. The chapter examines the specifics of the ECS approach to understand its relevance within the college world, to be reflected as an approach in the didactic implementation of future teachers. Teacher's competencies that we consider indispensable are therefore closely linked to the anthropological and complex vision of the person, being authentic must prevail over having knowledge.

In inviting readers to view and reflect on the contents of this volume, I would like to congratulate the authors for their precious contributions and thank them for having argued and thus given scientific weight to such important issues. It is thanks to these small research steps that we build the human architecture for our civilization's future.

Filippo Gomez Paloma
Department of Education Science,
Cultural Heritage and Tourism,
University of Macerata,
Macerata, Italy

Chapter 1

Introductory Chapter: Teacher Education between Science and Consciousness

Filippo Gomez Paloma

1. Introduction

Teacher education has been—is and will always be—a topic dear to my heart and of great social impact and significance. Perhaps it is because my career began with teaching in a middle school, or perhaps it is because, albeit for a little more than a year, I served as a headmaster; what is certain is that, although I am now a scholar (of course in Education Science), my heart always beats for and within the school world.

This strong passion and motivation of mine prompted me to study teacher education pathways not only from a mono-perspective point of view, hence pedagogical, but also an interdisciplinary one, starting with cognitive psychology and cognitive neuroscience. This is because in recent decades, the mentioned disciplines, together with philosophy, linguistics, and anthropology, have invested major energy and substantial funding toward investigating the topic of learning and training.

That is why this introductory chapter of mine will focus on the necessary dialog of these disciplines, without which teacher education risks failure. Its fragility, in fact, will manifest itself very soon if the cultural and deontological heritage of the teacher is not supported by a rich scientific knowledge of the neurobiological mechanisms, which include the processes of learning and training, as well as by an examination of the person/teacher, aimed at a deep awareness of the emotional significance and subjective value attached to the role and mission of a teacher.

To enhance this view of mine, I will articulate this contribution according to two paragraphs: the first on recent neuroscientific research that has elevated and detailed the knowledge of the mechanisms underlying learning processes and that, therefore, underpins the quality of methodological approaches inherent in teacher education; the second, consequently, on the pedagogical, didactic, and training implications that the aforementioned research has induced, focusing on an innovative, internationally recognized paradigm—embodied cognitive science—that, in order to qualify the professionalism of teachers, allows the indispensable richness of science to be combined with the ethical, emotional, intimate, and singular depth of each teacher's consciousness.

2. Educating, starting with the learning and forming brain

Recent contributions of neuroscience in pedagogy and education begin to consider the body as an integral part of the learning moment in that "…the mind must not only move from a nonphysical cogito to the realm of biological tissues but must also be related to a whole organism, possessing an integrated brain and body and in full interaction with a physical and social environment" ([1], p. 341).

Learning, moreover, is a process that can take place even without the appearance of new behavior; the fact that learning has taken place, in fact, can also be inferred from changes in preexisting behaviors, since "both observable changes in behavior and other changes that cannot be inferred from simple observation of external behavior reflect learning-induced brain changes" [2].

Concerning the topic of embodiment and corporeality, the dialog between psychological studies, cognitive research, neuroscience, and mathematical models on the one hand and phenomenology, cultural studies, and semiotic studies of language on the other could nowadays foresee a new breakthrough: the creation of intermediate models, such as the study of spatiotemporal patterns through which we humans perceive ourselves in an environment as well as in relation to body/space coordination and coordination between body and objects [3]. We could say with a slogan: neither bottom-up nor top-down, but levels that are the result of continuous mutual translation.

As we all know, excitable cells specialized in receiving stimuli and conducting impulses from nerves transmit information to other parts of the body thanks to synapses which, as H. Maturana and F. Varela argue, "...are the point of close contact between neuron and neuron or between neuron and other cells; at these points the membranes of both cells, besides adhering closely, are specialized for the secretion of special molecules, the neurotransmitters. Therefore, a nerve impulse, which travels through a neuron and finally reaches a synaptic termination, causes the secretion of the neurotransmitter that crosses the space between the two membranes and triggers an electrical change in the following cell" [4].

"The main consequence of this arrangement," writes Antonio Damasio, "is that whatever neurons do depends on the group of neurons that surrounds them...; that whatever systems do depends on how groups influence other groups, in an architecture of interconnected groups" (1995, p. 66). It is in the body, then, that there is an uninterrupted activity of information exchange, processing, and storage. This demonstrates the enormous pliability of the brain, especially in the early years of life, and the capacity for change in relation to environmental stimuli: the cognitive functions that have helped to establish the architecture of the mind are nothing more than the result of continuous interactions between precreated structures at the genetic level and the environment, in a feedback system that has enabled man, from the very beginning to process information, storing the data necessary for his adaptation.

Inputs from a stimulating environment can decisively affect synaptic formation because, although there are billions of them, the neurons that characterize an adult human brain are connected in a specific way; there are, in fact, orderly and well-defined connections and what comes to be, as Elisa Frauenfelder explains, is a kind of "...neural Darwinism: cells assemble, forming sets, groups of cells, that repeat themselves thousands of times and tend to compete to acquire the possibility of transmitting the greatest number of reproductions of themselves, thus fitting into the law of evolution" (2002, p. 46).

In a broader sense, such plasticity is identified with man's own ability to learn, through mechanisms of synaptic connection and disconnection. The phenomenon of *sprouting*, which literally means sprouting, explains how the number of synapses can increase exponentially during the early years of childhood. This is mainly due to an environment rich in stimuli and the presence of critical periods so defined because of their sensitivity to external stimulation that causes synapses to increase.

"It can be hypothesized that the first 10–15 years of life constitute the most fruitful period in which, in fact, new conceptual structures are formed: new cellular assemblies arising directly from sensory stimulation, or new higher-order assemblies. It is a period in which both the structural parts and the patterns of later thinking are developed. And this process may come to an end with the progressive channeling and control of perception by the earlier perceptual structures: new wine goes into the old barrels. After that, in adult thinking, each new concept is a reorganization of the preexisting ones; the possible quantity of new ideas depends on the quantity and variety of the more primitive ones, which were formed earlier" [5].

Another element to be considered in the study of the body/learning relationship is the assurance that affectivity conditions the learning and cognitive processes. On a biological level, in fact, there is a part of our brain, namely the limbic region, that is the seat of emotionality. It is connected to the environment by afferent nerve pathways, which convey sensations and perceptions to the brain, and is integrated with the cerebral cortex. Affections, therefore, are "the original magma of the self," and "the building blocks of its identity," as they dominate the subject and structure it. There is a deep connection between emotional processes and learning since it "always develops within an affective relationship." The educational relationship means the existential presence of the educator for the learner [6].

The emerging view of embodied cognition considers cognitive processes deeply rooted in the body's interaction with the world. This position, as read by scholar Margaret Wilson of the University of California at Santa Cruz, currently harbors several distinct versions, some of which are more controversial than others. The following six versions are distinguished and evaluated:

1. cognition is situated;
2. cognition is subject to time;
3. we reduce cognitive workload through the environment;
4. the environment is part of the cognitive system;
5. cognition is for action;
6. autonomous cognition is body-based.

Of these, the first three and the fifth appear to be at least partly true, and their usefulness is best assessed in terms of the range of their applicability. The fourth version, the scientist argues, is very problematic. The sixth has received less attention in the literature on embodied cognition, but may in fact be the best documented and the most powerful. To arrive more clearly and functionally at this concept, it is appropriate to start with some basic mechanisms of neural networks.

Understanding how these individual molecular axon guidance systems function at the individual axon level and how they compete to initiate and divert axon migration is, in fact, one of the main goals of neurobiology. Neural networks have been shown to be capable of adaptation and learning, although a deep and comprehensive study of the activity of their circuits has so far been prevented by the complexity of mammalian networks. Network plasticity can be defined as the modeling of network morphology and as the function induced predominantly by experience.

This process is based on the complex, activity-dependent changes in neurons that modulate the ability of the neural network to transfer, process, and store information.

After the first period of genetically determined development, neural circuits are continuously modified and shaped by experience (epigenetic development). Therefore, synaptic connections that are sparsely used are weakened, even to the point of disappearing, while frequently used synapses are strengthened and eventually grow in number [7].

As mentioned above, synaptic efficiency can be modulated, very finely and on a widely varying time scale, by a set of factors, including previous network activity, generation of second messengers, and functional changes in pre- and postsynaptic proteins, as well as regulation of the expression of genes involved in synaptic growth, survival, and transmission.

This results in changes in the efficiency of synaptic transmission, which can last from fractions of seconds to minutes in the case of short-term synaptic plasticity, to hours, days, or months in the case of long-term synaptic plasticity. These changes profoundly affect information processing between inputs and outputs of the network, ultimately shaping its flow.

Wanting to outline the salient points of the new neuroscientific research in order to reflect on possible spillovers in the field of teaching, particularly on the body/learning relationship, we can consider the following points incisive.

1. LeDoux's studies argue that changes in synaptic connectivity underlie learning and that memory represents the consolidation of these changes over time "...when weak and strong inputs to a cell are active at the same time, the weak pathway is enhanced through its association with the strong pathway" [8].

2. The theory of Giacomo Rizzolatti in which it is inferred that mirror neurons are a class of neurons that are selectively activated both when an action is performed and when its performance is observed by others. The observer's neurons thus "mirror" what is taking place in the mind of the observed subject, as if the observer himself were performing the action [9].

3. Vittorio Gallese's Embodied Cognition ("EC") theory encapsulates a notion of cognition rooted in the body's states and in the specific systems of our brain, emphasizing the fundamental role of the sensorimotor system in representations and cognitive operations [10].

A deepening of the discovery of mirror neurons, specifically the theory of language evolution proposed by Rizzolatti and Arbib [11], the discovery of audiovisual mirror neurons [12] and the discovery of mouth mirror neurons [13] lay the groundwork for new research aimed at investigating the involvement of linguistic cognitive activity in action understanding.

Very interesting has been the research already undertaken to understand whether and how far the conjugation of verbs in the future and past tenses can be related to the motor representations required to drive an upper limb movement forward or backward, respectively, referring to the studies conducted by Buccino et al. [14] regarding the representation of space and time.

For this purpose, a pilot experiment was performed involving 18 subjects who were required to semantically decode acoustically presented verbal stimuli conjugated in the present, future, and past tense and give a behavioral response involving a forward or backward movement of the upper limb. In the pilot experiment, analysis of the results was performed by analysis of variance (ANOVA), which considered past, present, future, forward movement, and backward movement as factors within groups and movement and time as factors between groups.

There was evidence of a tendency for subjects to respond faster in performing the forward motion associated with a future-conjugated hand motion verb. The faster reaction time of the subjects' forward movements following the presentation of the verb in the future tense is related to the direction of the movement itself; it is easier for the subject to perform a movement that goes in the same direction as the movement spatially evoked by the presented verb. In the present experiment, the acoustic stimulus itself represents the motor priming that modulates the response, as the subject listens to the verb and has plenty of time to discern and understand it before receiving the arrow stimulus that indicates the direction of the movement eventually to be made. The innovation brought by the results of this experiment lies in the modulatory effect on the motor response exerted by an implicit representation of the movement contained in the cognitive processing of the time that takes to conjugate the verb. In fact, the stimulus we presented explicitly does not actually manifest any reference to the direction of the movement to be made in the response, unlike studies conducted so far [14], in which the stimulus phrases explicitly reproduced spatially directed hand and foot motions. The experimental data thus seem to confirm that semantic comprehension modulates the motor system differently depending on the experimental delivery and the stimulus presented to evoke it. This data is, however, in the same vein as studies that confirm the involvement of the motor system not only in observing action but also in processing linguistically presented actions, both in reading and listening.

3. From science to consciousness, the step is short but complex

Recognizing the value of neuroscience, many scholars have been engaged for years in the study of links between new theories that have emerged from the latest research and psycho-pedagogy, in an attempt to understand, build, and possibly adopt new approaches to educational intermediation with respect to an interdisciplinary view of the subject of teacher education. However, it is essential, in our opinion, to point out some aspects in order to better understand how to make effective use of these findings and how to avoid their inappropriate use and/or distorted cultural dissemination.

While the criticisms made by some psychologists, who conceive of neuroscience and, in particular brain scanning techniques, as a new phrenology seem to us to be frankly excessive and misplaced, it remains true that the evidence provided by brain imaging is to be read as correlation data and not causation data. It is not enough, in our opinion, to identify which neural areas are activated to fully understand and possibly justify the mechanisms that regulate behavior.

Moreover, the risk of uncritically adopting a pure functional localization approach, or more or less explicit forms of phrenology, is always around the corner. In other words, it is not enough to stop proving that a given process corresponds to a given pattern of neural activation. We need to question not only the correspondences but the underlying mechanisms—not only the where but also the why.

Let us begin by reflecting on the recent discovery of mirror neurons, a discovery that testifies to the identification of a powerful mechanism, which can be referred to by the sometimes-debated term motor simulation [15, 16]. The research on mirror neurons has been conducted with an approach that, in our opinion, should be taken as an example; in fact, it represents an area of study that, far from a merely phrenological approach, identifies simulation as a mechanism that can help to better elucidate a variety of phenomena, ranging from the understanding of imitation to the development of empathy and the evolution of language.

However, this very hypothesis and discovery hints at the urgent need for intermediate models of applied translation; a conversion of the brain's neurological structures and related mechanisms into phenomenological justifications that function as filters linking bodily dynamics to the space in which bodies live and move: a space that, let us not forget, is perceived through a cultural and social construction.

In fact, as previously mentioned, from a theoretical and content point of view, a risk that the development of neuroscience has entailed and may entail is to emphasize the prominence of the brain and neural processes in explaining behavior. Highlighting the importance of the neural basis of behavior is crucial and helps to overcome the traditional Cartesian dualism between mind and brain, which has long influenced cognitive science. Nonetheless, the emphasis on the brain can lead to neglecting the role that the body plays in interacting with the environment. Only in recent decades has a new, embodied perspective emerged taking into account not only neural processes, but also emphasizing that organisms are endowed with a body as well as a brain, that the mind is not something separate, and that cognitive processes are based on sensory-motor processes.

Relatively recently, therefore, it has been emphasized in several areas that cognition is not information processing but is movement and action. The question now is whether it is sufficient to consider the body as a situated device of action or whether it is necessary, as we believe, to arrange such a view according to a constructivist perspective in the educational and didactic sphere, an even more complex element.

It is evident, therefore, that our reading of the listed scientific phenomena leads us to think that we need to shy away from forms of biological essentialism and from reductionism that do not help us understand complex behaviors. In more technical terms, embodiment and situatedness travel together. Cognition is not only embodied but also situated, variable, and contextually conditioned. And our body is our first context, our first element of cognitive genesis.

It must be acknowledged and socialized that the cultural hurricane brought about by the irruption of biology on the scene excites us greatly, but it also finds us somewhat unprepared, exposing us to new challenges as well as new risks. Within this framework, we really believe it becomes essential to invest in people who are open to the recognition of the synergy of multiple disciplines, who know the methods but are not confused by the new techniques, who have depth and theoretical aptitude, who are not naive in the uncritical adoption and misuse of the concept of the body, and who eschew the easy reductionism that the biologizing of phenomena can entail.

In short, make use of that healthy competition that drives us to scientifically delve deeper into our field, but which always keeps us aware that every discovery acquires value and expendability only if it is meaningfully and functionally connected to the web of studies of the phenomena of life and everything around us.

But what does all this mean for the world of education? And even more precisely, what do such neuroscientific theories imply in the dynamics of educational relations in the field of education?

Regarding the first point, starting from Donald Hebb's [5] "download and connect" theory, scholar Ivano Gamelli's [17] pedagogy of the body, and Maria Grazia Contini's [18] pedagogy of the emotions have researched a series of scientific elements to empirically justify the emotional valence of corporeality and its related spillover in the field of education. Plurisensoriality as well as a pedagogy that exalts emotional education have, in fact, outlined the cultural framework within which it was necessary to intervene with scientific discoveries of a biological nature; a framework that welcomes and tends to functionally metabolize the innovative neuroscientific theories, almost as if it expected them.

The discovery of mirror neurons, in fact, helped to revisit the way of conceiving the relationship between action, perception, and cognitive processes. It is at this point that the encounter with education through the phenomenology of perception takes place.

This means that when we are about to perform a given action, we are also able to predict its consequences. This kind of prediction is the result of the activity of the action model. If it were possible to establish a process of motor equivalence between what is acted upon and what is perceived, thanks to the activation of the same neuronal substrate in both situations, a direct form of understanding of others' actions would be made possible. And it is impossible to deny the value of such spillover in education [19, 20]. It is useful to recall that already Alain Berthoz was among those scientists who corroborated the proactive function of the brain, recognizing in movement not only the "physical and dynamic form of action" but also the tool that comes closest to a 'sixth sense' for the ability to anticipate action (1998).

Perceiving an action—and understanding its meaning—therefore, amounts to simulating it internally.

In this way, the strategy of mirror neurons provides the scientific basis for overcoming those solipsistic and egocentric logics hinging on the reductive mind-brain pair: their action can be encoded from the perspective of a "virtual resonant cavity," in which neural encoding makes dialog interactive and shareable. The resulting neural representations are thus shared, jointly, already at the intentional level. The existence of the other, of others, is in a sense written in our neurons; in fact, the mirror neuron system determines the emergence of a shared space of action, in which the process of communication and intersubjective understanding is generated. The root of human subjectivity is actually an original intersubjectivity. Husserl [21], for example, in the second volume of the Ideen, argues a comparison with recent findings in neurophysiology. According to the phenomenologist, in fact, every human being, thanks to his or her corporeality, stands in the spatial context, among things; within every other living body inheres its own empathetically posited psychic life, so that, when a living body moves and comes to be in new places, its psyche also moves; the psyche is in fact constantly fused to the living body.

Neuroscience, then, in order to contextualize its research, needs the contribution of the humanities, a contribution that, with what is asserted by Maurice-Merleau Ponty, we fully support. Indeed, he asserts the need to "find the origin of the object in the very heart of our experience. Our experiences suggest meanings to us, enable us to make hypotheses, and …such a procedure brings out the spontaneous method of perception that sort of life of meanings, which makes the concrete essence of the object immediately legible and only lets its sensible properties appear through it

(1945). In fact, the object/subject of our research pathway turns out to be the body in its interaction and full integration with a specific learning environment in which sensory stimuli, appropriately arranged, offer an original key to access disciplinary and nondisciplinary knowledge; in fact, "the influx of information from sensory organs and the continuous interaction with the environment then determine how the brain takes shape" [22].

Awareness of this information is also essential for understanding how knowledge construction takes place and is of fundamental relevance for teachers who aim to implement meaningful teaching through which students can be enabled to achieve authentic learning. As teachers, it is necessary to provide space for the widest possible expression through the practical and lived experience of students; indeed, if we want to form a solid foundation for their creative activity, we need to make them experience school actively, as the more they will explore, experience through their senses and assimilate, the more fertile their imaginative capacity will be [23].

Apart from the models just mentioned, which have long been studied by many scientists, embodied cognitive science to date represents one of the scientific approaches that is most influencing, especially internationally, in the research field of educational neuroscience [24]; the latter, thanks to the establishment of a virtuous dialog between different fields of study such as pedagogy, didactics, psychology, neuroscience (i.e., between the so-called soft sciences and hard sciences), has provided in the last two decades a solid contribution in explaining the functioning of the human mind, bringing evidence in favor of a close connection between mental functions and the relationships that exist between the body and the environment [25].

For some time, various authors have contributed to highlighting how complex phenomena need a nonlinear, manifold glance, more representative of the variety and unpredictability of developmental and educational dynamics and outcomes [26–29]. Thanks to this interdisciplinarity, and the studies derived therefrom, the notion takes shape that the mind is not independent and unrelated to the body but is one with it. Therefore, cognition results to be embodied or embedded, that is, it sees in the body the dimension from which the mind emerges. Based on this condition, cognition requires not only the participation of the brain and the body but also that of the environment in which it is immersed; this has opened an interesting, constructive, decade-long dialog between pedagogy and architecture [30]. Learning environments, as an extension of the human mind [31], therefore play a fundamental role in the interconnectedness of cognitive processes. The realization that cognition is embodied and dependent on bodily features, particularly our perceptual and motor systems, should therefore be acquired by all those working in the field of education.

A number of preliminary exploratory studies have been conducted in recent years [32]. During these studies, the structuring of the constituent elements of the EC-based integrated training approach has been gradually defined.

The EC-based approach is defined as integrated into that it involves the articulation of three nonhierarchical phases: theoretical training, practical experiential workshop, and final discussion. Each aims to influence and, in turn, be influenced by the others, through reflective practices [33] designed to activate metacognition.

Confirming the extent to which teaching professionalism is composed of elements of identity, personality, and value, in literature, reflection on one's core qualities has been found useful "[…] in consciously directing one's own professional development, establishing a harmonious link between one's personal identity and one's aspirations and enthusiasm for the profession" ([34], p. 91). The sharing of personal perceptions respects the observation of certain rules of communication, such as respecting one's own and others' elocution time, suspending judgment, practicing active listening, and exercising positive feedback; this is to sharpen each teacher's empathic and relational skills as well as derive the appropriate reflections on communication with and among students.

The main objective of EC-based Integrated Training is the possibility of generating in the learner embodied awareness and skills, strongly linked to concrete and simulated experiences "so that the elements of cognition are linked to experiential and pragmatic ones, so as to guide future decisions, leaving a sensitive, emotionally tangible, meaningful trace in the bodily memory of each learner" ([32], pp. 232–233).

So, in summary, reflexivity and narrative, action, sharing, and self-evaluation are the strategic principles and guidelines, which can direct the construction of educational experiences consistent with EC theory.

4. Conclusions

From this quick excursus, it can be seen, in addition to the many variations that have occurred over the years that, as much as we aspire to break away from it, the logic behind school teacher training courses is still predominantly transmissive, content-driven, and tied to disciplinary programs and theoretical knowledge of various teaching methodologies and strategies [35].

Although teachings regarding pedagogical and didactic areas, through inconsistent alternations, have been introduced over the decades, it cannot be thought that these teachings, concentrated in a few exams, are sufficient to establish a real dialog between disciplinary knowledge and the didactic approach based on interaction [36]; that is, an approach that is constructive in nature, offering space for expression and critical thinking to students, so as to allow their real growth, aimed at the autonomous construction of their own knowledge.

We also know that teachers tend to reintroduce the styles and attitudes they have experienced, which they have seen their teachers adopt, in a sort of consolidation of habits, conscious and unconscious, by reintroducing them to their students. This is because the teachers themselves continue to feel as a direct experience only the mode of teaching that they have already experienced, even in their internship experiences. All this generates the comfortable and reassuring conviction that "this is how it has always been done" is the best and easiest way to go.

To train professionals capable of implementing a change, universities should also change their approach, offering their students the possibility of experiencing these new teaching models in the common practice of teaching classes, not limiting them only to laboratory or internship activities. This would allow fostering the creation of a motivating learning environment that engages students through practical experiences, aimed at reducing the disconnect that occurs between what is learned at the theoretical level and what will be later and actually done in the classroom.

Alongside this innovative mode of university teaching, a further significant breakthrough in forming/changing the mindset of future teachers is to lead them to a greater awareness of themselves, how first and foremost they themselves learn, as well as what teaching really means to them. For example, by beginning to understand how the brain works, namely being aware of the fact that in each student the mechanisms that are generated as a result of the teaching stimuli will determine new circuit activations and new synapses, changing the anatomy and physiology of each student's nervous system differently. These aforementioned modalities, at first glance exciting and convincing, can acquire real significance only if the ways in which training actions are to be conducted respond, juxtaposedly, to a genuine rethinking of professional training. This implies that, in order to attribute significance to a real formative impact with the EC-based approach, first it is indispensable that trainers achieve deep awareness of the following cardinal principles of teacher education:

1. Too often the pedagogical focus of professional training turns out to be the cultural object (a specific topic to be studied in depth, the application of new reform, innovative methodological skills, etc.), without realizing that the real purpose is to make the person (future teacher) acquire a new mindset. In this delicate transition, what should often be considered the objectives to be learned become cultural mediators, objects of comparison, fields of experience, and experimentation. The active role of the trainee [37], on the other hand, enables participation by investing one's own ideas and one's own readings of the phenomenon to support a new construction of thinking and of actions to be taken. It is a training of the person, not of the knowledge and methodologies.

2. A rethinking that recognizes, not only in words but through attitudes and languages, the complex unity of body-mind. However much our rational minds may claim to recognize and marry such unity, the deep implicit world still directs actions and behaviors in education according to compartmental and dichotomous logics, denying the complexity of our body as a holistic entity through which knowledge and skills can be built [35, 38, 39].

3. Recognize and accept that emotions represent significant and indispensable elements in the learning process. It is precisely emotions, in fact, that attribute meaning and significance to cognition, making it permanent and usable even in different contexts [1].

4. Overcome the deterministic view of a being by approaching it in an anthropologically human way. The perceptual and action variables of each living being make up the configuration of the "synaptic self" [8], where the uniqueness of each reigns supreme and does not automatically respond to standards of intention and behavioral homologations.

5. A formative transformation that operationally recognizes the value of community as an integrating background on which to build personalization processes. Inclusion is not a phenomenon that concerns only people with disabilities but extends its gaze beyond, where cooperating in spite of differences is the greatest wealth that can be had [40].

6. A culture soaked with the acceptance of the complexity of phenomena [41], one that does not presume to govern them linearly and understands that immersing oneself within them is the only way to guide them. Rational control and governance are possible for what is predictable, not for the unpredictable world of educational complexity on which education "must feed."

7. Leverage especially the beliefs/cultures of the individual as the determining agent of the community to which he or she belongs. Each person's repertoire of knowledge always filters through cultural values constructed through experience

and is perceived implicitly by lived social patterns. The absolutism of knowledge clashes with the principles of the neuro-phenomenology of a living being (edited by Gomez Paloma [42]).

8. A rethinking that does not deny the value of technology and the opportunity it offers to learn about the world and to range culturally in divergent ways. At the same time, however, it does not deny the value of tradition, of "smells," and of affective experiences that represent the roots of our being a person. In this scenario, the local and the global are now not so "distant."

9. Deep awareness that providing fertile ground for sharing is the basis for the respect of everyone's rights/duties. Sharing does not only mean socializing one's ideas and skills but also autobiographically narrating one's experiences and lived experiences (edited by [43]), strong in the fact that, in a real way, only the stripping of roles and labels offers an authentic and respectful confrontation of differences to be accepted and valued.

10. In order to try to better understand dimensions and phenomena, as well as act effectively for their improvement, the formation of the person must take place starting from the principle of the extended mind [31], aware that, in light of the new neuroscientific paradigms, the mind is not enclosed in the person's head but expresses its full functions only when considered in its interaction with the world and its perceptual and action variables.

Author details

Filippo Gomez Paloma
Department of Education Science, Cultural Heritage and Tourism, University of Macerata, Macerata, Italy

*Address all correspondence to: filippo.gomezpaloma@unimc.it

References

[1] Damasio AR. L'errore di Cartesio. Emozione, Ragione e cervello Umano. Milano: Adelphi; 1995

[2] Kandel ER, Schwartz JH, Jessel TM. Principi di Neuroscienze, a Cura di Virgilio Perri. Giuseppe Spidalieri, Milano: CEA; 1994

[3] Lakoff G, Johnson M. Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought. University of California, Berkeley, and University of Oregon. New York: Basic Books; 1999

[4] Maturana H, Varela F. L'albero della conoscenza. Un nuovo meccanismo per spiegare le radici biologiche della conoscenza umana. Milano: Garzanti; 1987

[5] Hebb D. Mente e Pensiero. Bologna: Il Mulino; 1982

[6] Goleman D. Lavorare con intelligenza Emotiva. Milano: Biblioteca Universale Rizzoli; 2000

[7] Gallo B. Neuroscienze e Apprendimento. Napoli: Simone Editore; 2003

[8] LeDoux J. Il sé sinaptico. Milano: Raffaello Cortina Editore; 2002

[9] Rizzolatti G, Sinigaglia C. So quel che fai. Il cervello che agisce e i neuroni specchio, Milano: Cortina; 2006

[10] Gallese V, Goldman A. Mirror neurons and the simulation theory of mindreading. Trends in Cognitive Sciences. 1998:493-501

[11] Rizzolatti G, Arbib MA. Language within our grasp. Trend in Neurosciences. 1 May 1998;**21**(5):188-194

[12] Kohler E et al. Hearing sounds, understanding actions: Action representation in mirror neurons. Science. 2 Aug 2002;**297**(5582):846-848

[13] Ferrari PF et al. Mirror neurons responding to the observation of ingestive and communicative mouth actions in the monkey ventral premotor cortex. European Journal of Neuroscience. Apr 2003;**17**(8):1703-1714

[14] Buccino G, Lui F, Canessa N, Patteri I, Lagravinese G, Benuzzi F, et al. Neural circuits involved in the recognition of actions performed by nonconspecifics: An fMRI study. Journal of Cognitive Neuroscience. 2004:16

[15] Gallese V. Before and below "Theory of Mind": Embodied simulation and the neural correlates of social cognition. Philosophical Transactions of the Royal Society B. 2007;**362**:659-669

[16] Jeannerod M. Motor Cognition. What Actions tell the self. Oxford: Oxford University Press; 2007

[17] Gamelli I. Pedagogia del Corpo. Roma: Meltemi; 2006

[18] Contini MG. Per una Pedagogia Delle Emozioni. Firenze: Nuova Italia; 1992

[19] Berthoz A. Il Senso del Movimento. Milano: McGraw-Hill; 1998

[20] Frauenfelder E. Le Scienze Bioeducative: Prospettiva di Ricerca. Napoli: Liguori; 2002

[21] Husserl E. I Problemi Fondamentali Della Fenomenologia. Lezioni sul concetto naturale di mondo, a cura di V. Roma: Costa, Quodlibet; 2008

[22] Merleau-Ponty M. (1945), Phénoménologie de la perception.

Paris: Librairie Gallimard. Tr. it. In: Fenomenologia della percezione. Milano: Bompiani; 2003

[23] Vygotsky LS. Immaginazione e Creatività Nell'età Infantile. Roma: Editori Riuniti; 1972

[24] Gomez PF. Corporeità, Didattica e Apprendimento. Le Nuove Neuroscienze Dell'educazione. Salerno: Edisud; 2009

[25] Varela FJ, Thompson E, Rosch E. La via di Mezzo Della Conoscenza. Le scienze cognitive alla prova. Milano: Feltrinelli; 1992

[26] Canevaro A. Scuola Inclusiva e Mondo più Giusto. Trento: Erickson; 2013

[27] Contini MG. Disalleanze nei Contesti Educativi. Roma: Carocci; 2012

[28] Demetrio D. Pedagogia Della Memoria. Per se stessi, Con gli altri. Roma: Maltemi; 1998

[29] Kaneklin C, Scaratti G. Formazione e Narrazione. Milano: Raffaello Cortina editore; 1998

[30] Gomez PF, Buonanno E, Borrelli M. Scuole Innovative. L'Embodied Cognition Design Come Paradigma dei nuovi Spazi Educative. Roma: Edizioni Nuova Cultura; 2020

[31] Clark A. Curing cognitive hiccups: A defense of extended mind. The Journal of Philosophy. 2007;**104**(4):163-192

[32] Minghelli V, Damiani P. Modello di Formazione Integrata Embodied Embodied-Based, per il potenziamento delle competenze inclusive dei docenti. Mizar, Costellazione dei pensieri, n. 2021;**15**:230-235

[33] Schön DA. Formare il Professionista Riflessivo. Per una Nuova Prospettiva Della Formazione e Dell'apprendimento Nelle Professioni. Trad. it. Milano: Franco Angeli; 2006

[34] Korthagen FAJ. In search of the essence of a good teacher: Towards a more holistic approach in teacher education. Teaching and Teacher Education. 2004;**20**(1):77-97

[35] Gomez Paloma F, Damiani P. Manuale delle Scuole ECS. The Neuroeducational Approach, Brescia: Scholé; 2021

[36] Sibilio M. L'interazione Didattica. Brescia: Edizioni Scholé; 2020

[37] Dewey J. Experience and Education. New York: Macmillan Company; 1938

[38] Glenberg AM. Embodiemnt for education. In: Calvo P, Gomila A, editors. Handbook of Cognitive Sciences: An Embodied Approach. San Diego: Elsevier; 2008

[39] Goldberg E. La sinfonia del cervello, (traduzione di C. Blum I. e Zago F.). Milano: Ponte alle Grazie Editore; 2011

[40] Ianes D. Bisogni Educativi Speciali e inclusione. Trento: Erickson; 2005

[41] Bauman Z. La vita liquida. (traduzione di Cupellaro M.). Roma: Laterza Edizioni; 2008

[42] Gomez Paloma F, editor. Embodied Cognition. Theories and Applications in Education Science. New York: Nova Science Publishers; 2017

[43] Giaconi C, Caldin R. a cura di. In: Pedagogia speciale, famiglie e territori. Sfide e Prospettive, Milano: Franco Angeli Editore; 2021

Chapter 2

A Comparative Study of Groups of Teachers on the Perceived Nature of Effective Teaching and Learning Science

Kenneth Adu-Gyamfi, Isaiah Atewini Asaki and Benjamin Anim-Eduful

Abstract

The teacher is influential in the processes of teaching and learning science, organizing instruction to transform concepts into the understanding of students. Hence, teacher effectiveness is discussed in most educational forums as stakeholders look for more plausible ways of effective teaching and learning. As part of a large study on teachers' conception of an effective science teacher, we studied comparative views of mentors, mentees, and supervisors on the perceived nature of effective science teachers in the processes of teaching and learning science in basic schools. In a triangulation mixed methods design, 271 mentees, 160 mentors, and 85 supervisors were selected through multistage sampling procedures to respond to Effective Science Teacher Questionnaire and Interview Schedule. The data from the questionnaires were reduced to three factors through exploratory factor analysis. The qualitative data were analyzed thematically in line with the three factors. It was revealed that there was no statistically significant difference as supervisors differed not in their perceived nature of an effective science teacher compared to that of mentors and mentees. The Ministry of Education through the Ghana Education Service should provide opportunities for the three groups of teachers to share experiences on effective teaching and learning science in basic schools.

Keywords: effective teaching and learning, mentees, mentors, science, supervisors, and teachers

1. Introduction

Science educators, researchers, and stakeholders of science education among others have over decades agreed that the role of the [science] teacher in the classroom cannot be underestimated [1–6]. The role of the science teacher like any other teacher is to guide students to learn [1, 7]. However, this guidance (teaching) transcends just having a bunch of activities in the classroom [8]. It, thus, leaves science educators and researchers raising legions of questions including what is considered science teaching?

 IntechOpen

Is there anything that militates against the teaching process without which it cannot be considered science teaching? What does an analysis of the concept of teaching contribute to an appropriate conception of teaching science? [9]. For Ref. [10], the questions to be asked should be: what is science teaching about and who is an effective science teacher?

Across many disciplines, Ref. [11] looked at teaching as a social process that involves the teacher communicating and interacting with students focusing on helping the students develop their cognitive, affective, and psychomotor domains. It involves the teacher giving directions, asking questions and accepting or rejecting responses [11]. It is, also, seen as a scholarly activity, involving collecting experiences and critical thinking [12]. The teaching process involves guiding students to acquire higher knowledge or skills [13]. In the context of science education, effective science teaching is an art involving creativity, imagination, and innovation, along with planning, practice, decision-making, and evaluation.

Studies on effective [science] teachers and effective science teaching date over decades [3, 7, 14–17]. The literature also refers to effective teachers as good teachers [18, 19] and exemplary teachers [6]. Despite decades of studies, the puzzle of who an effective teacher is yet to be resolved [20–22]. It is noted that effective [science] teaching is difficult to describe [20, 21, 23] because it is multidimensional, highly individualized, and not always observed except only by students [21, 24]. Hence, the purpose of this research was to compare the views of three groups of teachers on the perceived nature of effective teaching and learning science in basic schools. To achieve this purpose, the following research question was crafted as a guide in this research:

How do supervisors' (college tutors') views on the perceived nature of effective teaching and learning science differ from that of mentors (in-service teachers in basic schools) and mentees (preservice teachers in colleges of education)?

To answer this research question, we explored the perceived nature of effective teaching and learning science from the three groups of teachers and the factors accounting for this perceived nature of effective teaching and learning science in basic schools. Finally, we examined whether there was a difference in how supervisors viewed the perceived nature of effective teaching and learning science in basic schools from that of mentors and mentees.

1.1 An effective teacher

In contemporary times, there is no widely accepted agreement about what exactly effective teaching is and how it should be measured [20]. Borich [20] explained that in the past an effective teacher was regarded as a good person and a role model who met community ideals for a good citizen, good parent, and good employee. Explaining further, Borich [20] noted that effective teacher was identified on the basis of their goodness as people with little attention to the teacher's classroom behavior and impact. Identifying teachers on this basis is untenable [15, 20]. Thus, in the past three decades, Borich [20] asserted that there is now a shift in this definition of an effective teacher with the focus being on teacher behavior and impact on students rather than their best.

Effective [science] teachers may be regarded as those who instill life-long learning habits in their students [25]. They share some common features regardless of their different teaching styles, disciplines (chemistry, physics, and biology), and backgrounds [25]. For Goe and Stickler [23], teacher effectiveness is a value-added assessment of the degree to which in-service teachers contribute to their student's learning, as indicated by higher-than-predicted increases in student achievement scores. Again, in contemporary studies, the effective teacher is described as one who does things right, that is they plan their lesson, prepare the learning environment, conduct proper lesson introductions, ask questions, and use instructional material [26]. Simply, in any field of study, effectiveness is the ability to produce the desired outcome [5].

Walker [27] identified 12 characteristics of effective teachers needed for students to behave appropriately and acquire information. These features are preparation, a positive attitude, high expectations, creativity, fairness, personal touch, developing a sense of belonging, accepting mistakes, a sense of humor, respect for students, a forgiving attitude, and compassion. Bransford et al. [28] noted that effective teachers do not only appreciate what students everywhere can agree that teaching is not just talking and learning is not just listening [8] but they can figure out in one breathe what they want to teach and in another breathe doing it in a way that students can comprehend and utilize the knowledge and skills acquired.

1.2 An effective science teacher

In the context of science teaching, what does the literature say about effective science teachers? Effective science teachers are persons who combine teaching skills with an active belief that instruction can make a difference in science learning [15]. Ginns and Watters [29] pointed out that the starting point for examining the attributes of an effective teacher of science is to assess the nature of a preservice teacher education program and the expectations implicit in that program. However, contemporary ideas about the teaching of science suggest that the effectiveness of classroom science teaching may be investigated using an analytical framework that takes into account the initial teachers' preparation, and implementation of lessons and the classroom learning environment established by the teacher [29]. Those frameworks may include examining the characteristics that effective teachers possess. Fitzgerald et al. [24] reported that effective science teaching is essential in changing students learning outcomes positively and that there is a need to extract the components of effective science teaching to get a better comprehension of their work in the classroom and why they do what they do.

Teachers' characteristics in science education have been studied under these areas: knowledge of science content and instructional pedagogy, learning environment, interest in students' academic improvement, instructional materials, advanced preparation, and time management [6, 14, 25, 30, 31]. For instance, Stronge [31] categorized the teacher characteristics into six ways: the teacher as a person, classroom management and organization, organizing and orienting for instruction, implementing instruction, monitoring student progress and potential, and professionalism. Cherif [25] asserted that in the perspective of literature, the characteristics of an effective science teacher can be categorized as understanding; explaining that this encompasses understanding the subject matter, student's needs and the various teaching models and evaluation techniques, and the learning environment; teaching philosophies and approaches; stating clear objectives and practical methods; management; evaluation philosophies and technique; professionalism; demonstrating equity, quality, and diversity; and teaching beyond the classroom.

In addition, Cimer [7] concluded from a review of literature that effective teachers deal with students' prior ideas and conceptions, encourage students to apply new knowledge in diverse contexts, encourage students to take part in lessons, encourage student inquiry, encourage cooperative learning among students, and offer continuous science. That is, effective science teachers utilize effective managerial practices, use strategies and activities that enable students, encourage student engagement in learning tasks, and maintain a favorable classroom environment [6].

1.2.1 Content knowledge of an effective science teacher

Among the various characteristics of effective science teachers so categorized in literature, knowledge of content and pedagogy (otherwise termed knowledge-based teaching) [32, 33] has been regarded as an integral part of effective teaching. Ababio [1] espoused that content knowledge is the subject matter, ideas, skills, or substance of what is taught. The three key areas advanced by Ababio [1] in relation to content, knowledge encompasses the teacher's familiarity with current knowledge in their subject area; the history and philosophy of teaching the subject; how the knowledge base of the subject informs or is formed by other disciplines; the teacher's knowledge and understanding of the different fields in their subject area (that is, the broad view of the subject in all its aspects); a firm understanding of its concepts, principles, values, theories, and generalizations; and having an unending enthusiasm for its study. Grant and Gradwell [34] referred to this enthusiasm as a teacher being ambitious, explaining that the teacher must have a good depth of understanding of the subject matter and effortlessly strive to connect it to students' experience.

From Ref. [1] three key areas, the teacher's content knowledge should be in-depth and must know the probable sources of knowledge in his/her subject from textbooks, journals, national dailies, and unpublished materials from where he/she should tap his/her content. According to Bransford et al. [28], content knowledge encompasses knowledge of learners and how they learn and develop within social contexts; knowledge of subject matter and curriculum goals; knowledge of teaching, such as subject matter, diverse learners, use of assessment; and classroom management.

A science teacher's knowledge has been found to be much more useful to students when it is combined appropriately with pedagogy [32, 35]. This pedagogy implies the whole philosophy and value system that leads teachers to make the choices they do in what and how to teach [16]. Cherif [25] opined that in the entire life of the effective teacher's career, he or she continues to develop the horizon of knowledge and understanding in their field of study and that he or she understands that it is one thing knowing how to teach and another having the content knowledge.

1.2.2 Assessment practices as a measure of an effective science teacher

Another characteristic of an effective science teacher is the attention paid to assessing students and providing feedback [19]. According to Zango et al. [19], effective teachers enable students to track their own performances, grade their homework, give oral and written feedback to students, document student progress and achievement, make instructional decisions based on student achievement data analysis, circulate in the room to assist students and provide praise, give pretests and graphs results, consider multiple assessments to determine whether a student has mastered a skill, use student intervention plans and maintains records of the plans' implementation, record team conference or teacher conference with students, give assessments on a regular basis, vary instruction based on assessment analysis, exercise testing accommodations for special-needs of students, and maintain copies of all correspondences concerning student progress.

1.2.3 Classroom management as a measure of effective science teacher

Effective teachers are also known to be good managers of time for teaching and learning and student behavior so as to maximize learning [36, 37] and as well consider how students learn best [38]. Teachers manage the teaching and learning sessions so that there is minimum wastage of class time and high levels of engagement [37]. According to Woolnough [37], effective teachers monitor their classrooms by anticipating disruptive behaviors as well as checking on student engagement by moving around the classroom during small group work. For Zango et al. [19], an effective teacher's plan for the environment, both the organization of the classroom and of students, allows the classroom to run itself during student-teacher interaction; positions chairs in groups or around tables to promote interaction; manages classroom procedures to facilitate smooth transitions; manages student behavior through clear expectations and firm and consistent responses to student actions; maintains a physical environment where instructional materials and equipment are in good repair; covers walls with student work, student made signs, memos, and calendars of student events; emphasizes students addressing one another in a positive and respectful manner; and encourages interactions and allows low hum of conversations about activities or tasks. Also, an effective teacher maximizes the physical aspect of the environment, manages emergency situations as they occur, maintains acceptable personal workspace, establishes routines for the running of the classroom and the handling of routine student behavior, disciplines students with dignity and respect, shows evidence of established student routines for responsibilities and student leadership, exhibits consistency in management style, posts classroom and school rules, and posts appropriate safety procedures. According to Cherif [25], effective teachers ensure there is a welcoming environment that fosters positive relationships among students regardless of disparities in ethnic background, gender, social class, handicap, or prior academic achievement. Tobin and Fraser [6] reported that effective science teachers actively monitored student behavior in their classes by moving around the room and speaking with individuals from time to time, but they also maintain classroom discipline at a distance over the entire class.

1.2.4 Instructional strategies as a measure of an effective science teacher

Clarity of lesson, as well as the use of varied instructional strategies in delivery, has also been found to be a feature of effective [science] teachers [20]. That is, according to Borich [20], being clear in a lesson implies communicating lesson objectives to learners (describing what behaviors will be tested or required on future assignments as a result of the lesson); giving learners advance organizers; giving instructions patiently and uniquely; and using examples, illustrations, and demonstrations to explain and clarify. Consequently, instructional variability is about how the teacher is flexible in delivering the lesson. Instructional variety is also about using supporting instructional resources, such as computer software,

Using variety (an effective teacher)	Examples of teaching strategies
a. Uses attention-gaining devices (for example, begins with a challenging question, visual, and example) b. Shows enthusiasm and animation through variation in eye contact, voice, and gestures (for example, changes pitch and volume and moves about during the transition to a new activity) c. Varies modes of presentation (for example, presents and asks questions and then provides for independent practice) d. Uses a mix of rewards and reinforcers (for example, extra credit, verbal praise, and independent study) e. Incorporates student ideas or participation in some aspects of instruction (for example, uses indirect instruction or divergent questioning) f. Varies types of questions (for example, divergent and convergent)	a. Begin the lesson with an activity in a modality that is different from the last lesson or activity (for example, change from listening to seeing) b. Change position at regular intervals (for example, every 10 minutes change speed or volume to indicate that a change in content or activity has occurred) c. Establish an order of daily activities that rotate cycles of seeing, listening, and doing d. Establish lists of rewards and expressions of verbal praise and choose among them randomly. Provide reasons for praise along with the expression of it e. Occasionally plan instruction in which student opinions are used to begin the lesson f. Match questions to the behavior and complexity of the lesson objectives. Vary the complexity of the lesson objectives in accordance with the unit plan.

Table 1.
Indicators of instructional variety and corresponding instructional strategies [20].

displays, the internet, and space in your classroom [20]. Hence, the "physical texture and visual variety of the classroom" also form part of the instructional variety ([20], p. 8). **Table 1** shows the indicators and instructional strategies effective teachers use.

Moreover, questioning has been found to be the hallmark of effective teachers [20, 37]. According to Woolnough [37], effective teachers encouraged students to raise questions and respond to them without making the students feel stupid. Thus, the effective teacher needs to know the art of asking questions and how to use the different questioning as: fact questions, process questions, convergent questions, and divergent questions [20]. Effective teachers, check on students' developing understanding by questioning and inviting questions from the students [37]. According to Tobin and Fraser [6], effective teachers use questioning as a form of verbal strategy to stimulate thinking and to probe student responses for clarification and elaboration.

1.3 Empirical views an effective teaching and learning

In an exploratory study conducted by Lumpkin and Multon [21] using 69 male and 30 female teaching fellows (recognized as effective teachers) reported that these effective teachers used various instructional strategies to convey course content to students and enhance their learning. Moreover, in analyzing the profile of effective college and university teachers, Young and Shaw [10] noted that effective teachers are rated very high because of their genuine respect for students, concern for student learning, and value of the course. Also, effective teachers are not necessarily effective in all aspects but they can have some deficiencies. However, an effective teacher can compensate for deficiencies in one or two areas by demonstrating outstanding skills in other areas.

In examining the profile of effective teachers in Greece, Koutrouba [39] concluded that many of the Greek secondary school teachers increased teaching effectiveness with their involvement of students in multimodal learning procedures, using communication techniques that helped to disseminate knowledge in a simpler, more understandable, individualized, and participatory way. Also, one thing that contributes to the effectiveness of the Greek teachers was their swift response to student needs during instruction, and they considered the classroom not as a technical workshop but as a place where human characters are being built. Greek teachers appeared to believe that a teacher's ability to satisfactorily ensure productive classroom management is an important feature of the effective educator, probably because "effective" does not, in any way, means unjustifiably soft and too pliant, but on the contrary, steady and objective during demanding. In addition, Greek teachers perceive cared about students' prior knowledge, simplifying the provided learning material in ways that meet individualized needs and respecting a diversity of any kind, ensuring solidarity and implementing democratic procedures, reducing students' learning load, and encouraging feedback, tend to be considered as effective teacher characteristics [39].

In analyzing the instructional practices of more versus less effective US teachers, Haynie and Stephani [4] reported that the most effective teachers have a more complete package of rigor, relevance, and relationship strategies than less effective teachers. More so, effective teachers have strong content knowledge, prepared their own materials, taught reading and note-taking skills, use time wisely, recognize the need to have a good relationship with the students, give frequent positive feedback, and believe that all students could succeed, create an atmosphere of mutual respect, in which both teachers and students are enthusiastic [4].

In Ghana, in a study involving pre-service teachers, Boadu [2] found out that the preservice teachers perceived effective teaching as comprising the acquisition of content knowledge, knowledge of learners, adequate planning, and collaboration with other teachers. In a related study in science, Adu-Gyamfi [14] examined 100 pre-service students on how they conceptualize who an effective science teacher is and reported that the pre-service teachers conceptualized an effective teacher in six ways. In these six ways, pre-service teachers conceptualize effective teachers to create an enabling learning environment suitable for teaching and learning, select and use appropriate teaching-learning materials, use appropriate teaching approaches and techniques, be mindful of what is expected of them as professionals, be interested in students' academic success, and have adequate content knowledge as well as instructional approaches.

Again, empirical study has shown that teacher preparation has a correlation with effective [science] teaching [40]. Because teacher preparation gives teachers knowledge, skill, and ability that are essential to their professional life [40]. Also, "teacher training molds the personality of teachers such that their attitudes are reshaped, their habits are reformed, and their personality is reconstituted through teachers training" ([40], p. 151). There are two types of teacher preparation: preservice training (training provided before employment of teachers and is generally required for employment) and in-service training (ongoing training teachers receive continuously throughout the educational life of a teacher). In assessing 80 participants to determine the relationship between teacher preparation and teacher effectiveness, Rahman et al. [40] reported that teachers had a positive attitude toward teacher training and its effectiveness in a classroom situation, such as actual instruction or academic work, classroom management, evaluation procedures, assignments, and developing human relationships with students, principal, and society in general. This relationship should be positive. Similarly, Druva and Anderson [3] found a relationship between teacher preparation programs and what their graduates do as teachers and noted that science courses, education courses, and overall academic performance are positively correlated with successful teaching. In this regard, Cimer [7] recommended that college science teachers (supervisors) should prepare preservice [mentee] teachers to develop appropriate knowledge, strategies, and techniques relevant to creating an enabling environment for learning science. Skamp and Mueller [41] in a longitudinal study of preservice teachers' conceptions of effective primary science teaching noted that preservice teachers' conceptions of good science teaching do influence their practice and indicated it is problematic. Thus, teacher educators need to be aware that many conceptions held on entry to preservice education may be retained despite methodology units and practicum experiences.

According to McKnight et al. [5], nations worldwide recognize that to obtain improvement and equity in educational outcomes, attention should be directed toward teacher effectiveness and a primary way of achieving this is for individual countries to identify the competencies required for effectiveness and take that as the basis for developing teaching standards, preservice teacher preparation, professional development programs, and performance evaluations. More so, for an impact to be made, those systems and processes will need to be based on common comprehension, within each country, of what it means to be an effective teacher [5]. To this far, making a comparative analysis of what college teachers (supervisors), in-service teachers (mentors), and preservice teachers (mentees) perspectives of effective teaching and learning science will be one of the best ways to contribute to the development of teaching standards for effective delivery of science lessons in basic schools in Ghana.

2. Research methods

2.1 Research design

This research was structured and executed along the procedures of triangulation mixed methods design. This was necessary as we intended to compare the quantitative results on effective teaching and learning science in basic schools to qualitative results. This helped to validate the quantitative results with the qualitative results in order to understand the views of supervisors, mentors, and mentees on the perceived nature of effective teaching and learning science in basic schools.

In this triangulation mixed methods, we intended to collect as much qualitative data from teachers as possible, collecting both qualitative and quantitative data at the same time. The quantitative data on effective teaching and learning science were analyzed separately from the qualitative data. Thereafter, the two results were compared to establish any convergence or divergence in the views of teachers on effective teaching and learning based on the five-point Likert scale questionnaire and interview schedule employed in the data collection.

2.2 Sample and sampling procedures

The colleges of education in Ghana were mandated to prepare preservice teachers for basic schools (comprising primary and junior high schools). Initially, the colleges of education awarded diplomas in basic education to graduating preservice teachers but since 2018 they have been mandated to award bachelor of education. To achieve this mandate, there were 46 public colleges and four private colleges of education spread across the 16 regions of Ghana involved as accredited institutions. The preservice teachers and their tutors, as well as the in-service teachers in their partner schools, in the 46 public colleges of education were the target population for this research. The 46 public colleges of education were mentored by the University of Ghana (six colleges), University for Development Studies (six colleges), University of Cape Coast (14 colleges), University of Education, Winneba (15 colleges), and Kwame Nkrumah University of Science and Technology (five colleges). The private colleges were as well mentored by some of the leading universities.

The 46 public colleges of education were classified into science colleges and non-science colleges. That is, there were some colleges of education that did not offer preservice teachers the sciences (as chemistry, biology, and physics) as major courses. Of the 46 public colleges of education, 12 were science colleges where preservice teachers pursued science as a major field of study. It was estimated that there were 96 science tutors in the 12 colleges who were selected by the census for this research. Per the best practices of the colleges, preservice teachers were assigned in a group of four members to each partner school of practice. Hence, there was one expected science mentee in 410 schools, where 300 were simply randomly selected together with their mentors to participate in this research. However, 85 science tutors (supervisors), 160 in-service teachers (mentors), and 271 preservice teachers (mentees) gave a total of 516 teachers who participated in the research by responding to the questionnaire. Of the 516 teachers, only 28 supervisors, 54 mentors, and 71 mentees participated in the interviews. Because most of the teachers gave reasons for engagement elsewhere and that they cannot be ready for the interviews at the scheduled times. The 153 teachers interviewed represented approximately 30.0% of the teachers who responded to the questionnaire.

2.3 Data collection instruments

There are two instruments used in this research to collect both quantitative and qualitative data to explore the perceived nature of effective teaching and learning science in order to compare the views of three teacher groups linked to colleges of education in Ghana [42]. The instruments were Effective Science Teacher Questionnaire and Effective Science Teacher Interview Schedule.

2.3.1 Effective science teacher questionnaire [ESTQ]

ESTQ was designed and developed by the researchers based on the findings of Adu-Gyamfi [14]. ESTQ had two sections. Section A comprised four items on teacher background information, such as the zone of college, sex of the teacher, level of teaching, and role of teachers. Section B comprised 69 items on the perceived nature of effective teaching and learning science. The items relating to the perceived nature of effective teaching and learning science were measured on a five-point Likert scale, ranging from a lower level of agreement of one to a higher level of agreement of five (Appendix A). To measure the internal consistency of ESTQ, it was pilot-tested with 10 science teachers outside the research zone. Thereafter, Cronbach's alpha coefficient of reliability was calculated. As the calculated value of Cronbach's alpha coefficient of reliability was *.94*, ESTQ was considered reliable, and none of the items was dropped.

2.3.2 Effective science teacher interview schedule [ESTIS]

ESTIS was designed and developed by the researchers with the intent of triangulating the findings from ESTQ. There were nine items grouped under Sections A and B. Section A had three items measuring the demographics of the teachers and six items in Section B measuring the views of teachers on effective teaching and learning science along instructional strategies, instructional materials, management of instructional time, academic improvement of students, teacher knowledge of content and pedagogy, and learning environment. Under each construct, there were carefully selected prompts to guide the interactions between interviewers and teachers (Appendix B). ESTIS was also designed along the lines of ESTQ and the findings of Adu-Gyamfi [14]. The validity of ESTIS was further achieved through honesty, depth, and richness of qualitative data collected on effective teaching and learning science from the three teacher groups. That is, teachers' views were reported as they were in detail for our audience to make their own judgment. Also, large data will be presented to support any induction leading to qualitative results on effective teaching and learning science. In addition, ESTIS was pilot-tested with 10 teachers and data were analyzed through thematic analysis. The themes were shared with teachers who participated in the pilot test for them to query how their views were used. This approach was repeated in the presentation of results in this chapter. That is, we shared the qualitative results with teachers who were interviewed prior to reporting them here.

2.4 Data collection procedures

The researchers visited the 12 colleges of education and discussed with college science tutors (supervisors) our intent to study effective teaching and learning science with them, their level 300 preservice teachers (mentees), and the mentors in the partner schools [42]. The three teacher groups were happy and prepared to contribute to the research though not all agreed to be interviewed. We used 4 weeks to collect both quantitative and qualitative data on effective teaching and learning science from teachers. ESTQ was first administered to teachers followed by interviews using ESTIS. That is, in each college researchers had first interactions with supervisors followed by mentees and mentors. There were instances the interviews were held immediately after the administration of ESTQ but for others, it took a day or two as we needed to schedule dates of convenience with teachers who were engaged as a result of their tight schedules. The interactions between researchers and teachers using ESTIS were audio-recorded.

2.5 Data processing and analysis

The data from ESTQ were checked to see that teachers had responded to all items. Thereafter, the five-point Likert scale was coded as 1 for a lower level of agreement, 2 for low agreement, 3 for moderate agreement, 4 for high agreement, and 5 for higher agreement. An exploratory factor analysis was used to reduce large data to factors. Multivariate ANOVA was used to examine whether differences existed among supervisors, mentors, and mentees on the factors established as the perceived nature of effective teaching and learning science.

The audio recordings were transcribed and cleaned. Thereafter, the qualitative data on effective teaching and learning science were open-coded and constantly compared using the factors generated from the exploratory factors analysis as the main themes. We made sense of the views of teachers and compared them as coming from supervisors, mentors, and mentees. Sample views and codes of supervisors (such as S001 for supervisor 1), mentors (such as MR001 for mentor 1), and mentees (such as ME001 for preservice teacher 1) were provided to support any induction made on the themes.

3. Results

3.1 Perceived nature of effective teaching and learning science

The research question, in part, explored how the three groups of teachers perceived the nature of effective teaching and learning science in the basic school. To study this, ESTQ was administered to 516 teachers and their mean perceptions are tabulated in **Table 2**. The results showed the perceptions of supervisors, mentors, and mentees leading to the perceived nature of effective teaching and learning science among the teachers. The selected teachers had a highly positive perception of effective teaching and learning science in basic schools. That is, all supervisors, mentors, and mentees highly agreed to effective teaching and learning science (N = *521*, M = *4.25*, and Std. = *1.013*). For instance, under Items 1–11, the results showed that a science teacher was considered effective when his or her teaching in the classroom was geared toward using alternative instructional strategies to support student learning science concepts (Items 1 and 2). Of the 521 teachers, 351 (Item 3, *67.4%*, M = *4.44*, Std. = *.971*) highly perceived that an effective teaching and learning science involved a teacher reviewing the previous knowledge of the learner and choosing activity-based strategies (Item 4, *54.7%*, M = *4.22*, Std. = *1.070*) rather than an expository strategy (Item 5, *16.9%*, M = *2.56*, Std. = *1.508*). The selected teachers, also, highly perceived the instructional strategies of an effective science teacher as being practical and collaborative in nature (Item 6, *65.3%*, M = *4.41*, Std. = *.976*), and the instruction was moderately perceived as often carried out in laboratories (Item 8, *20.5%*, M = *3.07*, Std. = *1.467*) rather than relying on textbooks. In addition, the instructional strategies of an effective science teacher were perceived as teachers used of strategies that enable students to learn by applying knowledge acquired to their life experiences (Item 9, *91%*, M = *4.22*, Std. = *1.065*) and by this, an effective science teacher used illustrations that were real life experiences (Item 10, *62.2%*, M = *4.35*, Std. = *1.065*) and varied the strategies (Item 11, *63.9%*, M = *4.37*, Std. = *1.043*) to aid teaching and learning science in basic schools. Thus, there is a generally high positive perception of effective teaching and learning science that is aided by instructional strategies used by teachers to create opportunities for students learning, perhaps one that lends itself to the constructivist approach.

Again, from **Table 2**, the results showed that an effective teaching and learning science was considered by the majority of the selected teachers to be one where teachers used instructional materials in teaching to aid student learning of science concepts (Items 12–17). For instance, an effective teacher used more than one of those instructional materials in science lessons (Item 12, *56.6%*, M = *4.32*, Std. = *.0942*) made sure the resources were available before the start of the lesson (Item 13, *63.5%*, M = *4.40*, Std. = *.951*), was good in improvising instructional materials where necessary (Item 14, *53.2%*, M = *4.26*, Std. = *.991*), employed multiples teaching and learning resource for explaining the same concepts (Item 15, *50.3%*, M = *4.19*, Std. = *1.021*), used the instructional materials to arouse students' interest in learning (Item 17,

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
1.	An effective science teacher selects and uses instructional strategies	19	3.6	35	6.7	38	7.3	134	25.7	295	56.6	4.25	1.084
2.	An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	7	1.3	34	6.5	33	6.3	96	18.4	351	67.4	4.44	.963
3.	An effective science teacher often reviews students' relevant previous knowledge and builds on them	10	1.9	29	5.6	34	6.5	97	18.6	351	67.4	4.44	.971
4.	An effective science teacher uses activity-based methods of teaching	18	3.5	29	5.6	58	11.1	131	25.1	285	54.7	4.22	1.070
5.	An effective science teacher uses a lecture method of teaching	191	36.7	94	18.0	76	14.6	72	13.8	88	16.9	2.56	1.508
6.	An effective science teacher uses methods that make his/her lessons practical and collaborative/ participatory	11	2.1	24	4.6	47	9.0	99	19.0	340	65.3	4.41	.976
7.	An effective science teacher teaches science through practical works that are laboratory-based to enhance student understanding	14	2.7	41	7.9	64	12.3	109	20.9	293	56.2	4.20	1.097
8.	An effective science teacher relies on textbooks to teach science	97	18.6	108	20.7	107	20.5	91	17.5	115	22.1	3.07	1.467
9.	An effective science teacher teaches scientific concepts and ideas using a methodology that aids the application of the knowledge to everyday life experiences	16	3.1	31	6.0	61	11.7	127	24.4	286	54.9	4.22	1.065
10.	An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts	13	2.5	28	5.4	49	9.4	107	20.5	324	62.2	4.35	1.019
11.	An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	18	3.5	27	5.2	33	6.3	110	21.1	333	63.9	4.37	1.043
12.	An effective teacher uses more than one teaching and learning material	9	1.7	18	3.5	66	12.7	133	25.5	295	56.6	4.32	.942
13.	Effective science teacher ensures that their teaching resources are available before they start their lessons	9	1.7	21	4.0	56	10.7	104	20.0	331	63.5	4.40	.951
14.	An effective science teacher is good at improvisation of teaching and learning materials	15	2.9	17	3.3	65	12.5	147	28.2	277	53.2	4.26	.991
15.	An effective science teacher uses multiple teaching and learning materials for the explanation of the same concept	16	3.1	20	3.8	75	14.4	148	28.4	262	50.3	4.19	1.021

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
16.	An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	7	1.3	20	3.8	58	11.1	138	26.5	298	57.2	4.34	.917
17.	An effective science teacher employs teaching and learning materials that arouse the desire of learners to learn	7	1.3	25	4.8	53	10.2	118	22.6	318	61.0	4.37	.942
18.	An effective science teacher prepares in advance before coming to class	13	2.5	18	3.5	48	9.2	96	18.4	346	66.4	4.43	.968
19.	An effective teacher is confident because he prepares well in advance to produce higher student achievements	12	2.3	18	3.5	52	10.0	108	20.7	331	63.5	4.40	.962
20.	An effective science teacher is someone who tries as much as possible to find something in the community, within his busy schedule, to relate every topic for easy student understanding	8	1.5	21	4.0	73	14.0	142	27.3	277	53.2	4.26	.950
21.	An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments	15	2.9	21	4.0	76	14.6	115	22.1	294	56.4	4.25	1.034
22.	An effective science teacher is creative in teaching science	12	2.3	26	5.0	59	11.3	125	24.0	299	57.4	4.29	1.005
23.	An effective science teacher is one who never misses his/her instructional hours	17	3.3	29	5.6	84	16.1	145	27.8	246	47.2	4.10	1.068
24.	An effective science teacher plans and teaches within the given instructional time	18	3.5	20	3.8	62	11.9	134	25.7	287	55.1	4.25	1.036
25.	An effective science teacher takes his/her time to teach without rushing through the presentation of lesson	14	2.7	19	3.6	44	8.4	123	23.6	321	61.6	4.38	.973
26.	During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	13	2.5	28	5.4	54	10.4	112	21.5	314	60.3	4.32	1.024
27.	An effective science teacher is a teacher who will have time to explain to students' aspects of topics that are difficult to understand	14	2.7	12	2.3	53	10.2	124	23.8	318	61.0	4.38	.950
28.	An effective science teacher uses instructional time consciously to the benefit of students	13	2.5	25	4.8	52	10.0	152	29.2	279	53.6	4.26	.992
29.	An effective science teacher creates a conducive environment for students to learn scientific concepts and ideas	14	2.7	17	3.3	52	10.0	140	26.9	298	57.2	4.33	.969
30.	Effective science teachers' lessons are always interesting and enjoyable.	11	2.1	25	4.8	65	12.5	137	26.3	283	54.3	4.26	.992
31.	An effective science teacher always responds appropriately to questions students ask	12	2.3	17	3.3	57	10.9	134	25.7	301	57.8	4.33	.957

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
32.	An effective science teacher uses formative assessment to sustain students' interest in learning	23	4.4	18	3.5	60	11.5	138	26.5	282	54.1	4.22	1.069
33.	An effective science teacher has good human relationships between science teachers and students during science lessons	14	2.7	22	4.2	71	13.6	118	22.5	296	56.	4.27	1.023
34.	An effective science teacher loves and shows empathy for students	17	3.3	31	6.0	68	13.1	139	266	51.1		4.16	1.072
35.	An effective science teacher is an open-minded person creating room for constructive criticism	15	2.9	19	3.6	67	12.9	158	30.3	262	50.3	4.21	.996
36.	An effective science teacher motivates students to learn science	13	2.5	16	3.1	50	9.6	118	22.6	324	62.2	4.39	.957
37.	An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied	8	1.5	12	2.3	62	11.9	113	21.7	326	62.6	4.41	.897
38.	An effective science teacher guides students on how to search for answers to questions raised	14	2.7	20	3.8	64	12.3	160	30.7	263	50.5	4.22	.987
39.	An effective science teacher builds his/her students' confidence in the learning of the subject of science	14	2.7	13	2.5	69	13.2	121	23.2	304	58.3	4.32	.978
40.	An effective science teacher provides students with the experiences needed to learn science	12	2.3	17	3.3	59	11.3	139	26.7	294	56.4	4.32	.958
41.	An effective science teacher has good class control	10	1.9	22	4.2	55	10.6	114	21.9	320	61.4	4.37	.964
42.	An effective science teacher presents his/her lessons systematically and orderly	13	2.5	17	3.3	52	10.0	112	21.5	327	62.8	4.39	.966
43.	An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	16	3.1	15	2.9	59	11.3	114	21.9	317	60.8	4.35	.998
44.	An effective science teacher ensures that everyone understands the first topic before moving to the next topic	15	2.9	29	5.6	75	14.4	127	24.4	275	52.8	4.19	1.059
45.	An effective science teacher gives a kind of exercise that will demand a lot of research for about a week	50	9.6	44	8.4	94	18.0	128	24.6	205	39.3	3.76	1.311
46.	An effective science teacher evaluates learners in science class	15	2.9	27	5.2	62	11.9	149	28.6	268	51.4	4.21	1.029
47.	An effective science teacher monitors learners in science class	9	1.7	29	5.6	66	12.7	135	25.9	282	54.1	4.25	.992
48.	An effective science teacher gives students enough work examples for them to practice	11	2.1	20	3.8	73	14.0	136	26.1	281	53.9	4.26	.979
49.	An effective science teacher always gives an assignment, to his/her students, marks, and discusses it so the students know their shortcomings for rectification	10	1.9	19	3.6	68	13.1	111	21.3	313	60.1	4.34	.968

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
50.	An effective science teacher distributes questions to all students in science lessons	17	3.3	15	2.9	69	13.2	130	25.0	290	55.7	4.27	1.014
51.	An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	16	3.1	19	3.6	46	8.8	110	21.1	330	63.3	4.38	1.001
52.	An effective science teacher communicates science terminologies very well to the understanding of students	15	2.9	15	2.9	60	11.5	130	25.0	301	57.8	4.32	.984
53.	An effective science teacher can be tolerant of all students' questions and issues in science lessons	20	3.8	22	4.2	70	13.4	144	27.6	265	50.9	4.17	1.063
54.	An effective science teacher responds swiftly to students' questions raised during lessons	14	2.7	32	6.1	97	18.6	143	27.4	235	45.1	4.06	1.060
55.	An effective science teacher provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom.	8	1.5	18	3.5	63	12.1	114	21.9	318	61.0	4.37	.932
56.	An effective science teacher considers individual intellectual abilities in teaching scientific concepts and ideas to a class of students	12	2.3	23	4.4	74	14.2	146	28.0	266	51.1	4.21	.997
57.	An effective science teacher considers the academic level of students in teaching scientific concepts and ideas	11	2.1	17	3.3	67	12.9	134	25.7	292	56.0	4.30	.959
58.	An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	11	2.1	20	3.8	56	10.7	132	25.3	302	58.0	4.33	.960
59.	An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	11	2.1	21	4.0	70	13.4	138	26.5	281	53.9	4.26	.979
60.	An effective science teacher prepares students to perform creditably well in examinations.	10	1.9	21	4.0	66	12.7	137	26.3	287	55.1	4.29	.965
61.	An effective science teacher demonstrates sufficient knowledge of science to students	15	2.9	26	5.0	64	12.3	148	28.4	268	51.4	4.21	1.028
62.	An effective science teacher should have in-depth knowledge of the topic before teaching	1	0.2	15	2.9	25	4.8	57	10.9	115	22.1	4.29	1.048
63.	An effective science teacher is a teacher who justifies what he/she is teaching to the admiration of students	19	3.6	27	5.2	74	14.2	127	24.4	274	52.6	4.17	1.085
64.	An effective science teacher is abreast of the current state of scientific knowledge	10	1.9	26	5.0	68	13.1	131	25.1	285	54.7	4.26	.993
65.	An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	13	2.5	17	3.3	68	13.1	113	21.7	310	59.5	4.32	.989

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
66.	An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	11	2.1	19	3.6	66	12.7	127	24.4	298	57.2	4.31	.970
67.	An effective science teacher can justify what he/she is teaching using the appropriate approach	7	1.3	13	2.5	63	12.1	123	23.6	315	59.1	4.39	.890
68.	An effective science teacher uses appropriate instructional strategies to present the content	13	2.5	12	2.3	52	10.0	135	25.9	308	59.1	4.37	.936
69.	An effective science teacher uses a variety of approaches to avoid boredom during science lessons	13	2.5	9	1.7	57	10.9	85	16.3	356	68.3	4.47	.936
	Overall											**4.25**	**1.013**

LW = Lower, L = Low, M = Moderate, H = high, HH = higher, SD = standard deviation, F = frequency, M = Mean.

Table 2.
Mean perceptions of teachers on the perceived nature of teaching and learning science (N = 516).

61.0%, M = *4.37*, Std. = *.942*), and aided students' comprehension of science concepts in basic schools (Item 16, *57.2%*, M = *4.34*, Std. = *.917*). Hence, supervisors, mentors, and mentees perceived positively that characteristically, and effective teaching and learning science involves teachers acquiring and appropriately using instructional materials for lesson delivery to aid learning science by students in basic schools.

The results under Items 18–28 of **Table 2** provided the image of effective teaching and learning science in terms of preparation and time management of teachers. For instance, the selected teachers highly perceived that an effective science teacher prepared in advance (Item 18, *66.4%*, M = *4.43,* Std. = *.968*) to ensure his or her confidence to produce higher students' achievement (Item 19, *63.5%*, M = *4.40*, Std. = *.962*). Also, the selected teachers highly perceived that creativity was needed in teaching and learning science (Item 22, *57.4%*, M = *4.29*, Std. = *1.005*) to make effective use of materials in the immediate environment to aid learning science concepts (Item 20, *53.2%*, M = *4.26*, Std. = *.950*). Besides the selected teachers perceived that an effective science teacher was punctual (Item 23, *47.2%*, M = *4.10*, Std. = *1.068*) making effective use of time in lesson delivery (Item 24, *55.1%*, M = *4.25*, Std. = *1.036*) to demonstrate science concepts and explain difficult parts of the concept (Items 26 and 27) and not misusing instructional hours (Items 28, *53.6%*, M = *4.25*, Std. = *.992*). Hence, all teachers (supervisors, mentors, and mentees) perceive that another nature of effective teaching and learning is related to advanced preparation and instructional time management in basic school science.

Moreover, the results showed that the selected teachers perceived that an effective teaching and learning science was a unique one and should be held in a conducive learning environment (Items 29–55). For instance, the majority of the selected teachers highly perceived an effective science teacher was one who created a conducive environment for students to learn (Item 29, *57.2%*, M = *4.33*, Std. = *.969*), leading to interesting lessons on science concepts (Item 30, *54.3%,* M = *4.26,* Std. = *.992*). Because students can ask questions and are responded to (Items 31, 53, and 54) establishing a good personal relationship with students and their teachers to foster learning science by students in basic schools (Items 33, 34, 35, 37, and 38). Thus, in creating a conducive learning environment, the selected teachers perceived that effective science teachers made attempts to motivate and inspire students to learn science (Items 36 and 39) and to assess students' learning (Items 32 and 45). Also, effective teaching and learning science demanded that lessons were presented by teachers systematically and sequenced from simple to complex with well-ordered concepts (Items 42, 43, and 44). Hence, the three groups of teachers perceive that another nature of effective teaching and learning science is teachers' creation of a conducive environment friendly to students' learning science in the basic schools.

Again, the results showed that the selected teachers perceived effective teaching and learning science as that of which teachers were interested in students' successes in their academics. Because under Items 56–60, teachers perceived that an effective science teacher considered the individual intellectual capability when teaching to aid students in learning science concepts (Items 56 and 57), allowing this to guide the selection of instructional strategies and resources (Item 58, *58.0%,* M = *4.33*, Std. = *.960*). Besides, the selected teachers highly perceived that an effective science teacher used instructional strategies and materials to create room for addressing student weaknesses in science concepts (Item 59, *53.9%,* M = *4.26,* Std. = *.979*) aiding students in preparation for examinations to perform creditably well (Item 60, *55.1%,* M = *4.29,* Std. = *.965*). Hence, characteristically, the three groups of teachers perceive that effective teaching and learning science should be geared toward great interest in students' success.

Also, the results from **Table 2** showed that the selected teachers perceived effective teaching and learning science as one where teachers demonstrated adequate knowledge of content and instructional strategy. Because under Items 61–69, supervisors, mentors, and mentees perceived that an effective science teacher should have sufficient knowledge of science concepts (Items 61 and 62) through research to demonstrate detailed explanations of science concepts to basic school students (Items 65 and 66). More so, an effective science teacher was capable of transforming content knowledge using appropriate instructional strategies in science lessons (Items 68, *59.1%,* M = 4.37, Std. = *.936*) and being able to sustain students' interest (Item 69, *68.3%,* M = *4.47*, Std. = *.936*). Hence, the supervisors, mentors, and mentees perceive that another nature of effective teaching and learning science is demonstrated through teachers' knowledge of science content and instructional strategy.

3.2 Factors accounting for perceived nature of effective teaching and learning science

Having established the nature of effective teaching and learning as perceived by supervisors, mentors, and mentees, there was need to explore further the factors that accounted for this positive perception of the selected groups of teachers. In order to explore the factors that accounted for the teacher's perception of effective teaching and learning science, a principal component analysis (PCA) was conducted on the 69 items on ESTQ. To begin with, the Kaiser-Meyer-Olkin (KMO) measure was verified to be *.979* with Bartlett's test for sphericity (*34066.712*) being significant (p = *.000*, df = *2346*). With KMO above *.50* and Bartlett's test for sphericity being significant, factor analysis was conducted because none of the assuptions under factor analysis was violated [43–46]. Factor analysis was conducted with the 69 items and based on Kaiser Criterion of *1*, seven components were obtained with a cumulative explanation of variance being *67.8%.* The percentage variance of the seven components is presented in **Table 3**.

In order to ascertain if all components were worth retaining, the scree plot was examined. The results from the scree plot are presented in **Figure 1**.

From **Figure 1**, it is apparent that three components were worth retaining. Because according to Pallnt [45], when checking the scree plot to determine the factors to retain, one needs to look for the change in the shape of the plot and consider only components above it for retention. Thus, components 1, 2, and 3 were retained as the factors that accounted for the perceived nature of effective teaching and learning science. Aside from the three components being above the change in shape, they explained more (*60.1%* cumulative explanation) of the variance than the other components.

A parallel analysis (PA) was further run to ascertain if the three components were worth retaining [47]. The actual eigenvalues from the PCA were compared with the criterion values from the PA. A decision was made to accept eigenvalues of the PCA greater than the criterion value of the PA, and fewer values were rejected [45, 47, 48]. The results of the comparison of the PCA and PA are presented in **Table 4**.

The results from **Table 4** showed that only three factors were to be retained. Because only the three factors have their eigenvalues greater than the criterion values from the parallel analysis. Therefore, only three factors were retained for the determination of the selected teachers' perception of effective teaching and learning science in the basic school.

Component	Total	% of variance	Cumulative %
1	37.146	53.835	53.835
2	2.628	3.809	57.644
3	1.775	2.572	60.215
4	1.542	2.235	62.450
5	1.346	1.951	64.401
6	1.283	1.859	66.261
7	1.032	1.496	67.757

Table 3.
Percentage variance explained by the extracted components.

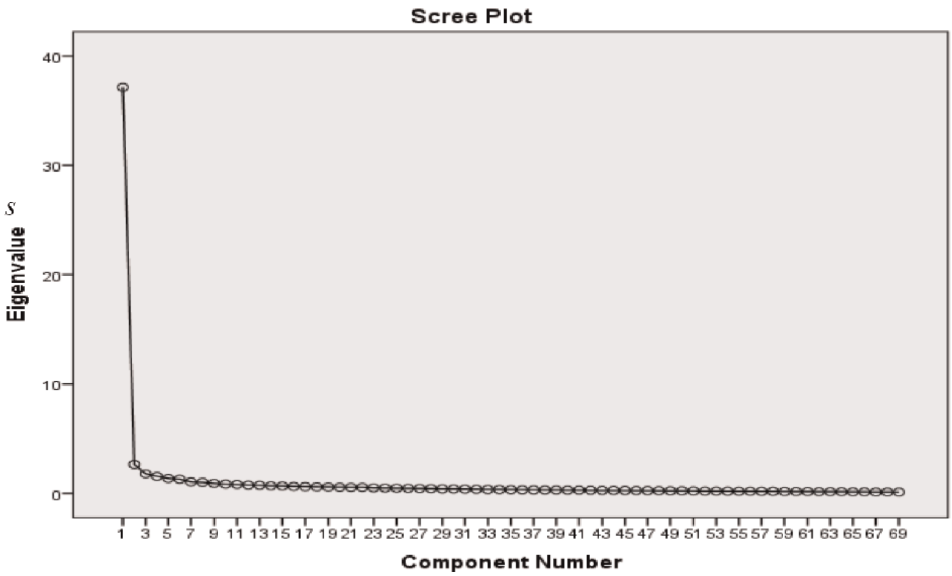


Figure 1.
An illustration of components of the perceived nature of effective teaching and learning science.

Component number	Actual eigenvalue from PCA	Criterion value from parallel analysis	Decision
1	37.146	1.798937	Accept
2	2.628	1.729698	Accept
3	1.775	1.681724	Accept
4	1.542	1.641841	Reject

Table 4.
Comparing eigenvalues from PCA to criterion values from PA on effective teaching and learning science.

The principal component analysis was conducted again with only the three factors. Inspection of the commonalities of the various items revealed some extremely low commonalities. Hence, items whose commonalities were below .6 [44, 46] were deleted and a re-run of the PCA was conducted. Consequently, 36 items were re-run after the deletion of 28 items with low communalities and those 36 items gave a KMO value of *.975* and Bartlett's test for sphericity (*17625.684*) to be (df = *630*, ρ = *.000*). However, to make the data interpretable, varimax rotation was conducted [44–46]. For practical significance, a factor loading of *.7* or above for a sample size of 100 or more was appropriate [44], as it implied such factor loading accounted for more than 50.0% of the variance explained by a variable. Thus, in this research, factors that loaded above *.5* were considered. In the case of cross-loadings, only factors with higher loading under a particular component were considered [39]. From the varimax rotation as shown in **Table 5**, factor 1 explained *59.97%*, factor 2 explained *4.66%*, and factor 3 explained *2.75%*. However, the total variance explained remained almost the same *67.38%* as obtained from the initial analysis. The reliabilities of the factors were determined to be *.973* for factor 1, for factor 2, *.921*, for factor 3, *.932,* and the overall reliability was *.981*. The factor loadings together with the variance explained and Cronbach alpha of the components are shown in **Table 5**.

The three factors retained were conceptualized as a conducive learning environment (being teacher's knowledge of how to transform the content in a classroom that

Statement	Eigenvalues
An effective science teacher often reviews students' relevant previous knowledge and builds on them	.664
An effective science teacher uses methods that make his/her lessons practical, and collaborative/participatory	.749
An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts	.740
An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	.652
An effective teacher uses more than one teaching and learning materials	.647
An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	.708
An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	.497
An effective science teacher prepares in advance before coming to class	.638
An effective teacher is confident because he prepares well in advance to produce higher students achievements	.654
An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessment	.619
An effective science teacher is creative in teaching science	.650
During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	.674
An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand	.626
An effective science teacher uses instructional time consciously to the benefit of students	.659
An effective science teacher has good human relationships between science teachers and students during science lessons	.626

DOI: http://dx.doi.org/10.5772/intechopen.110366

Statement	Eigenvalues		
An effective science teacher loves and shows empathy for students	.691		
An effective science teacher motivates students to learn science	.574		
An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied,	.616		
An effective science teacher guides students on how to search for answers to questions raised	.732		
An effective science teacher builds his/her students' confidence in learning of the subject science	.671		
An effective science teacher provides students with experiences needed to learn science	.703		
An effective science teacher presents his/her lessons systematically and orderly	.630		
An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	.529		
An effective science teacher gives students enough work examples for them to practice	.694		
An effective science teacher always gives an assignment, to his/her students, marks, and discusses it so the students know their shortcomings for rectification	.714		
An effective science teacher distributes questions to all students in science lessons	.759		
An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	.732		
An effective science teacher communicates science terminologies very well to the understanding of students	.677		
An effective science teacher can be tolerant of all students' questions and issues in science lessons	.727		
An effective science teacher provides students with opportunities to develop knowledge, skills, and attitudes they need in the classroom	.646		
An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	.542		
An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	.584		
An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	.564		
An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	.550		
An effective science teacher can justify what he/she is teaching using the appropriate approach	.527		
An effective science teacher uses appropriate instructional strategies to present the content	.602		
% variance explained	59.97	4.66	2.75
Cumulative % variance explained	67.38		
Cronbach alpha	.973	.921	.932
overall Cronbach alpha	.981		

Table 5.
Factors evolving from the component matrix on the perceived nature of effective science teachers by supervisors, mentors, and mentees.

is friendly enough to meet the learning needs of students), instructional processes (the steps taken by the teacher to support students make meaning of science concepts in the classroom), and consciousness of professional demands (being teacher awareness of what are expected of him or her and preparing to in advance to boost confidence to implement lessons within scheduled time) [14].

3.2.1 Conducive learning environment

This factor explained what effective science teachers do in the classroom as they attempt to transform their knowledge of the content to suit the learning needs of students in a friendly manner. The means of agreement of the groups of items under a conducive learning environment are presented in **Table 6**.

The results showed that the average mean of conducive learning environment was *4.32* (Std. = *.97*). This indicated that the selected teachers highly perceived conducive learning environment as nature of effective teaching and learning science in the basic school. To further understand this, all three groups of teachers were interviewed using ESTIS. From the analyzed interviews, the selected teachers viewed effective teaching and learning science as associated with the creation of a

Statement	M	Std.
An effective science teacher has good human relationships between science teachers and students during science lessons	4.27	1.023
An effective science teacher loves and shows empathy for students	4.16	1.072
An effective science teacher motivates students to learn science	4.39	.957
An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied,	4.41	.897
An effective science teacher guides students on how to search for answers to questions raised	4.22	.987
An effective science teacher builds his/her students' confidence in learning of the subject science	4.32	.978
An effective science teacher provides students with experiences needed to learn science	4.32	.958
An effective science teacher presents his/her lessons systematically and orderly	4.37	.964
An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	4.39	.966
An effective science teacher gives students enough worked examples for them to practice	4.26	.979
An effective science teacher always gives an assignment, to his/her students, marks and discusses it so the students know their shortcomings for rectification	4.34	.968
An effective science teacher distributes questions to all students in science lessons	4.27	1.014
An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	4.38	1.001
An effective science teacher communicates science terminologies very well to the understanding of students	4.32	.984
An effective science teacher can be tolerant of all students' questions and issues in science lessons	4.17	1.063
An effective science teacher provides students with opportunities to develop knowledge, skills, and attitudes they need in the classroom.	4.37	.932

DOI: http://dx.doi.org/10.5772/intechopen.110366

Statement	M	Std.
An effective science teacher considers level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	4.33	.960
An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	4.26	.979
An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	4.32	.989
An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	4.31	.970
An effective science teacher can justify what he/she is teaching using the appropriate approach	4.39	.890
An effective science teacher uses appropriate instructional strategies to present the content	4.37	.936
Overall	**4.32**	**0.97**

Table 6.
Mean agreements of teaching and learning science in conducive learning environment.

conducive learning environment to inspire students to learn science concepts. An excerpt is;

> *By creating a very conducive and good teacher-student relationship in order to arouse the interest of students during lessons. This eliminates fear from students and subsequently boosts learning* (ME006).

In a conducive learning environment, teachers motivated students to freely ask questions. Excerpts are;

> *Yes, because when there is a good relationship between teacher and students, a very conducive academic environment is created for students to willingly ask questions and teachers demonstrate their knowledge here* (ME050).

> *Yes, when there is a conducive environment and a good relationship between teacher and student, they are motivated to feel free and willing to ask questions during lessons. In this kind of environment, students feel the knowledge of their teacher* (S024).

Also, in a conducive learning environment, teachers demonstrated in-depth knowledge of the content of science to make students feel comfortable in learning. An excerpt is;

> *Should be well knowledgeable in scientific content and instructional strategies so as to know what they teach and to instill confidence in his/her students* (MR028).

3.2.2 Instructional processes

The instructional processes described effective teaching and learning science as encompassing all the steps taken by teachers to aid in the presentation of science concepts in lessons to the understanding of their students. **Table 7** shows the mean agreement on the perceived nature of effective teaching and learning science in relation to instructional processes.

Statement	M	Std.
An effective science teacher often reviews students' relevant previous knowledge and builds on them	4.44	.971
An effective science teacher uses methods that make his/her lessons practical and collaborative/participatory	4.41	.976
An effective science teacher is the teacher who uses real-life illustrations to explain various scientific concepts	4.35	1.019
An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	4.37	1.043
An effective teacher uses more than one teaching and learning materials	4.32	.942
An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	4.44	.963
An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	4.34	.917
Overall	**4.38**	**.980**

Table 7.
Mean agreements of effective teaching and learning science in relation to instructional processes.

It can be deduced from **Table 7** that the selected teachers had a high positive perception (M = *4.38*, Std. = *.980*) of the instructional processes as a factor of effective teaching and learning. That is, all supervisors, mentors, and mentees perceived highly that instructional processes such as making science lessons practical and participatory (M = *4.41*, Std. = *.976*) through the use of multiple teaching and learning resources (M = *4.32*, Std. = *.942*), and selecting and using relevant resources in science lessons (M = *4.44*, Std. = *.963*) contributed to effective teaching and learning science in basic schools. Also, teachers taking steps to vary the instructional strategies in a lesson (M = *4.37*, Std. = *1.043*) and using real-life illustrations to explain concepts (M = *4.35*, Std. = *1.019*) were dimensions of instructional processes that contributed to effective teaching and learning science in basic schools.

To further understand issues relating to instructional processes, the outcomes of the interviews using ESTIS with supervisors, mentors, and mentees were analyzed under this theme. The three groups of teachers confirmed that effective teaching and learning science involved the use of participatory approaches in science lessons. Because the teachers interviewed were of the view that adopting steps to use group activities, demonstrations, hands-on activities, and other participatory instructions was key to effective teaching and learning science in basic schools. Excerpts are;

> *These participatory teaching methods are effective because learners are able to construct knowledge among themselves and this aids their understanding* (ME051).
>
> *The use of group activities helps involve everybody in the class including the weaker ones to make meaning with some ease* (MR055).
> *… because students learn well when they are made to actively participate through hands-on experiences (experiments)* (S021).

There appeared to be agreement on the viewpoint of the teachers interviewed that effective teaching and learning science involved selection and usage of more than one instructional resource and that they either improvise these or go for realia. Excerpts are

> *They improvise or buy them from shops. Because teachers need variety to spice their teaching* (ME013).

> *Picking them from their locality is important but measures should be put in place by the science teacher to use more conventional materials. Because they enrich students' experiences* (MR001).

> *… purchase them from the market and also through the internet. Because to be effective, you will need the materials and then, adopt means as a teacher to help students in the classroom* (S028).

Teachers taking steps to use a variety of instructional resources in science lessons was made stronger as the teachers interviewed believed that the multiple uses of instructional materials aided students' comprehension of science concepts. Excerpts are;

> *To give students the experience of diversified ways of learning and solving problems using a number of materials in a single lesson is important* (S008).

> *… the more instructional materials used, the more in-depth knowledge and understanding they provide to students* (S021).

3.2.3 The consciousness of professional demands

Continuous professional development described a teacher's awareness of what was expected of him or her leading to preparation in advance to boost confidence in implementing lessons within the scheduled time. The mean agreement on the perceived nature of effective teaching and learning science in relation to the consciousness of professional demands is presented in **Table 8**.

As shown in **Table 8**, the selected teachers' highly perceived effective teaching and learning science was influenced by teacher consciousness of professional demands. Because all supervisors, mentors, and mentees highly agreed that teacher consciousness of professional demands (M = *.4.33,* Std. = *.991*) is one of the factors of effective teaching and learning science in basic schools. That is, effective science teachers prepared in advance prior to meeting students in science classrooms (M = *4.43*, Std. = *.968*) to boost their confidence in teaching (M = *4.40,* Std. = *.962*) leading to effective management of instructional time in teaching difficult science concepts (M = *4.38,* Std. = *.950*) to the benefit of students (M = *4.26*, Std. = *.992*).

To validate the factor and consciousness of professional demands as contributing to effective teaching and learning science, some selected supervisors, mentors, and mentees were interviewed with ESTIS. The outcomes of the interviews were analyzed with the consciousness of professional demands as one of the themes. From the viewpoint of the teachers interviewed, effective teaching and learning science should involve teachers making a conscious effort to meet the demands of their job, especially their interactions with students in the classroom. For instance, teachers interviewed mentioned that effective teaching and learning science involved teachers preparing well ahead to address any envisaged shortfalls to aid students in learning science concepts. Excerpts are;

Statement	M	Std.
An effective science teacher prepares in advance before coming to class	4.43	.968
An effective teacher is confident because he prepares well in advance to produce higher students achievements	4.40	.962
An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments	4.25	1.034
An effective science teacher is creative in teaching science	4.29	1.005
During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	4.32	1.024
An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand	4.38	.950
An effective science teacher uses instructional time consciously to the benefit of students	4.26	.992
Overall	**4.33**	**.991**

Table 8.
Mean agreements of effective teaching and learning science in relation to consciousness of professional demands.

> *… teachers prepare by planning and allocating a number of minutes that will be used at every stage of the lesson because when teachers prepare ahead, they can work around any problem that will hinder effective teaching* (S008).

> *… prepares by having proper planning on when and what to use. You see without preparing in advance the teacher will not see any problem ahead* (MR001).

Professionally, teachers teaching in basic schools needed to plan their lessons. That is, planning for effective teaching and learning science included their preparation of lesson notes. A well-planned lesson contributed to teachers' confidence in the process of teaching and learning science. Excerpts are:

> *Effective teaching is achieved through the preparation of lesson plans. This makes you a professional teacher from the nonprofessionals* (MR045).

> *… This makes the teacher confident to do a better explanation of scientific concepts without deviating* (ME005).

> *The demands of the lesson plan as professional teachers make lesson presentations effective, efficient, and good time managers* (MR013).

The teachers interviewed mentioned that, professionally, the essence of advanced preparation helped teachers to manage their time well. Excerpts are:

> *Yes, in order not to spend so much time, which will lead to waste of time, as a would-be professional teacher, I'm trained to plan for effective use of time during teaching* (ME028).
> *Time budgeting is an important aspect of a well-planned science lesson. Hence, to be effective in science lessons, I look forward to seeing how teacher trainees manage time during science lessons as I supervise them* (S0031).

3.3 Differences in perceived nature of effective teaching and learning science among supervisors, mentors, and mentees

Also, the research question sought to examine whether differences existed among supervisors, mentors, and mentees on the three factors established as contributing to the perceived nature of effective teaching and learning science. To achieve this, multivariate analysis of variance (MANOVA) was used. To be sure of having selected the right statistics, first, normality and the presence of multivariate outliers were determined using the Mahalanobis distance [45]. Tabachnick and Fidell [46] explained Mahalanobis distance as the distance of a case from the centroid of the remaining cases where the centroid was the point created at the intersection of the means of all the variables. The purpose was to reveal any cases that lie at a distance from the other cases and such cases were considered outliers. In order to detect which cases were multivariate outliers, the critical X^2 value of the degree of freedom of the independent variables was compared with the Mahalanobis distance of the cases [46]. Any case whose Mahalanobis distance value was greater than the critical X^2 was considered an outlier.

According to Tabachnick and Fidell [46], research with the independent variable at three levels, such as teachers (supervisors, mentors, and mentees) should have a critical X^2 value of *16.27*. Thus, with the three independent variables in this research, the Mahalanobis were examined and five cases with extremely high critical values (case 49 with a critical value of 56.8; case 287 with 54.64; case 425 with 31.09; case 515 with 30.72, and case 498 with 29.24) were deleted [45, 46]. Another calculation of the Mahalanobis distance after deletion produced a few outliers whose critical values were much closer to the cutoff point. Hence, it was maintained to form part of the study. When Cook's distance (a measure of the influence of outliers on the model) was also examined, the maximum value was found to be *.056*. According to Ref. [46], if the Cook's distance was greater than *1*, then there was suspicion of the presence of outliers with a potential effect on the results. Since Cook's distance was less than *1*, then the researchers assumed there was no problem and that the data on effective teaching and learning science was suited for MANOVA statistics.

In furtherance, an inspection of the mean scores and results of the mean perceptions are presented in **Table 9**.

The results from **Table 9** indicated that mentors' perception of an effective science teachers' instructional processes was slightly higher (M = *22.52*, Std. = *3.46*) than supervisors (M = *21.88*, Std. = *3.78*) and mentees (M = *21.76*, Std. = *4.74*). Their lower standard deviation values also implied the scores were closely spread around their mean values. Again, the mean perception of effective teaching and learning science in terms of consciousness of professional demands in relation to supervisors (M = *30.78*, Std. = *5.72*), mentors (M = *30.51*, Std. = *5.12*), and mentees (M = *30.20*, Std. = *6.18*) were virtually the same. For a conducive learning environment, all three groups of teachers showed slight differences in their means with mentors showing a higher mean score (M = *105.54*, Std. = *14.68*) than mentees (M = *103.77*, Std. = *18.51*) and supervisors (M = *102.25*, Std. = *15.54*). Although differences in mean values existed in some cases, it was difficult to claim the difference was significant. Hence, there was the need to further examine the perceived nature of effective teaching and learning science by the groups of teachers using MANOVA.

In addition to assessing the fitness of the data on effective teaching and learning science for MANOVA statistics, homogeneity of variance was assessed and the results are presented in **Table 10**.

	N	Role as a teacher	M	Std.
Instructional processes	85	Supervisor	21.88	3.78
	160	Mentor	22.52	3.46
	271	Mentee	21.76	4.74
	516	Total	22.02	4.23
Consciousness of professional demands	85	Supervisor	30.78	5.72
	160	Mentor	30.51	5.12
	271	Mentee	30.20	6.18
	516	Total	30.39	5.79
Conducive learning environment	85	Supervisor	102.25	15.64
	160	Mentor	105.54	14.68
	271	Mentee	103.77	18.51
	516	Total	104.07	16.95

Table 9.
Mean scores on perceived nature of effective teaching and learning science.

Box's M	F	df1	df2	p
37.81	3.17	12	328844.497	.000*
*Significant at p < .01.				

Table 10.
Test of homogeneity of variance on effective teaching and learning science for MANOVA.

From **Table 10**, the results showed that the Box's M (*37.81*) was significant (p = *.000*). This implied there was a violation of the assumption on the homogeneity of variance. However, Tabachnick and Fidell [46] reported that with a large sample size, such as 516 in this research, the violation can occur because Box's M was too strict for larger sample sizes. Also, given that in this research the sample size was over 500, the violation was not a problem and hence, MANOVA was run. The researchers then went further to examine Levene's test of equality of variance. The results on equality of variance are presented in **Table 11**.

From **Table 11**, the results showed there was a violation of the assumption of the equality of variance at a significance value of *.01*. However, Pallant [45] indicated that where there was a violation of assumptions, Pillai's trace should be chosen over Wilker in presenting the findings and that a more conservative significance level of *.01* was needed.

Having checked these assumptions, a one-way between-groups MANOVA was performed to investigate how the three groups of teachers perceived the nature of effective teaching and learning science. The dependent variable, the perceived nature of effective teaching and learning science were of three levels; conducive learning environment, instructional processes, and consciousness of professional demands. The independent variable, the three groups of teachers (caption as the role of the teacher) was of three levels; supervisor, mentor, and mentee. The results of the multivariate test of significance are presented in **Table 12**.

	F	df1	df2	p
Instructional processes	6.961	2	513	.001*
Consciousness of professional demands	3.653	2	513	.027**
Conducive learning environment	6.895	2	513	.001*
***Not significant at p* > .01.				

Table 11.
Test of equality of error variances on effective teaching and learning science using Levene's test.

Effect		Value	F	Hypothesis df	Error df	p	Partial Eta Squared
Role as a teacher	Pillai's Trace	.087	7.77	6.000	1024.000	.000*	.044
**Significant at p* < .017.							

Table 12.
Multivariate test of significance on perceived nature of effective teaching and learning science.

The results from **Table 12** showed there was a statistically significant difference between the three groups of teachers (supervisors, mentors, and mentees) on the perceived nature of effective teaching and learning science. Because the calculated Pillai's Trace vale (*.087*) was significant (F(*3, 511*) = *7.77*, p = .000). Hence, there was the need to examine further the differences in relation to supervisors, mentors, and mentees on the perceived nature of effective teaching and learning science. To do this, the researchers set a high alpha level to avoid committing a *type 1 error.* As the perceived nature of teaching and learning science was of three levels, the alpha level was set at *.017*. The results are presented in **Table 12**.

This MANOVA was conducted to examine the role of teacher (supervisor, mentor, and mentee) differences on the perceived nature of effective teaching and learning science. The continuous variables used in this aspect of the research were instructional processes, the consciousness of professional demands, and a conducive learning environment. The results are presented in **Table 13**.

Source	Perceived nature of effective teaching and learning science	Type III sum of squares	df	Mean square	F	p	Partial Eta Squared
Corrected model	Instructional processes	59.699[a]	2	29.850	1.670	.189*	.006
	Consciousness of professional demands	25.099[b]	2	12.550	.374	.688*	.001
	Conducive learning environment	654.766[c]	2	327.383	1.140	.321*	.004
Intercept	Instructional processes	201675.326	1	201675.326	11284.625	.000**	.957
	Consciousness of professional demands	385550.665	1	385550.665	11483.662	.000**	.957
	Conducive learning environment	4472229.780	1	4472229.780	15574.763	.000**	.968

Source	Perceived nature of effective teaching and learning science	Type III sum of squares	df	Mean square	F	p	Partial Eta Squared
Role as a teacher	Instructional processes	59.699	2	29.850	1.670	.189*	.006
	Consciousness of professional demands	25.099	2	12.550	.374	.688*	.001
	Conducive learning environment	654.766	2	327.383	1.140	.321*	.004
Error	Instructional processes	9168.177	513	17.872			
	Consciousness of professional demands	17223.381	513	33.574			
	Conducive learning environment	147305.860	513	287.146			
Total	Instructional processes	259324.000	516				
	Consciousness of professional demands	493726.000	516				
	Conducive learning environment	5736299.000	516				
Corrected Total	Instructional processes	9227.876	515				
	Consciousness of professional demands	17248.481	515				
	Conducive learning environment	147960.626	515				

**Not significant at p* > .017.

Table 13.
MANOVA statistics of three groups of teachers on perceived nature of effective teaching and learning science.

The results from **Table 13** showed that there was no statistically significant difference (using a Bonferroni adjusted alpha level of *.017*) in how the selected teachers perceived effective teaching and learning science in the basic schools. Because the mean perceived nature of effective teaching and learning science in relation to a conducive learning environment (M = *104.07*, Std. = *16.95*, F(*2, 513*) = *1.140*, p = *.321*) was not statistically different from the mean perception of instructional processes (M = *22.02*, Std. = *4.23*, F(*2, 513*) = *1.670*, p = *.189*) and the mean perception of consciousness of professional demands (M = *30.39*, Std. = *5.79*, F(*2, 513*) = *.374*, p = *.688*).

To triangulate this finding of no difference in the perceived nature of effective teaching and learning science among supervisors, mentors, and mentees, some selected teachers were interviewed using ESTIS. The results from the interview suggested all three groups of teachers perceived the nature of effective teaching and learning science in similar ways in terms of a conducive learning environment, instructional processes, and consciousness of professional demands. For instance, when all the teachers interviewed were quizzed "*How would you describe the effective science teacher's knowledge of content and instructional strategy?*" In terms of how he/she demonstrates the knowledge to create a conducive learning atmosphere. All supervisors, mentors, and mentees explained that effective teaching and learning science involved teachers giving a correct explanation of science concepts. That is, it reduced the ease with which students learn science in the classrooms. Excerpts are;

DOI: http://dx.doi.org/10.5772/intechopen.110366

> *… explaining concepts well for learners to understand and attract their attention in class* (ME053).
> *An effective science teacher is someone who is confident and competent in explaining scientific concepts to students. You see this confidence will attract students to your lessons* (ME040).
>
> *… his/her ability to teach well the content with mastery and engagement of students for better understanding (*MR033).
>
> *through his/her lesson delivery on how systematic topics are explained for students' understanding. I must say I have seen students asking that mentees whose delivery is good should be retained in our school* (MR014).
>
> *The classroom environment strives for teachers' know-how. … by explaining concepts taught well for learners to understand* (S005).
>
> *A good learning classroom is attained through his/her lesson delivery on how systematic topics are explained for students' understanding* (S011).

The teachers interviewed mentioned that at times some skills are needed in creating an enabling environment for students to learn science concepts. Those skills and knowledge can be acquired through professional development programs. Excerpts are:

> *personal reading and attending seminars, workshops, and symposiums on curriculum updates* (ME001).
>
> *Through reading science books and watching science documentaries. It can also be attained through researching more scientific concepts from the internet for further knowledge or attending seminars and workshops for the needed skills and knowledge teaching in the basic schools* (MR033).
>
> *personal reading and attending seminars, workshops, and symposiums on curriculum updates* (S002).
>
> *By upgrading through schooling or seminars. I must say knowledge of some skills is vital for the classrooms. They make students learn science at ease* (S005).

Also, the teachers interviewed mentioned that effective teaching and learning science should occur in a learning environment that sought to build students' confidence. Excerpts are:

> *… the classroom should be ideal for encouraging learners by placing them at the center of teaching and learning processes* (ME028).
> *Yes, because it builds students' confidence in the classroom and helps them satisfy their curiosity* (MR013).
>
> *building confidence by applauding students who perform well and encouraging those who do not do well*" (MR046).
> *by encouraging learners and then building their confidence in learning science … the teacher places the students at the center of teaching and learning processes* (S010).

To create a conducive learning environment for students learning science in the basic schools, effective science teachers managed their classrooms. This was achieved through effective class control measures put in place by teachers. Excerpts are:

> *Yes, the creation of a learning classroom by giving clear and simple directions to obey rules and regulations in class which is seen through quietness … effective teachers use question skills to achieve this* (ME018).

> *students have been made to set classroom rules themselves knowing their respective consequences regarding rewards and punishments to help in class control* (ME024).

> *Yes, by giving clear and simple directions to obey rules and regulations in class, which is seen through quietness and giving questions to inattentive students in a class* (S012).

The teachers viewed mentioned that good class control would result in a conducive environment for a good teacher-student relationship leading to students feeling free to ask questions to aid their understanding of science concepts. An excerpt that was common to all teachers is:

> *Yes, when there is a conducive environment and good relationship between teacher and student, they are motivated to feel free and willing to ask questions during lessons* (ME024, MR013, and S024).

This and other common views probably explain why the mean perception values of the three groups of teachers are slightly different but not statistically significant.

With respect to the instructional processes, the teachers interviewed mentioned that effective teaching and learning science involved teachers selecting and using appropriate instructional strategies in the classroom to aid students' active participation in learning science concepts. Excerpts are:

> *Learning through active involvement in the lesson ensures quick absorption of science concepts by learners, hence, I expect an effective science teacher to organize his lesson to achieve that* (ME016).

> *An effective science is aware that the use of group activities helps involve everybody in the class including the weaker ones, so I present my lessons with that in mind* (MR055).

> *The use of group activities for teaching science is effective because two heads are better than one so students working in groups help them to share ideas* (S001).

The teachers interviewed mentioned that how teachers structured their instruction contributed to students' development of understanding of science concepts. Hence, instructional processes were key to effective teaching and learning science. Excerpts are:

> *The way the teacher plans and implements his or her teaching will make the lesson effective because students are able to construct knowledge among themselves and this aids their understanding* (ME051).

> *This is effective due to the different ideas possessed by group members, which are shared among themselves. It helps students to understand even difficult science concepts* (S002).

With respect to the consciousness of professional demands, the teachers interviewed held a much similar view. That is, for effective teaching and learning science to occur in basic schools, teachers should appreciate that they were to prepare a lesson plan and implement it in the classroom as planned. Excerpts are:

> *An effective science teacher prepares by planning and allocating a specific number of minutes to every stage and making sure times are used as planned* (ME028).

> *Effective teaching involves a teacher who prepares by having proper planning on when to use even the teaching materials* (MR001).

> *prepares by planning and allocating a number of minutes that will be used for every stage. The teacher has to follow the plan when teaching being conscious of the time scheduled for each stage of the lesson. I normally check and discussed with teacher trainees during supervision* (S008).

4. Discussion

The findings that effective teaching and learning science involves teachers who are mindful of instructional strategies to use in aiding students learning, perhaps one that lends itself to a constructivist approach confirms the findings of Adu-Gyamfi [14] that effective science teachers use appropriate teaching approaches and techniques and of Lumpkin and Multon [21] that effective teachers use various instructional strategies to convey course content to students to enhance their learning. It could be that the three groups of teachers are aware of Borich [20] indicators of instructional varieties and instructional strategies and that form the basis upon which all three groups of teachers evaluate effective science teachers. Because the characteristics of effective science teachers are evident and common [25] and can be recognized everywhere by science educators such as the three groups of teachers. Hence, it is not out of place that the three teacher groups (supervisors, mentors, and mentees) have a highly positive perception of teaching and learning science in basic schools. The Ghana Education Service through heads of the basic schools should occasionally engage the three teacher groups in professional development programs to share best practices and experiences on effective teaching and learning science. Again, the finding that effective teaching and learning science involves teachers who use instructional materials in their lesson delivery resonates with Lupascua et al.'s [26] assertion that in contemporary times effective science teachers use instructional materials. It, thus, implies that effective science teachers need to use instructional materials taking into consideration the concepts in context to explain the different learning styles of the learners and employ multimodal instructional materials as well as vary them. The perception of the three teacher groups of effective teaching and learning science is linked to teachers who prepare in advance and manages instructional time judiciously. This finding confirms earlier studies on effective [science] teachers as they manage their classes so that there is minimum wastage of class time and high levels of engagement [4, 36, 37]. Perhaps, it could be that they are able to do this because they prepare in advance [4, 27] and appreciate that contact hours are one of the important resources that teachers need not waste in order to cover the selected content by the curriculum developers. It is worth learning from this finding that when science teachers prepare in advance, they do things right [26]. Hence, school inspectors, during the monitoring of schools, should look out for whether teachers consciously budget for the time they would spend in the classroom with students. Moreover, effective teaching and learning science involve teachers who have the ability to establish a good learning environment to facilitate the teaching and learning of science concepts. This finding is in line with earlier findings and descriptions of effective science teachers as those who plan for the environment, both the organization of the classroom and students [6, 19, 25, 29, 31]. Those organizations are geared toward creating a welcoming environment that fosters positive relationships among students regardless of disparities in ethnic background, gender, social class, handicap, or prior academic achievement [19]. It could be that effective science teachers are able to establish their enabling learning environment by monitoring students' behavior in the classroom [6]. In this enabling environment of science, teachers show great interest in their student's success and this cannot be ignored. It is, also, in line with Young and Shaw's [10] finding that effective teachers are rated very high because of their genuine respect for students, concern for student learning, and value of the course. Consequently, this enabling learning environment is one where teachers demonstrate adequate content knowledge and instructional strategy [2, 14]. Since knowledge is not constant, it stands to mean that effective science teachers strive to update their knowledge through research. It is also worth suggesting that opportunity needs to be provided to science teachers through in-service training, by managers of basic schools, to keep updating their knowledge and to broaden the horizon of their knowledge for effectively teaching science.

Three factors principally accounted for the teacher's perception of the nature of effective teaching and learning science are a conducive learning environment, instructional processes, and consciousness of professional demands. In a conducive learning environment, it is apparent that the teachers perceive that effective teaching and learning science involves teachers who show love and empathy to their students and create a good human relationship with their students. Such environments make students feel comfortable to ask questions to help build their knowledge and understanding [14, 37]. The supervisors, mentors, and mentees who have gone through science training themselves recognize that proper knowledge of the content of science and knowledge of how to transform this content form an integral part of science teaching and learning. Thus, teachers perceive that an effective teacher demonstrates this knowledge by giving detailed explanations of concepts, which is well justified with an appropriate instructional strategy. As educators, the teachers appreciate that effectiveness needs to be sustained as such they perceive effective teaching and learning science involves a teacher who conducts research to update his/her knowledge and conceptual understanding of science concepts, ideas, and principles that needed explaining to students. There is, therefore, a need for Ghana Education Service to organize professional development programs for experts to share experiences on contemporary approaches to creating a conducive learning environment for basic school students. On the part of instructional processes, it came to bear that effective teaching and learning science involves teachers who by nature care about students' prior knowledge, simplifying the provided learning material in ways that meet individualized needs and respecting the diversity of any kind, ensuring solidarity and implementing democratic procedures, reducing students' learning load, and encouraging feedback [39]. The teachers' perception that as part of the instructional processes of effective teachers, they make their lessons participatory could be because they might have been aware that participatory approaches, a constructivist approach, enable students to make meaning of science concepts by themselves. Moreover, the teachers' perception of effective teaching and learning science in relation to teacher consciousness of professional demands helps basic school teachers to manage their time well. This confirms earlier findings [14, 37] that effective teachers manage their time to avoid wastage of instructional time. The teachers perceive that effective science teachers by their nature take time to explain to students difficult concepts. As much as possible, science educators in colleges of education should maximize the use of instructional time as they prepare preservice teachers. This will make their students see them as role models and, hence, adopt best practices as they handle science in the basic schools.

The findings that there was no statistically significant difference in the mean perceptions of the three groups of teachers on conducive learning environment, instructional processes, and consciousness of professional demands in relation to effective teaching and learning science implies that the science teacher educators (supervisors) might be doing a good job. Because of this, no statistically significant difference among supervisors, mentors, and mentees has once been reported [42] on teachers' perspectives on the effective use of teaching and learning resources in science lessons. Hence, science educators and researchers should conduct further research to investigate curriculum structure and how college tutors conduct their classroom activities to share with the world what the initial teacher training is and its impact on preservice teachers. It could also be that the supervisors have instilled in their students (mentors & mentees) lifelong learning of effective teaching and learning science. In addition, it could be a confirmation of earlier studies that educators have an influence on preservice (mentees) and in-service (mentors) teachers' conception of effective teaching, and this also influences their practices [3, 40, 41]. It is that the supervisors prepare the preservice teachers to develop appropriate knowledge, strategies, and techniques relevant to creating an enabling environment for learning science who eventually continue this acquired (mentors). However, the supervisors need to be aware preconceptions held on by preservice education may be retained by preservice teachers despite methodology units and practicum experiences [41] and help them to address them appropriately.

5. Conclusion and implications

This chapter studied the perceived nature of effective teaching and learning science among supervisors (who were college tutors), mentors (who were in-service teachers in basic schools), and mentees (who were preservice teachers in colleges of education). These teacher groups were linked in common as they were mandated to effective teaching and learning science in the basic schools. Having responded to a questionnaire and interview, through the triangulation mixed methods, the three groups of teachers had highly positive perceptions of effective teaching and learning science in basic schools. Hence, science educators and researchers should case-study effective teaching and learning science in basic schools through observer participation or participation observer to further investigate whether teachers practice what they professed to teach. The factors underpinning this highly positive perception of effective teaching and learning science were a conducive learning environment, instructional processes, and consciousness of professional demands. However, supervisors, mentors, and mentees shared a common perception and did not differ statistically on conducive learning environments, instructional processes, and consciousness of professional demands in relation to effective teaching and learning science though qualitatively some issues were expressed differently by the three groups of teachers.

Hence, the Ministry of Education through the Ghana Education Service should provide opportunities for the three groups of teachers to meet and share experiences on effective teaching and learning science in basic schools.

Appendix A

A.1 Effective science teacher questionnaire

Dear teacher,

This questionnaire seeks your opinions and concerns about the perceived nature of an effective science teacher**.** You are required **NOT** to write your **name** and the name of your **college or school**. Your response(s) to this questionnaire will remain **confidential** and any comment made will not be personalized in this research. The information provided will be used to improve the teaching and learning of science in schools and colleges. Completing the questionnaire means you are consenting to take part in the research.

Please carefully read all the instructions in each section before giving your response(s).

SECTION A: Background Information.

1. Zone

… .

2. Sex

Male [] Female [].

3. Level of Teaching

College Tutor [] Primary School Teacher [] JHS Teacher []

4. Role as a Teacher

Supervisor [] Mentor [] Mentee []

SECTION B: Perceived Nature of Effective Teaching and Learning Science.

Indicate your level of agreement (**from 1 to 5**) to the following statements on how you consider as an effective science teacher. A rank of 1 is the lowest agreement and a rank of 5 is the highest agreement.

Tick [√] to show your level of agreement.

Lowest to Highest Agreement

Item	Statement	1	2	3	4	5
5.	An effective science teacher selects and uses instructional strategies					
6.	An effective science teacher studies the curriculum to guide their choice of appropriate teaching method					
7.	An effective science teacher often reviews students' relevant previous knowledge and builds on them					
8.	An effective science teacher uses activity-based methods of teaching					
9.	An effective science teacher uses the lecture method of teaching					
10.	An effective science teacher uses methods that make his/her lessons practical, and collaborative/participatory					

Item	Statement	1	2	3	4	5
11.	An effective science teacher teaches science through practical works that are laboratory-based to enhance student understanding					
12.	An effective science teacher relies on textbooks to teach science					
13.	An effective science teacher teaches scientific concepts and ideas using a methodology that aids the application of the knowledge to everyday life experiences					
14.	An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts					
15.	An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students					
16.	An effective teacher uses more than one teaching and learning material					
17.	Effective science teacher ensures that their teaching resources are available before they start their lessons					
18.	An effective science teacher is good at improvisation of teaching and learning materials					
19.	An effective science teacher uses multiple teaching and learning materials for the explanation of the same concept					
20.	An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas					
21.	An effective science teacher employs teaching and learning materials that arouse the desire of learners to learn					
22.	An effective science teacher prepares in advance before coming to class					
23.	An effective teacher is confident because he prepares well in advance to produce higher student achievements					
24.	An effective science teacher is someone who tries as much as possible to find something in the community, within his busy schedule, to relate every topic for easy student understanding					
25.	An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments					
26.	An effective science teacher is creative in teaching science					
27.	An effective science teacher is one who never misses his/her instructional hours					
28.	An effective science teacher plans and teaches within the given instructional time					
29.	An effective science teacher takes his/her time to teach without rushing through the presentation of lesson					
30.	During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students					
31.	An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand					
32.	An effective science teacher uses instructional time consciously to the benefit of students					
33.	An effective science teacher creates a conducive environment for students learning of scientific concepts and ideas					
34.	Effective science teachers' lessons are always interesting and enjoyable.					
35.	An effective science teacher always responds appropriately to questions students ask					

Item	Statement	1	2	3	4	5
36.	An effective science teacher uses formative assessment to sustain students' interest in learning					
37.	An effective science teacher has good human relationships between science teachers and students during science lessons					
38.	An effective science teacher loves and shows empathy for students					
39.	An effective science teacher is an open-minded person creating room for constructive criticism					
40.	An effective science teacher motivates students to learn science					
41.	An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied					
42.	An effective science teacher guides students on how to search for answers to questions raised					
43.	An effective science teacher builds his/her students' confidence in learning of the subject science					
44.	An effective science teacher provides students with the experiences needed to learn science					
45.	An effective science teacher has good class control					
46.	An effective science teacher presents his/her lessons systematically and orderly					
47.	An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex					
48.	An effective science teacher ensures that everyone understands the first topic before moving to the next topic					
49.	An effective science teacher gives a kind of exercise that will demand a lot of research for about week					
50.	An effective science teacher evaluates learners in science class					
51.	An effective science teacher monitors learners in science class					
52.	An effective science teacher gives students enough work examples for them to practice					
53.	An effective science teacher always gives an assignment to his/her students, marks, and discusses it for the students to know their shortcomings for rectification					
54.	An effective science teacher distributes questions to all students in science lesson					
55.	An effective science teacher uses simple vocabulary that can be understood by all students in science lesson					
56.	An effective science teacher communicates science terminologies very well to the understanding of students					
57.	An effective science teacher can be tolerant of all students' questions and issues in science lessons					
58.	An effective science teacher responds swiftly to students' questions raised during lesson					
59.	An effective science teacher provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom.					
60.	An effective science teacher considers individual intellectual abilities in teaching scientific concepts and ideas to a class of students					

Item	Statement	1	2	3	4	5
61.	An effective science teacher considers the academic level of students in teaching scientific concepts and ideas					
62.	An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching					
63.	An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science					
64.	An effective science teacher prepares students to perform creditable well in examinations.					
65.	An effective science teacher demonstrates sufficient knowledge of science to students					
66.	An effective science teacher should have in-depth knowledge of the topic before teaching					
67.	An effective science teacher is a teacher who justifies what he/she is teaching to the admiration of students					
68.	An effective science teacher is abreast of the current state of scientific knowledge					
69.	An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles					
70.	An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching					
71.	An effective science teacher can justify what he/she is teaching using the appropriate approach					
72.	An effective science teacher uses appropriate instructional strategies to present the content					
73.	An effective science teacher uses a variety of approaches to avoid boredom during science lessons					

Appendix B

B.1 Effective science teacher interview schedule

This interview schedule is designed to interact with science teachers on a one-to-one interview to seek their views on who an effective science teacher is. Your response (s) to this interview will remain **confidential** and any comment made will not be personalized in this research. The information provided will be used to improve the teaching and learning of science in schools and colleges. Transcribed audiotapes will be sent to teachers for their approval and any materials that will form part of the final study will have their consent.

A. Bio-Data for teachers

1. How long have you been teaching in this school?
   …

2. How long have you been teaching science?
   …

3. What is your academic/Professional qualification?
… …

B. Who is an effective science teacher?

4. What instructional strategies do effective science teachers normally use in teaching science?

Prompt 1: why those strategies?
… …
… …
… …

Prompt 2: is it by group activities? Why?
… …
… …
… …

Prompt 3: is it by hands-on activities? Why?
… …
… …
… …

Prompt 4: is it by demonstration? Why?
… …
… …
… …

Prompt 5: is it by lecture? Why?
… …
… …
… …

5. How does an effective science teacher acquire and use Instructional materials?
… …
… …
… …

Prompt 1: what type of instructional materials do they use? Why?
… …
… …
… …

Prompt 2: how do they get them?
… …
… …
… …

Prompt 3: do they use more than one instructional material for lesson delivery? Why?
… …
… …
… …

6. How does an effective science teacher prepare in advance as well as manage his/her time for science lessons?

Prompt 1: does he/she prepare lessons before coming to class? Why?
… …
… …
… …

Prompt 2: does he/she allocates time for each stage of lesson delivery? Why?
… …
… …
… …

Prompt 3: how does he/she organizes his/her instructional materials? Why?
… …
… …
… …

7. How do you see the learning environment of an effective science teacher's class?

Prompt 1: does he/she build the student's confidence? how?
… …
… …
… …

Prompt 2: does he/her have good class control? What are the indicators?
… …
… …
… …

Prompt 3: are students free and willing to ask questions? Why?
… …
… …
… …

Prompt 4 does he/she provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom? How?
… …
… …
… …

8. How would you describe the effective science teacher's interest in students' academic improvement?

Prompt 1: does he/she considers the students in the preparation of lessons? Why
… …
… …
… …

prompt 2: is his/her lesson structured to prepare to work toward their success? Why?
… …
… …
… …

Prompt 3: does he/she consider the intellectual abilities of the learners? Why
… …
… …
… …

9. How would you describe the effective science teacher's knowledge of content and instructional strategy?

Prompt 1: how is his/her knowledge being demonstrated?
… …
… …
… …

Prompt 2: how does he/she updates his/her knowledge? why?
… …

… …
… …

Prompt 3: how does he/she explain scientific concepts, ideas, and principles when teaching? Why?

… …
… …
… …

Author details

Kenneth Adu-Gyamfi*, Isaiah Atewini Asaki and Benjamin Anim-Eduful
Department of Science Education, University of Cape Coast, Ghana

*Address all correspondence to: kenneth.adu-gyamfi@ucc.edu.gh

References

[1] Ababio BT. Nature of teaching: What teachers need to know and do. International Journal for Innovation Education and Research. 2013;**1**(3):37-48

[2] Boadu G. Effective teaching in history: The perspectives of history student-teachers. International Journal of Humanities and Social Sciences. 2015;**3**(1):35-51. Available from: https://www.researchgate.net/publication/279537543

[3] Druva CA, Anderson RD. Science teacher characteristics by teacher behavior and by student outcome: A meta-analysis of research. Journal of Research in Science Teaching. 1983; **20**(5):467-479

[4] Haynie G, Stephani M. Effective teaching practice in US history. Research Watch: Evaluation and Research Department. 2008;**7**(5):1-30

[5] McKnight K, Graybeal J, Yarbro J, Graybeal L. Canada: What makes an effective teacher? Series 15 of 23. In: McKnight K et al., editors. The Heart of Great Teaching: Pearson Global Survey of Educator Effectiveness. London, England: Pearson Education, Inc.; 2016. Available from: https://www.pearson.com/corporate/efficacy-and-research/schools-education-research/research-reports/global-survey-of-educator-effectiveness.html

[6] Tobin K, Fraser BJ. What does it mean to be an exemplary science teacher? Journal of Research in Science Teaching. 1990;**27**(1):3-25. DOI: 10.1002/tea.3660270103

[7] Cimer A. Effective teaching in science: A review of literature. Journal of Turkish Science Education. 2007;**4**(1): 20-44

[8] Loughran J, Berry A, Mulhall P. Understanding and Developing Science Teachers' Pedagogical Content Knowledge. 2nd ed. Rotterdam: Sense Publishers; 2012

[9] Hewson PW, Hewson MGAB. An appropriate conception of teaching science: A view from studies of science learning. Science Education. 1988;**72**(5): 597-614

[10] Young S, Shaw GD. Profiles of effective college and university teachers. The Journal of Higher Education. 1999; **70**(6):670-686. DOI: 10.1080/00221546.1999.11780803

[11] Denga VB. Curriculum and Instruction for Near and Distance Learners. Lagos: Rainbow Royale Publishers; 2001

[12] National Research Council. Science Teaching Reconsidered: A Handbook. Washington, D.C.: National Academies Press; 1997. DOI: 10.17226/5287

[13] Nilsen B, Albertalli V, Albertalli G. Introduction to Learning and Teaching Infants through Elementary Age Children. 2nd ed. New York: Delma; 2002

[14] Adu-Gyamfi K. Pre-service teachers' conception of an effective science teacher. The Case of initial teacher training. Journal of Turkish Science Education. 2020;**17**(1):40-61. DOI: 10.36681/tused.2020.12

[15] Ajaja PO, Eravwoke UO. Teachers' characteristics and science teachers' classroom behaviour: Evidence from science classroom surveys. US-China Education Review B. 2013;**3**(1): 36-53

[16] Dillon J, Manning A. Science teachers, science teaching: Issues and challenges. In: Dillon J, Osborne J, editors. Good Practices in Science Teaching: What Research has to Say. New York: Open University Press; 2010. pp. 6-20

[17] Medley D. Research in teacher effectiveness - Where it is and how it got here. The Journal of Classroom Interaction. 1978;**13**(2):16-21. Available from: https://www.jstor.org/stable/2386982

[18] Bybee RW. NGSS and the next generation of science teachers. Journal Science Teacher Education. 2014;**25**: 211-221. DOI: 10.1007/s10972-014-9381-4

[19] Zango HUS, Kwalli M, Danlami A. The characteristics of a good teacher and how to become one. Chemsearch Journal. 2010;**1**(1):48-51

[20] Borich GD. Effective Teaching Methods: Research-based Practice. 9th ed. New Jersey: Pearson Merrill Prentice Hall; 2017

[21] Lumpkin A, Multon KD. Perceptions of teaching effectiveness. The Educational Forum. 2013;**77**(3):288-299. DOI: 10.1080/00131725.2013.792907

[22] Sancassani P. The effect of teacher characteristics on students' science achievement. 2021. Available from: http://hdl.handle.net/10419/231544

[23] Goe L, Stickler LM. Teacher Quality and Student Achievement: Making the Most of Recent Research. (TQ Research & Policy Brief). Washington, DC: National Comprehensive Center for Teacher Quality; 2008

[24] Fitzgerald A, Dawson V, Hackling M. Perceptions and pedagogy: Exploring the beliefs and practices of an effective primary science. Teacher Teaching Science. 2009;**55**(3):19-22

[25] Cherif AH. Traits of effective science teacher: Literature perspective. Forward to Excellence. 1995;**2**(2 & 3):10. Available from: https://www.researchgate.net/publication/318510835

[26] Lupascua AR, Panisoara G, Panisoara I. Characteristics of effective teacher. Procedia - Social and Behavioral Sciences. 2014;**127**:534-538

[27] Walker RJ. 12 characteristics of an effective teacher. 2010. Available from: https://files.eric.ed.gov/fulltext/ED509938.pdf

[28] Bransford J, Darling-Hammond L, LePage P. Introduction. In: Darling-Hammond L, Bransford J, editors. Preparing Teachers for a Changing World: What Teachers Should Learn and Be Able to Do. San Francisco, CA: Jossey-Bass; 2005. pp. 1-39

[29] Ginns IS, Watters JJ. Beginning elementary science teachers and the effective teaching of science. Journal of Science Teacher Education. 1999;**10**(4): 287-213

[30] Davis EA. Preservice elementary teachers' critique of instructional materials for science. Science Teacher Education. 2006;**90**(2):348-375. DOI: 10.1002/sce.20110

[31] Stronge JH. Qualities of Effective Teachers. 2nd ed. Alexandria: ACDC; 2007

[32] Magnusson S, Krajcik J, Borko H. Nature, sources, and development of pedagogical content knowledge for science teaching. In: Gess-Newsome J, Lederman NG, editors. Examining

Pedagogical Content Knowledge. Science & Technology Education Library. Vol. 6. Dordrecht. Retrieved from:: Springer; 1999. pp. 95-132. DOI: 10.1007/0-306-47217-1_4

[33] Shulman LS. Knowledge and teaching: Foundations of the new reform. Harvard Educational Review. 1987;**57**:1-22

[34] Grant SG, Gradwell JM. The road to ambitious teaching: Creating big idea units in history classes. Journal of Inquiry & Action in Education. 2009; **2**(1):1-26

[35] Rollnick M, Bennett J, Rhemtula M, Dharsey N, Ndlovu T. The place of subject matter knowledge in pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. International Journal of Science Education. 2008;**30**(10): 1365-1387. DOI: 10.1080/09500690802187025

[36] Raizen SA, Michelsohn AM. The Future of Science in Elementary Schools. Educating Prospective Teachers. San Francisco, CA: Jossey-Bass Inc. Publishers; 1994

[37] Woolnough BE. Effective Science Teaching. Developing Science and Technology Education. Bristol, PA: Open University Press; 1994

[38] World Health Organization. [WHO]. Effective Teaching: A Guide for Educating Healthcare Providers. Geneva: WHO Press; 2005

[39] Koutrouba K. A profile of the effective teacher: Greek secondary education teachers' perceptions. European Journal of Teacher Education. 2012;**35**(3):359-374. DOI: 10.1080/02619768.2011.654332

[40] Rahman F, Jumani NB, Akhter Y, Chisthi SH, Ajmal M. Relationship between training of teachers and effectiveness teaching. International Journal of Business and Social Science. 2011;**2**(4):150-160

[41] Skamp K, Mueller A. Student teachers' conceptions about effective primary science teaching: A longitudinal study. International Journal of Science Education. 2001;**23**(4):331-351. DOI: 10.1080/09500690119248

[42] Osei-Himah V, Adu-Gyamfi K. Teachers' perspective of effective use of teaching and learning materials in basic school integrated science lessons. Asian Journal of University Education. 2022; **18**(1):256-270. DOI: 10.24191/ajue.v18i1.17195

[43] Ayuni NWD, Sari IGAMKK. Analysis of factors that influencing the interest of Bali state polytechnic's students in entrepreneurship. Journal of Physics Conference Series. 2018;**953**. DOI: 10.1088/1742-6596/953/1/012071

[44] Hair J, Anderson R, Tathan R, Black W. Multivariate Data Analysis. 7th ed. Edinburgh Gate, Harlow: Pearson Education Limited; 2014. pp. 21-29

[45] Pallant J. SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows. 3rd ed. Maidenhead, Berkshire: McGraw Hill Education; 2007

[46] Tabachnick BG, Fidell LS. Using Multivariate Statistics. 7th ed. Boston: Pearson Education, Inc.; 2019

[47] Ledesma RD, Valero-Mora P. Determining the number of factors to retain in EFA: An easy-to-use computer program for carrying out parallel analysis. Practical Assessment, Research,

and Evaluation. 2007;**12**(2):1-11. DOI: 10.7275/wjnc-nm63

[48] Cokluk O, Kocak D. Using Horn's parallel analysis method in exploratory factor analysis for determining the number of factors. Educational Sciences: Theory & Practice. 2016;**16**(2):537-551. DOI: 10.12738/estp.2016.2.0328

Chapter 3

Assessment of Students' Reading Comprehension Skills in Teaching English

Farida Huseynova

Abstract

This article presents the reading comprehension skills of freshmen and sophomores majoring in English at the Azerbaijan State Pedagogical University. The main goal of the paper is to discuss the value of assessment in identifying students' reading proficiency in higher education. Another goal is to help teachers identify assessment criteria and give feedback to students in developing reading comprehension skills. In addition, the article explains the application of assessment strategies and evaluation criteria for various reading comprehension skill levels. The last goal of the research paper is to demonstrate the benefits of formative assessment to both teachers and students. For this purpose, the experiment examines the students' reading comprehension abilities. The study included 31 female and 23 male student participants from the English language faculty. The participants were chosen on purpose from the first and second years of the academic year 2021-2022. The designed survey questions were used to collect data. Qualitative analyses were used to analyze the students' results. According to the findings, teachers believe that reading assessment is an important component of effective reading instruction. Throughout the study, both teachers and students valued the role of formative assessment in improving reading comprehension.

Keywords: reading comprehension, strategies, formative assessment, bottom-up, top-down, criteria

1. Introduction

This research presents the importance of assessment as one of the most effective steps in teaching English. Moreover, developing reading comprehension skills in teaching English is more explored by many researchers [1, 2]. Recent research highlight a few considerations exploring measuring reading comprehension that is most typically performed among university students [3].

The term "assessment of reading skills" [4] is seen as the practice of defining the students' reading ability of their skimming, scanning, pronunciation, and interpretation skills). In addition, the term "assessment criteria" is used to refer to the reading process and what criteria measure reading scores in teaching. The concept of "ongoing assessment" includes elements of formative assessment, such as activities, methods, or techniques used in evaluating students reading skills regularly. In brief, "giving constructive feedback" conduct' or "washback effect" [5] mean what happens between teacher and students to determine students' strength and weaknesses while reading texts of different genres.

The research will focus on the following research questions:

- *What are the benefits of applying reading assessment?*
- *What are the challenges faced by the teachers in implementing reading assessment?*
- *How is the role of formative assessment in reading comprehension defined?*

Assessment in developing reading comprehension skills involves the ability of readers to critically evaluate information in a text in addition to word decoding and content comprehension [6, 7]. Moreover, this research aims to explore the main obstacles and difficulties that impede students' text comprehension, as well as developing linguistic, communication, and critical thinking skills. The article presents a new type of standardized reading assessment tasks formats by applying formative assessment tasks that motivate students in reading comprehension.

It is known that from the secondary school level, students have experience with linguistic assessment of reading, and at the university level, there is a need to acquire new skills based on previous knowledge.

Furthermore, this research introduces one of the main issues, the differences between the assessment and evaluation process, in many cases, teachers find it difficult to explain the difference between assessment and evaluation. Although these two terms are each a quality factor, they are used interchangeably, there is a noticeable difference between them. Assessment collects evidence of learner performance, evaluation process provides a measurement of performance based on data collection and analysis [8].

Additionally, it is essential that assessing students' reading skills in English at an intermediate level is crucial in starting the steps of bachelor's degrees in universities. It is known that freshmen and sophomore students at the university should take reading classes in English at a more adequate level. In this case, students' interest in reading is measured by the assessment of their comprehension skills.

The evaluation of reading comprehension in the teaching English language provides teachers with important information about students' weaknesses and reading needs, obstacles, and challenges. The article attempts to provide fair evidence for adequate assessment of reading comprehension.

It is contradictory, in many cases, accepting the assessment from the learning as a separate process makes a great challenge in the assessment of language skills because of time limitations [9].

Another purpose of the paper aims the importance of using reliable criteria to assess reading skills in achieving learning outcomes and to give constructive feedback to the students for improving their reading. In this paper, the authors introduce essential skills that must be assessed in reading, as well as good morphological, syntactical, and vocabulary knowledge, recall of relevant details, and summarizing skills for these study levels. Therefore, this article focuses on examining to assess students' interpretation skills in reading texts when using interactive and genre knowledge [10].

Recently, many studies have been conducted on the correct assessment of reading in the development of bottom-up and top-down skills in reading.

According to Richards and Alderson, curricula play an important role in providing students with the necessary skills to understand fiction, documentaries, and non-academic texts at the intermediate reading level. There has been a growing interest in the development of an English language curriculum that promotes the acquisition of bottom-up and top-down skills in reading effectively [11, 12].

Nevertheless, in checking the comprehension level of reading texts of different genres teachers face many problems in evaluating reading performance at the initial stage of higher education [13]. However, the university system is focused on test-based examinations or taking the paper-based exam on writing theoretical rules of reading strategies to provide sophomore students with reading effectively. Short-answer items are the most preferred tests utilized in ongoing assessment (formative assessment) methods.

Thus, it is necessary to avoid such assessment tools that disturb students to demonstrate their true abilities. Therefore, it was important to ask them about the effective assessment criteria that they do not use. The students emphasized the importance of using ongoing classroom tasks and activities as useful assessment tools during the experiment. Thus, assessment tools for developing reading abilities do not impose test conditions and help students learn without fear or stress.

2. Literature review

2.1 Reading assessment in the English language teaching

Assessment has become an essential part of effective teaching and learning. Azerbaijan Education has shifted the assessment norms in English language teaching in universities. Several guidelines have already been developed on the simultaneous application of assessment in education in teaching English. Although there has been some progress in applying new assessment guidelines, the summative assessment has been taken as a student outcome in learning. Traditionally, summative assessment has been accepted to identify students' English language knowledge and skills [14].

Developing reading comprehension skills in teaching English is considered an essential language skill in foreign language teaching. Therefore, this study examines and presents the exploration and analysis of different new theoretical approaches to developing adequate reading assessment.

According to Douglas Brown [15], assessment is an integral part of the teaching cycle and is applied throughout the learning process. Assessment tasks and tests in reading can provide motivation, feedback, and authenticity to the students in learning. Moreover, the role of reading comprehension in English in students' understanding of problems, evaluation, and independent thinking is undeniable in higher education [1].

In addition, the researchers Barr, Tagg [16], Black, Wiliam [17] state that the effective acquisition of reading skills in teaching English in higher education is also measured by the assessment obtained in the exams. It is known that an exam-oriented assessment process does not ensure uniform language skills in reading. Students can play an active role in the learning process to evaluate each other's reading skills with peers [8]. Rethinasamy [18] and Mermelstein [19] noted that classroom assessment is an ongoing process that uses judgments about students' language learning, knowledge, skills, abilities, and other achievements. Thus, reading assessment should allow them to improve their reading in English.

Literature analysis shows that the difficulties during the reading process are indicated in three areas: students' low-level communication skills in reading activities and low students' motivation to engage in reading. Though teachers use reading assignments and class tests to evaluate student reading skills and development, they are more likely to choose the summative assessment method than the formative or alternative assessment for improving reading comprehension. It allows teachers to assess as part of the classroom's ongoing learning activities, thus directly linking assessment with the curriculum. The curriculum should reflect learning outcomes related to acquiring bottom-up and top-down skills in reading comprehension. It is essential to evaluate student performance in direct relation to the curriculum and learning outcomes [20, 21].

Furthermore, reading assessment in English language teaching is considered in four aspects: students' general reading level, students' reading comprehension, reading for information and argument, reading strategies, and reading as leisure [22]. Regarding these, conducting a formative assessment is more productive than a summative assessment in the learning process. Black and Wiliam [9] stated that assessing reading is the main factor influencing students' ability to develop reading comprehension skills in formative classroom-based assessments.

Finally, it is proved that the assessment should be carried out by teachers in the classroom and get an opportunity to use formative assessments instead of summative tests. Students feel free to demonstrate their performance in the classroom performances and participate in the reading process using dialogs, role plays, stories, and summaries. It allows students to develop their personalities, talents, needs, and interests in the reading process. Classroom-based assessment promotes student progress in reading and contributes to their language learning [16].

2.2 Reading assessment strategies

Recently Perera-Diltz and Moe [23] claimed that formative assessments improve teachers' instructional practice and allow them to track students' progress toward standards. This assessment motivates students to build self-confidence pre, while, and after the reading process to comprehend the content. Linse & Nunan [24] and Freeman and Brown [17] point out that reading strategies open good opportunities for assessing reading in an ongoing process. Reading strategies encompass many aspects in conducting pre, while, and after the reading process. Students can respond to all questions, select a word or structure, identify new information, visualize it, schematically interpret content, or summarize in a short context.

It is clear that to become efficient readers of English, two required skills are crucial:

a. bottom-up strategies for recognizing words and phrases to enrich vocabulary size.

b. top-down skills to drive reading strategies and conceptual comprehension.

Moreover, bottom-up strategies entail assessing reading ability measured for the effectiveness of comprehension. In the top-down approach to reading, students can comprehend content and format schemata to demonstrate cultural experiences for interpretation. The main essential factor in bottom-up strategies is assessing students' metacognitive skills (predicting, questioning, paraphrasing, visualizing, evaluating, and summarizing) through using formative classroom assessments [15, 25].

Additionally, reading comprehension skills in English are understood as reading for comprehending meaning in different genres and entertainment. It involves decoding specific words to demonstrate higher-order thinking skills. First, they must be able to practice fundamental bottom-up strategies, such as selecting new words, phrases, and appropriate terminologies, and new information on fiction, documentaries, and non-academic texts [7].

Finally, the readers boost a top-down approach, freewriting in summarizing the content on a schema, using prior knowledge and background information, and acquiring all interpretations effectively [26].

2.3 Formative assessment criteria in reading

According to Gipps [27] and Gladwell, L. Leslie [28], the main goal of applying formative assessment are to provide students with appropriate tasks and tests that motivate them to read. Moreover, Cohen [25] and Hudson [29] emphasized that the teacher should make descriptive rubrics for analyzing students' cognitive and metacognitive skills in reading. Teachers should prepare holistic and analytic assessment criteria for assessing various reading activities. In addition, the assessment criteria or descriptive rubrics aim to boost students' critical and creative skills to accomplish reading tasks. According to these criteria, students should improve their linguistic, communicative, and discourse skills in reading. For this purpose, teachers should give constructive or judgmental feedback to each student with clear explanations. Thus, the analysis of the study shows formative assessment tasks and testing are helpful for students to achieve the main goal and support teachers' activity in teaching [13, 30, 31]. Finally, Cohen [25] presents the following formative assessment criteria for reading comprehension (**Table 1**).

Brown [17], Linse and Nunan [24], Rouet and Britt [7] stated that the comprehension process constructs meaning and fluency. Fluency is the main criterion for checking to understand and focuses on developing spoken language. Fluency contributes to students' boosting memory and provides an opportunity for understanding reading [32].

They mentioned that university students must become efficient readers of English. The different types of reading help develop students' micro-skills in reading comprehension. Learners should focus on learning reading style to acquire short-term memory in reading fiction, documentaries, and non-academic reading. Recognizing words, word classes, as nouns and verbs, and sequence of tenses, agreement, and different grammatical forms is significant for effective paraphrasing.

According to Kendeou et al. [13] different genres improve students' macro skills that entail developing communicative functions. Therefore, it is essential to assess learners' genre reading skills to identify their purpose for reading. They read extensive types of

Bottom-up strategies criteria	Top-down strategies criteria
Demonstrating reading speed and fluency	Demonstrating scanning
Showing phonemic awareness	Identify types genres and meaning
Reading Think aloud	Predicting the content
Recognizing words and phrases	Participating in questioning
Comparing morphological and syntactical structures	Visualizing events and facts
Demonstrating reading speed and fluency	Analyzing the passages
	Summarizing the text

Table 1.
Reading assessment criteria [25].

reading, as well as novels, fiction, non-fiction, journals, magazines, announcements, job-related articles, schemata, and other genres of reading. The learners should describe facts and opinions, chronological events, causes and effects, and problem solutions. Several issues were raised in reading schemata in reading. The schemata reading assists students in extracting appropriate meaning and accomplishing the purpose of information. In this case, students need to relate data using numbers and activities for a good interpretation. It is essential to read schemata in English at the university level.

2.4 Standardized reading tasks in formative assessment

Standardized reading tests are conducted for assessing students' linguistic skills, phonemic, lexical, grammatical, reading aloud, vocabulary, and grammar skills. This assessment has only one tool for indicating students' cognitive or bottom-up skills [6]. On the contrary, Dennis [33] and Brown H. Douglas [15] proved that utilizing different formats of tests can improve comprehension skills as the best assessment tool.

According to Perera-Diltz and Moe [23], contrary to using standardized assessment tasks, formative assessment must be used for students' reading comprehension to acquire essential top-down skills (**Table 2**).

Comparing formative assessment tasks with standardized general reading tests in the table, it can be seen that ongoing assessment tasks are more effective in developing critical thinking and understanding. Standardized testing in reading seems very traditional today. The formative assessment tasks on reading comprehension make it possible for the readers to acquire both linguistic and communicative skills [3].

2.5 Methodology

The participants in this study enrolled 54 undergraduate students, 4 teachers, and 2 instructors from the teaching department of the university were registered for

No.	Assessing reading comprehension	
	Standardized reading tasks	**Formative assessment tasks**
1	Filling in gaps	Choosing keywords for specific information
2	Cloze test	Finding the main idea
3	C-tests (removing initial letters of words)	Answer the open-ended questions
4	Making the passages in order	Read aloud and pronounce correctly
5	The gaps in the text	Delete the extra ideas from the text
6	Putting heading in paragraphs	Visualize the content of the text
7	Multiple choice test	Choose the author's ideas and paraphrase
8	Sentence completion	Evaluate the new information
9	Matching the sentences	Combine the paragraphs on schemata
10	Choosing extra ideas	Relate the new ideas to the real life
11	Choosing True and False answers	Use the "Think aloud" method in reading
12	Summarizing	Prepare a short report on reading text

Table 2.
Formative assessment tasks for reading comprehension [23].

the study. The average age of the participants is between 19 and 20. The setting is Azerbaijan State Pedagogical University. First, there was a whole assessment criterion for selection. Secondly, the participants were divided randomly among boys (N = 23) and girls (N = 31). Gladwell [34] claimed: "Qualitative Reading Inventory is more important to identify students' strengths and difficulties in assessing reading skills". Qualitative research is a methodology tool for exploring challenges and searching for research questions to gather all of the information on the anticipated study. Therefore, the study presents the following research questions:

1. *What measurement tools should be used in assessing freshmen and sophomore students' reading skills?*

The qualitative research approach was utilized to examine students' and teachers' perceptions of using formative assessments in reading classes. Participants claimed that formative assessment is the best tool to identify their strengths and weaknesses in reading. The research conducted open-ended interview questions so that participants could share their reading skills, and experiences with formative assessment. Additionally, the interviews and observations were compared and problems were identified. The records were taken from focus group members and teachers' responses are compared to reading assessment criteria.

First, all interviews were recorded in transcription.

Interview questions:

1. *What kind of tasks is appropriate to assess students' reading skills?*

2. *What can you say about bottom-up technologies in reading?*

3. *How do you explain top-down or metacognitive skills in reading?*

However, the study planned procedures in the following phases for adjusting students' reading levels.

Phase 1. To select participants from the general student population, including English Language Learners and other respondents.

Phase 2. The goal of assessing students' reading levels and selecting appropriate test items must be clear to generate feedback and assign valid scores. In addition, tests should have various purposes to evaluate students' different reading skills. The content of tests is to achieve students' cognitive and metacognitive skills. Participants were provided holistic and analytic rubrics for assessing reading comprehension to identify their levels. Thus, it is also crucial for teachers and learners to understand specific criteria and scores in reading [11].

Phase 3. Developing reading tasks and testing items according to the scoring criteria.

The first step in this phase is to develop reading tasks that can assess score items.

The items are supposed to measure specifications on learning outcomes in reading comprehension and content standards. Reading assessment should be measured on standardized assessment tasks (Rethinasamy S. and Ramanair J.) [18].

The common problem realized that teachers and students improve only linguistic skills (bottom-up) in reading comprehension skills than communicative or discourse skills. They need to achieve metacognitive skills (top-down) in comprehending completely.

2.6 Findings and discussion

Surveys were conducted among the students enrolled, and the purpose of the surveys was to design the students' strengths and weaknesses in their reading skills. The data survey questions included student levels, and gender differences among students were mainly included. A survey was conducted to check the level of understanding of reading strategies among boys and girls. Tests and exercises were presented to determine the levels of comprehension among the students, and as the survey result, the frequency of reading, acquisition rate, and the final score were described in the table (**Table 3**).

The survey aimed to collect several assessment methods and activities learners applied in the learning process and how they acquired good reading skills. They could demonstrate comprehension, predict, and recognize the words, improve vocabulary, use it in interpretation, and analyze different types of texts adequately. The observations showed that the girls have more achievements than the boys participating in reading activities to demonstrate good reading comprehension skills (**Table 4**).

Another survey was conducted between boys and girls on reading comprehension frequency, quick understanding of new information and the percentage of understanding and mastering the content of the text, and finally the acquisition of metacognitive skills. For this purpose, several evaluation techniques were incorporated into the survey design. As a result, respondents were able to obtain a medium score after completing the formative assessment tasks (**Table 5**).

Survey analysis proved that many students have good linguistic skills in reading and approved that comprehending seemed challenging perceptions. Several

Assessment methods	Boys	Girls
Spelling in vocabulary	37%	63%
Identifying the meaning of words	42%	42%
Skimming for specific information	42%	58%
Scanning for analysis in details	38%	62%
Participating in questioning	45%	55%
Doing multiple choice test	34%	66%
Comprehending cloze test	32%	63%
Generalizing ideas	36%	64%

Table 3.
Survey analysis on doing reading comprehension tasks between girls and boys.

Gender	Frequency	Rate	Medium score
Boys	16	39%	28
Girls	21	61%	35
Total	40	100%	63

Table 4.
Survey results of students' reading acquisition levels (frequency, rate score).

Reading comprehension skills	Agree	Disagree
I can spell and recognize the words	77%	23%
I can memorize the meaning of words	58%	42%
I can select specific information	49%	51%
I can comprehend the meaning	62%	38%
I can answer the questions	71%	29%
I can do grammar test	78%	22%
I can visualize the events	37%	53%
I can make a short summary	31%	69%

Table 5.
The survey analysis of students' attitudes in doing reading assessment tasks.

time observations were taken during the learning process to determine students' perceptions in assessing their reading skills. The class observations are conducted in some reading sessions as constructive tools to take notes or data in detail [35]. Regarding the qualitative research methodology, it is more important to collect data on students' progress in getting knowledge and skills in assessing reading. Thus, observation lists were used in the classes, and some notes in comparison were taken.

2.7 Challenges in reading assessment

Observations realized that students have some issues with predicting, identifying information, questioning, visualizing, and summarizing. Sophomore students have background knowledge in reading with translating, identifying new words and structures, choosing true and false answers, and responding to close-ended questions on a text model. They have some problems getting confused about the meaning of words and sentences; lack of skills to connect ideas in a passage; eliminate some words that are not important; analyze statements to distinguish important information from the text using minor detail; making passages in order; to explore cause and effect relationship; to use comparison and contrast; to concentrate themselves during reading [16, 36, 37]. Students' attitudes toward reading skills in different genres were observed with different indicators between boys and girls (**Table 6**).

The biggest problem is in reading and understanding texts of different genres. The main problem is reading various genres without analyzing them because of misunderstanding. The study proved that students have more interest in reading non-academic texts in English.

Gender	Fiction (%)	Documentaries (%)	Non-academic text (%)
Boys	14%	23%	26%
Girls	32%	29%	35%
Total	46%	52%	61%

Table 6.
Survey analysis of students' reading skills in different genres.

2.8 Teachers' challenges in the assessment of reading skills

The research aim is for students to improve assessment reading comprehension skills and explores various theoretical basis on this issue. Rethinasamy and Ramanair [18] suggests that teachers should implement reading assessment as an activity and procedure in English language teaching. These procedures include planning, implementing, and documenting the assessment process. However, teachers' assessment experience of reading skills is limited [13] in teaching. Teachers' main problem is to design formative assessment tasks for assessing reading. They get satisfied having students do more linguistic tasks, vocabulary tasks, multiple-choice tests on mastering good grammar, and several phonetic tasks for spelling in reading [34].

Artieda [38] and Veloo et al. [39] discovered that more university teachers hardly used classroom-based assessment in developing reading skills because they do not consider it helpful to the students. This explains why they practice limited classroom-based assessment because the higher education assessment model determines students reading levels by doing paper-based tests instead of practicing reading strategies. They argued that high-stakes testing has negative effects on reading assessment.

First, the discussion revealed that the majority of students should be aware of the requirements of assessment in improving their reading comprehension skills. They argue that the assessment criteria were helpful to identify their levels of reading. Only a few of them (2–3 students) feel stressed while assessing. Secondly, the study discovered that high leveled exam tests that entail theoretical explanations on papers cause fear in students and they could not solve any problems in the current situation.

It is a fact that in the assessment of reading comprehension, students should be involved in various tests, assignments, and daily classroom activities to develop cognitive and metacognitive skills in reading. The variations of tasks are based on well-structured tests and activities to ensure a comprehensive understanding of the texts for assessment. According to the survey responses, most of the teachers were able to make some progress in reading comprehension by using these types of tasks. The study has related factors that several measurements in formative assessment provide evidence in reading [40]. This evidence was identified in students' activities in the classroom-based reading process.

Moreover, data analysis shows that teachers' practice in assessing students' reading skills should be based on using different instructions to measure students' reading comprehension. They preferred using linguistic tests to communicative task techniques. Hence, students have challenges in involving reading activities and assessing their linguistic, cognitive, and communicative skills to comprehend texts. Another challenge is to have a lack of motivation, reading fluency, and using vocabulary in reading.

Additionally, formative assessment tasks provide all requirements shown above so that teachers could collect all detailed information about their student's progress. Furthermore, all information allows teachers to provide students with appropriate feedback to the students that master their expected skills in reading.

Discussing some lack in the observation process with students expressed their lack of motivation and getting stressed in the assessment process. Therefore, this lack is shown in comprehension of the text and achieving top-down skills. They need appropriate activities to predict the content, predict further events, find cause-effect, make the comparison, analyze the passages, and give a short summarization.

Finally, teachers and students mentioned that effective feedback is the best option to boost learners' further learning. Students are unaware of what areas are being assessed during reading or if they needed feedback to improve their reading. The feedback from the teacher helps them be aware of their level. Another finding was that teachers have an average level of insufficient experience in assessment or measuring scores of reading comprehension, therefore they need to involve training in implementing the assessment.

3. Conclusion

The research paper presents the importance and the role of assessment in reading comprehension which has been proven by many theoretical studies. This study showed that the reading comprehension assessment of undergraduate students makes them aware of their strengths and weaknesses in reading. The assessment provides students with opportunities for them to improve their reading comprehension skills across different reading strategies. Therefore, the assessment process should depend on clear criteria to indicate and inform teachers and learners about their reading levels.

Moreover, the article proved that it is necessary to provide freshmen and sophomore students with productive assessment tasks that provide metacognitive skills, rather than linguistic tests and tasks. The formative assessment tasks presented in the article respond to assessing students more adequately.

Nevertheless, both teachers and students have enough difficulties in the assessment of reading. It was pointed out that linguistic tests in reading comprehension do not develop any thinking skills, only content repetition and grammar knowledge. It realized that summative assessment in reading has a negative effect on students' comprehension. Students get stressed because of a lack of knowledge of reading strategies in a short period of time.

For this purpose, motivation, stress relief, and the principle of authenticity should be fully provided so that they feel self-development in reading, but not a test of knowledge in reading. In this case, the tasks on reading strategies should be applied in the reading assessment.

The methodology of the research showed that the qualitative method was the most successful tool for conducting this research. The article comments on the importance of tasks applied in formative assessment and evidence showed students' dynamic growth in reading comprehension skills through surveys.

Formative assessments based on measurable criteria and rubrics can also provide correlation in daily reading activities. It is a fact, the formative assessment allows teachers to see intensively students' strengths and weaknesses in reading. Therefore, tasks that meet formative assessment criteria can provide excellent information about learner achievement. The survey results showed that the respondents believed that ongoing formative assessment was the best tool for assessing reading comprehension.

In addition, teachers need sufficient training and experience in assessing reading comprehension skills in English. This research realized that teachers need to assess this skill on the criteria and to get.

a clear view of their learners' needs.

Hence, this study can benefit the improvement of English reading comprehension skills of lower-course university students and new strategies can be effectively applied in the assessment of reading skills.

At the same time, it will improve both students' and teachers' assessment knowledge and skills in the.

reading process.

Author details

Farida Huseynova
Azerbaijan State Pedagogical University, Baku, Azerbaijan

*Address all correspondence to: feridehuseynova21@gmail.com

References

[1] Auerbach ER, Paxton D. It's not the English thing: Bringing reading research into the ESL classroom. TESOL Quarterly. 1997;**31**(2):237-261

[2] Carrell PL. Can Reading strategies Be successfully taught? Australian Review of Applied Linguistics. 1998;**21**:1-20. DOI: 10.1075/aral.21.1.01car

[3] Huang H. Formative assessment in l2 classroom in China: The current situation, predicament and future. Indonesian Journal of Applied Linguistics. 2014;**3**(2):18-34

[4] Alderson JC, Haapakangas E-LA, Huhta LN, Ullakonoja R. The Diagnosis of Reading in a Second or Foreign Language. New York, NY: Routledge; 2015. pp. 265. $54.95 (paperback). ISBN: 978-0415662901

[5] Magliano JP, Millis KK, Ozuru Y, McNamara DS. A multidimensional framework to evaluate reading assessment tools. In: McNamara DS, editor. Reading Comprehension Strategies: Theories, Interventions, and Technologies. Mahwah: Erlbaum; 2007. pp. 107-136

[6] Afflerbach P, Cho BY, Kim JY. Conceptualizing and assessing higher-order thinking in reading. Theory into Practice. 2015;**54**(3):203-212

[7] Rouet JF, Britt MA. Relevance processes in multiple document comprehension. In: McCrudden MT, Magliano JP, Schraw G, editors. Relevance Instructions and Goal-Focusing in-Text Learning. Greenwich, CT: Information Age Publishing; 2011. pp. 19-52

[8] Breen MP, Barratt-Pugh C, Derewianka B, House H, Hudson C, Lumley T, et al. How Teachers Interpret and Use National and State Assessment Frameworks. Canberra: Department of Employment, Education, Training and Youth Affairs; 1997. pp. 91-128

[9] Black P, Wiliam D. Assessment and Classroom Learning. Assessment in Education. 1998;**5**:7-71. DOI: 10.1080/0969595980050102

[10] Anderson RC, Biddle WB. On asking people questions about what they are reading. In: Bower GH, editor. The Psychology of Learning and Motivation. New York: Harcourt Brace Jovanovich; 1975. pp. 89-132

[11] King-Sears ME, Burgess M, Lawson TL. Applying curriculum-based assessment in inclusive settings. Teaching Exceptional Children. San Diego, CA: Singular Publishing Group; 1999. pp. 30-38

[12] Anderson P, Fearnley-Sander M, Anzai D, Walker M, Mendelovits J, Turner R, et al. Shaping Reading Pedagogy and Assessment for Sustainable Learning. UKFIET. 2015. Available from: https://research.acer.edu.au/monitoring_learning/24

[13] Kendeou P, McMaster KL, Christ TJ. Reading comprehension: Core components and processes. Policy Insights From the Behavioral and Brain Sciences. 2016;**3**:62-69

[14] National Qualifications Framework – Azerbaijan (2018) Cabinet of Ministers of the Republic of Azerbaijan. Approved by decision. No. 311 dated July 18, 2018 Baku -Azerbaijan

[15] Douglas BH. Language Assessment—Assessing Reading Full Description with Picture and Chart. 2015. pp. 185-218

[16] Barr RB, Tagg J. Stakeholders' perceptions and implications of

classroom-based Reading assessment: A literature review, a new paradigm for undergraduate education. Change. 1995;**27**:13-25

[17] Brown DH. Language Assessment Principles and Classroom Practices. New York: Pearson Education; 2004

[18] Rethinasamy S, Ramanair J. Developing Rubrics For Performance Based Assessment Through Collaborative Effort. In: iCLS2021 Faculty of Language and Communication, International conference on Language studies -ICLS UNIMAS (virtual). Malaysia: Borneo University; 2021;**1**(1):1

[19] Mermelstein AD. Reading Level Placement and Assessment for ESL/EFL Learners: The Reading Level Measurement Method. ORTESOL Journal. 2015;**32**:44-55

[20] Trim J, editor. Common European Framework of Reference for Languages: Learning, Teaching, Assessment – A Guide for Users. Strasbourg: Langauge Policy Division, Council of Europe; 2001. Available from: https://rm.coe.int/1680697848

[21] Venn J. The diagrammatic and mechanical representation of propositions. Philosophical Magazine and Journal of Science. 2007;**5**:10-19

[22] Richek MA, Caldwell JS, Jennings JH, Lerner JW. Reading Problems:Assessment and Teaching Strategies. 4th ed. Boston, MA: Pearson Education, Inc; 2002

[23] Perera-Diltz D, Moe J. Formative and summative assessment in online education. Journal of Research in Innovative Teaching. 2014;**7**(1):130-142

[24] Linse C, Nunan D. Incorporating Reading in Writing Classes and its Effects on ESL Learners' Writing. Practical English Language Teaching. Creative Education. McGraw-Hill; 2005. pp. 121-134

[25] Cohen AD. The process of responding to an assessment instrument. In: Assessing language ability in the classroom. 2nd ed. Boston: Heinle & Heinle; 1994. pp. 115-159

[26] Bintz WP. Using freewriting to assess reading comprehension. Reading Horizons. 2000;**40**(3):205-223

[27] Gipps C. Beyond Testing: Towards a Theory of Education Assessment. London: The Falmer Press; 1994. pp. 112-114

[28] Gladwell JS. Lesile L. Intervention Strategies to Follow Informal Reading Inventory Assessment: So what do i do now? – Myeducationlab book series -3rd Edition. 2009. pp. 34-56

[29] Hudson RF, Holly B, Lane P, Pullen C. Reading Fluency Assessment and Instruction: What, Why, and How? 2011. DOI: 10.1598/RT.58.8.1

[30] Applegate MD, Quinn KB, Applegate AJ. Levels of thinking required by comprehension questions in informal reading inventories. Reading Teacher. 2002;**56**(2):174-180

[31] Kamhi AG. Three perspectives on comprehension: Implications for assessing and treating comprehension problems. Topics in Language Disorders. 1997;**17**(3):62-74

[32] Hattie J, Timperley H. The power of Feedback. Auckland, New Zealand: Rev Educ. Res. 2007;**77**:81-112. DOI: 10.3102/003465430298487

[33] Dennis D. "I'm not stupid": How assessment drives (in) appropriate

reading instruction. Journal of Adolescent and Adult Literacy. 2009;**53**(4):283-290

[34] Galdwell L. Intervention Strategies to Follow Informal Reading Inventory Assessment: So What Do I Do Now? 3rd ed. 2011. pp. 34-56

[35] Gall MD, Gall JP, Borg WR. Qualitative and descriptive research: Data type versus data analysis Educational research: An introduction (8th ed.). Boston: Pearson. Canberra: Department of Employment, Education. Training and Youth Affairs. 2007:91-128

[36] Mohd DZ, Abdullah MH. The Reform of English Language Education in Malaysia. 2019. Available from: https://www.freemalaysiatoday.com/category/opinion/2019/05/22/the-reform-of-english-language-education-in-malaysia/

[37] Nicol DJ, Boyle JT. Peer instruction versus class-wide discussion in large classes: A comparison of two interaction methods in the wired classroom. Studies in Higher Education. UK: Centre for Academic Practice, University of Strathclyde; 2003;**28**(4):457-473

[38] Artieda G. The Role of L1 Literacy and Reading Habits on the L2 Achievement of Adult Learners of English as a Foreign Language. System. 2017;**66**:168-176. DOI: 10.1016/j.system.2017.03.020

[39] Veloo A, Ramli R, Khalid R. Assessment practices among English Teachers in Malaysian Secondary Schools. International Journal for Infonomics. 2016;**9**:1220-1227. DOI: 10.20533/iji.1742.4712.0149

[40] Kline TJB. Psychological testing: A practical approach to design and evaluation. Thousand Oaks, CA: Sage Publications; 2005

Chapter 4

Critical Thinking, Problem-Solving and Computational Thinking: Related but Distinct? An Analysis of Similarities and Differences Based on an Example of a Play Situation in an Early Childhood Education Setting

Francesca Granone, Elin Kirsti Lie Reikerås, Enrico Pollarolo and Monika Kamola

Abstract

In the twenty-first century, four important different and intertwined domains for children's skills have been identified: cognitive, interpersonal, intrapersonal and technical. In the cognitive domain, key terms such as critical thinking, problem-solving and computational thinking have been highlighted. Although these terms have been identified as fundamental for preschool children, the literature draws attention to early childhood teachers' difficulty in including them in curriculum activities, which can therefore hinder children's learning. This chapter aims to analyse the similarities and differences in the characteristics of the three terms computational thinking, problem-solving and critical thinking. Such analysis of the terms will be of importance, both for further research in the area and for clarification in communication with teachers. In this way, the concepts may be more accessible for teachers. In particular, in this chapter, the concepts will be analysed and explained through an example from an educational setting where a group of children and a teacher play together with a digital toy.

Keywords: computational thinking, problem-solving, critical thinking, ECEC, teachers' competence

1. Introduction

In a rapidly changing world, supporting children in developing specific skills that help them understand and make choices in various situations has been recognised as essential. These skills have been identified as twenty-first-century skills [1]. Amongst the skills classified as cognitive competencies, critical thinking, problem-solving and computational thinking have been highlighted and considered part of higher-order thinking skills [2–4]. These terms have been identified as fundamental for preschool children [1, 5, 6], especially when mathematics is the learning goal [7, 8]. Granone et al. conducted a study in Norway on early childhood education settings (ECECs), where some terms, such as problem-solving and critical thinking, are known and well-introduced [8, 9], whereas computational thinking at an educational level is only mentioned in the curriculum for schools [10].

Wing, who introduced for the first time the term "computational thinking" [11], stressed the importance of making this term accessible, to allow teachers not only to use it but also to understand its meaning in all its parts without only carrying out procedures [12]. Some attempts have been made in the literature to analyse the similarities between the constituent characteristics of the three terms computational thinking, problem-solving and critical thinking [13] but never through a detailed analysis of the different elements that characterise each of them. Moreover, each of these terms has been analysed through Bloom's taxonomy [14] or the revised Bloom's taxonomy [15], but never all together [16–18]. However, the taxonomy seems to be a possible key for analysing all these terms together.

This chapter intends to present this analysis to identify any common aspects. Such an analysis of the terms will be of importance, both for further research in the area and for clarification in communication with teachers. In this way, the concepts may be more accessible for teachers, and this will help them to support children's acquisition of problem-solving, critical thinking and computational thinking skills more effectively [7, 8]. In this chapter, the concepts are analysed and explained through an example from an educational setting.

2. Problem-solving, critical thinking and computational thinking

The three skills that we analyse (problem-solving, critical thinking and computational thinking) can all be enhanced in different ways; they can also be enhanced through technology [7, 19]. Children's learning of these skills is considered fundamental, and teachers' roles have been highlighted in the literature as essential [20–22]. Hence, we explain these terms through an example taken from an educational setting where a group of children and a teacher play together with a digital toy.

A possible way to compare these terms seems to be offered, as anticipated, from the revised Bloom's taxonomy [15].

This taxonomy is a framework elaborated by Bloom [14] and modified by Anderson and Krathwohl for expressing skills through verbs. It consists of six major categories for describing learning skills: three defined "lower-order skills" (remember, understand and apply) and three defined "higher-order skills" (analyse, evaluate and create). Each category contains subcategories:

- Remember
    - Recognising: Locating knowledge in the long-term memory that is consistent with the presented material.
    - Recalling: Retrieving relevant knowledge from long-term memory.

- Understand
    - Understand: Changing from one form of representation (e.g. numerical) to another (e.g. verbal).
    - Exemplifying: Finding a specific example or illustration of a concept or principle.
    - Classifying: Determining that something belongs to a category.
    - Summarising: Abstracting a general theme or major point(s).
    - Inferring: Drawing a logical conclusion from the presented information.
    - Comparing: Detecting correspondences between two ideas, objects and the like.
    - Explaining: Constructing a cause-and-effect model of a system.
- Apply
    - Executing: Applying a procedure to a familiar task.
    - Implementing: Applying a procedure to an unfamiliar task.
- Analyse
    - Differentiating: Distinguishing relevant from irrelevant parts or important from unimportant parts of the presented material.
    - Organising: Determining how elements fit or function within a structure.
    - Attributing: Determining a point of view, bias, value or intent underlying presented material.
- Evaluate
    - Checking: Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented.
    - Critiquing: Detecting inconsistencies between a product and external criteria; determining whether a product has external consistency; detecting the appropriateness of a procedure for a given problem.
- Create
    - Generating: Coming up with alternative hypotheses based on criteria.
    - Planning: Devising a procedure for accomplishing some task.
    - Producing: Inventing a product.

2.1 Problem-solving

Children's problem-solving is presented as a key element in Norwegian ECECs [9].

The term problem-solving has been used for identifying a cognitive activity (what problem-solvers do), a learning goal (something to be taught) and an instructional approach (something to teach through) [23]. Furthermore, it has also been highlighted that problem-solving is a quite complex term that presents many nuances and that has been described according to many interpretations [24].

For example, the literature presents problem-solving from different points of view, referring to it as a cognitive process. It has been presented as a process that has as a goal to find a way out of difficulties or as a variety of cognitive processes, such as attention, memory, language and metacognition [25–27].

If we consider problem-solving as a learning goal, it has been described as a competence that children can reach through very different approaches, such as technology [7], or during outdoor activities [28].

However, problem-solving can also be identified as an instructional approach for helping children learn, for example, mathematics [29].

If we look at the evolution of the problem-solving framework [30], it is possible to see that it has been a development from the original definition introduced by Polya [31]. For example, we can find a model that identifies six steps instead of four [32] or a model that focuses more on the solver than on the process [33]. Because we are more interested in the process than in the solver and because Schoenfeld phases can be related to Polya's phases, we choose Polya as a reference for the analysis in our study. The three first phases of Schoenfeld ("read", "analyse" and "explore") can be related to Polya's phase "understand the problem", whereas the other phases are clearly similar.

In addition, recent literature still uses Polya as the main reference [7, 25–29]. Hence, we analyse Polya's problem-solving process, aiming to increase accessibility to this term.

Polya describes problem-solving through four phases: understand the problem, make a plan, carry out the plan and look back. Each phase is important because it leads to a different understanding of the problem and the process [31] (**Table 1**).

2.2 Critical thinking

Children's critical thinking is another key element presented in ECECs [9].

Critical thinking has been defined in different ways in the literature, and a consensus has not been reached [34]. In particular, some authors consider the terms critical thinking and problem-solving components of separate domains, whereas others include problem-solving in the term critical thinking or vice versa [34]. The term problem-solving has also been used as a synonym for thinking and as related to creative thinking and critical thinking [35]. This is because creative thinking is described as the ability to generate an idea that can be used to solve a problem, whereas critical thinking is more on evaluating ideas that can be used to solve a problem.

With the aim of describing in more detail critical thinking through the roots that he has in academic disciplines, three separate academic strands can be identified: the philosophical approach, the cognitive psychological approach and the educational approach [34].

The focus of the philosophical approach is on the critical thinker rather than on the actions that a critical thinker performs. This approach describes a critical thinker

	Polya's subphases	Description
Understand the problem	Getting acquainted	The problem has to be understood, identifying what is known and unknown and what is allowed. The problem has to be seen as a whole without concerning the details too much. The problem should stimulate memory and prepare for the recollection of previous knowledge.
	Working for better understanding.	The principal part of the problem can be isolated. Then, each part has to be considered in turn in various combinations and in relation to the main problem. The problem's details can be identified.
Make a plan	Generalisation	The phase "making a plan" means understanding the steps, at least in a rough way, that leads to determining what is unknown. This "bright idea" needs to be based on past experience, formerly acquired knowledge and formerly solved problems. Generalisation refers to seeing the problem more generally to find if there are similar aspects, in some related problems.
	Specialisation	This implies that a possible answer or a possible solution can be tried out if we know that it is incomplete. In any case, this leads to a new situation that must be reanalysed to elaborate a new strategy for finding the solution.
	Analogy	Analogy is used to identify connections amongst various problems, identify similar elements and determine how they can help in solving similar problems.
	Dropping a part of the condition.	All elements are not considered, and the problem is seen as a similar but simplified one.
Carry out the plan	Insight	The plan must be carried out carefully, checking each step. The correctness of each step can be checked intuitively.
	Formal proof	The correctness of each step can be checked formally.
Look back	Solution improvement	The results and the process have to be checked. The solution can always be improved (a solution that can need less time, fewer steps, ...).
	Understanding improvement	The understanding of the solution will improve. Re-examining both the solutions and the process (results and arguments) will consolidate knowledge and develop the ability to solve problems because they will use the same process for solving other problems.

Table 1.
Polya's phases. Ref: Polya [31].

as a person who is open-minded, flexible and interested in being well informed and in understanding other perspectives [36]. Some researchers have defined this approach as not always in accordance with reality [37].

The cognitive psychological approach is instead more focused on the thoughts and mental processes used to solve problems [37], identifying the critical thinker by the action or behaviour that they have [38]. An important element recognised is the ability to see both sides of an issue [39].

The educational approach is based on years of experience and observations and has Bloom's taxonomy as a key element [40], where the three highest levels are related to critical thinking. However, this approach has been criticised for being too undefined [34].

Because these approaches are quite different, we refer to the definition presented in Lai's literature review [34], where critical thinking is identified through skills that include both cognitive skills and dispositions. In this article, we focus only on cognitive skills (abilities) for analysing which common aspects can be identified amongst problem-solving, computational thinking and critical thinking (**Table 2**).

2.3 Computational thinking

Even if the term computational thinking is not explicitly present in the.

Norwegian Framework Plan for Kindergartens [9], other similar concepts, such as digital practice and the use of digital tools, are presented.

The term computational thinking was introduced by Wing as "a fundamental skill […] that involves solving problem, designing systems and understanding human behavior, by drawing on the concepts fundamental to computer science" [11].

The definition has evolved, and the literature presents various models that can be used to describe the computational thinking process. A framework is presented by Angeli [41], where computational thinking is described as a process where various steps occur, such as algorithmic thinking, modularity, debugging, pattern recognition, generalisation and abstraction.

In contrast, another framework points out abstraction, decomposition, debugging, remixing and productive attitudes against failure as the elements that should be considered for describing computational thinking [42].

Another model describes computational thinking as composed of the ability to think algorithmically in terms of decomposition, generalisations, abstractions and evaluation [43].

The models presented have some common aspects but also some differences. The description presented originally by Wing is broader and contains all the aspects presented later in various models [11]. The step "reformulating or reduction/transformation" is in relation to "remixing" [42]; "decomposition or thinking recursively" is in relation to "modularity" and "algorithmic thinking" [41, 43]; "choosing a representation" is in relation with "pattern recognition" [41]; and "learning" is in relation with "debugging" [41, 42], "productive attitudes against failure" [42] and "evaluation" [43].

Hence, we analyse the description of the different phases of computational thinking, starting from Wing's definition (**Table 3**).

3. Method

Four stages that compose a content analysis method have been followed in content analysis [44]. These stages are "decontextualisation", "recontextualisation", "categorisation" and "compilation". Decontextualisation is the stage in which meaningful units are identified. After reading a whole text to understand its meaning, a small part is identified and coded. Each researcher wrote a coding list to avoid changing during the analysis. The articles were analysed through an inductive approach, identifying the keywords that describe the various steps of each term. On the contrary, the practical example was analysed deductively, trying to identify the different parts in the transcription used as an example. The decontextualisation process was conducted repeatedly to guarantee stability.

DOI: http://dx.doi.org/10.5772/intechopen.110795

Critical thinking skills		Description
Cognitive skills	Analysing arguments, claims or evidence.	The ability to investigate the various elements that can, for example, explain or be part of a problem or a situation.
	Making inferences using inductive or deductive reasoning.	The ability to connect various elements and understanding connections to find an explanation or a solution.
	Judging or evaluating	The evaluation of an argument or a process in each single and basic part.
	Making decisions or solving problems.	The implementation of the strategies identified as suitable to answer a question or solve a problem.
	Asking and answering questions for clarification.	The ability of using dialogue for completely understanding a question or a problem.
	Defining terms	The importance of understanding the problem through a clear definition of each element.
	Identifying assumptions	To identify the ideas that are "taken for granted" in order to evaluate them and eventually open up to other strategies and solutions.
	Interpreting and explaining.	The evaluation of a process and the analysis of results or the explanation of a solution.
	Reasoning verbally, especially in relation to the concepts of likelihood and uncertainty.	The ability to think constructively to verbalise (and then probably understand) a question or a problem.
	Predicting	To anticipate what the result might be.
	Seeing both sides of an issue.	To analyse more than one aspect in each question or problem.
Dispositions	Open-mindedness Fair-mindedness The propensity to seek reason Inquisitiveness The desire to be well-informed Flexibility Respect for and willingness to entertain others' viewpoints.	

Table 2.
Critical thinking skills. Ref: Lai [34].

Steps in computational thinking	Description
Stating of the difficulty of a problem.	To understand if the problem can be understood and solved and how approximate the solution can be.
Reformulation or reduction/ transformation.	The ability of describing the same problem in a different way (more understandable) or to transform the problem into another problem.
Decomposition or thinking recursively.	The process of dividing a problem into smaller problems so that they can be solved one by one, in sequence. This is connected to what is called modularisation.
Choosing of a representation.	To choose a representation (a pattern) that can be identified as a model for describing a possible solution/procedure.
Generalisation	To identify the common elements amongst various patterns or problem-solving situations.
Abstraction	The process of eliminating information that is not fundamental in order to shape a procedure that can be used in another problem-solving situation.
Heuristic reasoning	The approach of solving a problem through shortcuts, strategies and through estimation.
Planning	Following the different steps described before for reaching the goal.
Learning	A result of applying computational thinking is learning how to solve a problem.

Table 3.
Steps in computational thinking. Ref: Wing [11].

Recontextualisation is necessary to ensure that all aspects of the content have been covered. This foresees that the text is read in its whole again, and that all the uncoded parts are evaluated with attention to understanding if those can also be coded. If those parts are evaluated again, not in relation to the aim of the study, they are then definitively excluded.

The categorisation process indicates when the codes are condensed and assembled into categories and themes. The themes should be chosen to avoid data that fit into more than one group or that fall between two themes.

Compilation is the process of choosing the appropriate units for each theme.

As suggested in the content analysis, each stage was performed several times to guarantee the quality and trustworthiness of the analysis. To draw realistic conclusions, different authors checked the keywords identified, as well as the connections amongst them. This is necessary for maintaining the quality of the process, assuring both the validity and the reliability of the study and avoiding mistakes or biases.

A content analysis of a vignette from an educational setting, including a group of children and a teacher playing together with a digital toy, was the basis for developing a comparison of the three terms. The play situation was in an early childhood setting, with four children aged 4–5 years and their teacher. They were all participants in the larger project DiCoTe "Increasing professional digital competence in early childhood teacher education with a focus on enriching and supporting children's play with coding toys", which the present study is a part of. The teacher and the parents of the children gave written permission to participate.

A second comparison starts from the results of the previous analysis and discusses a possible explanation of those results through the revised Bloom's taxonomy [45].

4. Results and discussion

Given that the purpose of this study was to highlight any similarities and differences between the terms problem-solving, critical thinking and computational thinking in an understandable way, we made two types of comparisons.

As indicated in the methods chapter, the analysis shows a comparison of the three terms based on practice, that is, on an example from an educational setting, where a group of children and a teacher play together with a digital toy. The use of technology is useful for having a greater chance to identify all three terms. The results are reported in **Table 4**.

The second comparison starts from the results of the previous analysis and discusses a possible explanation of those results through the revised Bloom's taxonomy [45]. The results are presented in **Table 5**.

Example from the field of practice	Problem-solving	Critical thinking	Computational thinking
The teacher asks the children to remember what they did before with the arrows and how the robot moved on each arrow.	Getting acquainted.		Stating the difficulty of a problem.
The teacher asks the children to explain what they have understood in order to check if they know how to proceed with the activity.	Working for a better understanding.	Asking and answering questions for clarification. Defining terms. Reasoning verbally, especially in relation to the concepts of likelihood and uncertainty.	Reformulating or reduction/transformation.
The teacher invites the child to look at each step, trying to exemplify how the robot can move on each arrow to go through the whole path.	Working for a better understanding.		Decomposition or thinking recursively.
To solve the problem, the teacher invites the children to observe the situation and try to understand if the present problem is similar to some situation previously encountered.	Analogy	Analysing arguments, claims or evidence. Making inferences using inductive or deductive reasoning.	Choosing a representation.
Having identified some similarities, the teacher invites the children to use the same solution previously used, trying not to be too focused on the differences and observing if something has to be modified.	Generalising		Generalisation Abstraction
The teacher then asks the children to guess how to build a new path based on their experience.	Insight	Predicting	Heuristic reasoning
Then, the children must build a new path using the same approach previously used.	Analogy	Making inferences using inductive or deductive reasoning.	

Example from the field of practice	Problem-solving	Critical thinking	Computational thinking
The children then try out the new solution.		Making a decision or solving a problem.	
The teacher invites the children to apply the solution that they have learned to a new situation (a new starting point and arrival point).	Analogy Formal proof		
The teacher invites the children to observe the robot moving on the path that they have built.	Analogy Formal proof		
The children are invited to analyse the solution they have chosen and distinguish relevant from irrelevant parts or important from unimportant parts.	Dropping a part of the condition.		
The teacher observes what the children have done in building the path and challenges them to think differently without following some unrevealed limitation that they have decided.	Specialisation	Identifying an assumption.	
The robot moves on the path but suddenly turns right when it is supposed to go forward. The teacher asks the children if they identify some errors, if everything is how they thought, or if they think that another solution could have been better.	Formal proof	Judging or evaluating. Interpreting and explaining.	Learning
The robot moves on the path but suddenly turns right when it was supposed to go forward. The teacher invites the children to observe each step in the path that they have built to see whether they can identify any errors. Then, she asks if someone can change the arrow that seems wrong and asks for an explanation of the error.	Formal proof	Judging or evaluating. Interpreting and explaining.	Learning
The teacher invites the children to find a new path that starts at the same point and arrives in the same arrival point but that is shorter.	Solution improvement.	Seeing both sides of an issue.	
The teacher decides on a new starting point and arrival point and asks the children to explain to her the path that they want to build, planning their strategy.			Planning
The teacher asks the children to invent a path and justify their choice.	Understanding improvement.		

Table 4.
Example from the field of practice analysed through the terms.

Problem-solving	Critical thinking	Computational thinking	(Anderson & Krathwohl, [45])
Getting acquainted.		Stating the difficulty of a problem	Recognising
Getting acquainted.			Recalling
Working for a better understanding.	Asking and answering questions for clarification. Defining terms. Reasoning verbally, especially in relation to concepts of likelihood and uncertainty.	Reformulation or reduction/ transformation.	Interpreting
Working for a better understanding.		Decomposition or thinking recursively.	Exemplifying
Analogy	Analysing arguments, claims or evidence. Making inferences using inductive or deductive reasoning.	Choosing a representation.	Classifying
Generalising		Generalisation Abstraction	Summarising
Insight	Predicting	Heuristic reasoning	Inferring
Analogy	Making inferences using inductive or deductive reasoning.		Comparing
	Making a decision or solving a problem.		Explaining
Analogy Formal proof			Executing
Analogy Formal proof			Implementing
Dropping a part of the condition.			Differentiating
			Organising
Specialisation	Identifying an assumption.		Attributing
Formal proof	Judging or evaluating. Interpreting and explaining.	Learning	Checking
Formal proof	Judging or evaluating. Interpreting and explaining.	Learning	Critiquing
Solution improvement.	Seeing both sides of an issue.		Generating
		Planning	Planning
Understanding improvement.			Producing

Table 5.
Discussion based on the revised Bloom's taxonomy. Ref: Anderson and Krathwohl [45].

4.1 Comparison based on an example from practice

The present vignette is an example of a play situation in an early childhood setting with four children aged 4–5 years and their teacher.

> *The teacher is sitting on the floor in a circle with four children. They have a coding toy in the centre of the circle. The coding toy is a robot that can be programmed without a screen through tactile arrows that can be puzzled on the floor and on which the robot moves. It is not the first time that the group is playing with the coding toy, so the teacher asks the children to remember what they did the day before, when they observed the movement of the robot on each arrow. To ensure their understanding, the teacher asks the children to verbally explain what they have learned, step by step. The teacher asks the children to build a path from a decided starting point to an arrival point. The children start building the path, and the teacher asks them after each step why they are choosing those arrows. A child puts an arrow that is for a "forward" movement, but he says verbally that the robot is going to turn. The teacher asks the child to reflect on a similar situation that happened the day before to help him see the similarity of the two problems and invite him to use the same solution that he used the day before. Then, the teacher asks for a verbal explanation of the error and of the correcting process. To help them further, the teacher highlights that when they have to find a solution, it is wise to try to remember similar problems without focusing too much on details. The teacher points out that many solutions are good, but sometimes, some solutions are better, maybe because a solution needs fewer arrows or maybe because it is faster. The teacher asks them to build a path from the same starting point and to the same arrival point, but that is shorter.*
>
> *The teacher challenges the children to build a new path but asks them to guess what they need before building the real path. The children suggest a solution and build it.*
>
> *The teacher then challenges the children again to use the same building strategy, suggesting a new starting point and a new arrival point. Whilst the robot moves on the path, the teacher invites the children to observe the robot and asks them if some elements could have been different because not every arrow may not be necessary. Then, the teacher challenges the children to think differently, going beyond some decisions and limitations that were correct but not necessary.*
>
> *As a last challenge, the teacher asks the children to decide on a new path, define the starting point and the arrival point, describe it verbally and justify how they will build it.*

Each part of the vignette was analysed through the three terms to highlight how each step of each term can be visible in a practical situation. The results in **Table 4** present a clear explanation.

4.2 Comparison based on the revised Bloom's taxonomy

To understand the results presented in Section 4.1 more clearly, we focus on the verbs used in each description to analyse whether they can be put in relation to Bloom's taxonomy in his revised form [45]. When the teacher asked the children to remember and describe what they learned through a verbal explanation, she was clearly helping the children to understand the problem [31], to reason verbally [34] and to decompose the problem [11]. Looking at the verbs used, we can identify a connection with the thinking skills "remember" and "understand" from the revised Bloom's taxonomy (Anderson and Krathwohl, [45]). In the same way, the teacher invited the children to think about similar problems and try out similar solutions. This can be seen as an invitation to think in analogy [31], making inferences [34] and choosing representation [11]. Then, she explained that the solutions could be different, that another solution can be better, and that it is important to reflect and analyse the situations to identify errors or possible improvements. This can be seen as a suggestion for a solution improvement [31], and a process of judgement and evaluation [34] or a learning process [11]. The thinking skills that can be identified here are "apply", "analyse" and "create".

However, from a more detailed analysis based on the specific verbs used in each step of each term and on each thinking skill, important considerations can be deduced.

Table 5 presents a discussion about how computational thinking, problem solving and critical thinking can be related to the educational goals that are relevant for the 21st-century skills [1], which are related to higher-order skills (Brookhart, [2]).

In our analysis, we can see that the three terms problem-solving, critical thinking and computational thinking have similar elements, but they do not completely overlap. For example, the element "identifying assumptions" [34] can be considered as a way for "understanding the problem" [31]. However, because of the specificity of the definitions, we did not include it in the first line of the table. This can, in our opinion, reduce the bias related to our point of view. The same consideration can be done for "planning" [11] and the step in problem-solving called "carry out the plan" [31].

The description that Polya gives on the step "make a plan: specialisation", and that can be identified through the guiding questions reported in the second part of his publication [31], point to a quite creative approach. It is not an approach composed only of various steps that are compiled recursively (as in the step "decomposition or thinking recursively" [11]) or a heuristic approach, but is connected to the question "What can I do with an incomplete idea?" [31]. This means having a plan that may not be complete yet, but that can be tried out for developing a different plan when a partial answer is acquainted.

Similarly, we were not able to create a relation between the various steps of computational thinking and one element that composes the critical thinking definition. The element "seeing both sides of an issue" [34] implies a broader analysis of a situation than the one that is in the step "stating the difficulty of a problem" [11]. This is because a path must be chosen to apply a computational thinking approach. This means that it should not be possible to change the condition during the process or analyse both sides of an issue at the same time.

What can be highlighted is that some skills can be supported simultaneously through enhancing children's problem-solving, critical thinking or computational thinking skills. However, some skills can be supported merely by enhancing children's problem-solving (recalling, executing, implementing, differentiating and producing), others by merely enhancing children's critical thinking (explaining) and others by merely enhancing children's computational thinking (exemplifying and planning).

This provides evidence of the importance of supporting all these skills, for example, by playing activities in ECEC. The analysis presents the key role of the teacher in supporting children's learning through questions and guidance. What seems to be highlighted is that different skills can be supported depending on the type of questions or guidance that the teacher uses.

5. Conclusions

The aim of the present article was to investigate the existing relationship amongst three important twenty-first-century skills: problem-solving, critical thinking and computational thinking. The results indicate a significant degree of congruence between the concepts but also highlight some differences. In particular, the analysis shows that all three terms can stimulate skills that can be described through Anderson and Krathwohl's taxonomy [45], but those skills are different if problem-solving, critical thinking or computational thinking is enhanced. The analysis, based on a correlation amongst a practical example from a play situation in an early childhood setting with four children aged 4–5 years and their teacher, shows that all three skills can be stimulated. However, the role of the teacher and how she stimulates and supports children's learning seem crucial. The example analysis suggests that a teacher's questions and guidance can lead children to learn various skills. This points out the fundamental aspects of a teacher's knowledge and awareness.

Acknowledgements

The present chapter is a part of the project "DiCoTe - Increasing professional digital competence in ECTE with focus on enriching and supporting children's play with coding toys", financed by the National Council of Norway, project number NFR-326667.

Conflict of interest

The authors declare no conflicts of interest.

Author details

Francesca Granone*, Elin Kirsti Lie Reikerås, Enrico Pollarolo and Monika Kamola
University of Stavanger, Stavanger, Norway

*Address all correspondence to: francesca.granone@uis.no

References

[1] Ananiadou K, Claro M. 21st Century Skills and Competences for New Millennium Learners in OECD Countries (OECD Education Working Papers No. 41). Paris, France: OECD Publishing; 2009. DOI: 10.1787/218525261154

[2] Brookhart SM. How to Assess Higher-order Thinking Skills in Your Classroom. Alexandria, VA: ASCD; 2010

[3] Collins R. Skills for the 21st century: Teaching higher-order thinking. Curriculum & Leadership Journal. 2014;**12**(14). Retrieved from: http://www.curriculum.edu.au/leader/teaching_higher_order_thinking,37431.html

[4] Zaharin NL, Sharif S, Mariappan M. Computational thinking: A strategy for developing problem solving skills and Higher Order Thinking Skills (HOTs). International Journal of Academic Research in Business and Social Sciences. 2018;**8**(10):1265-1278

[5] Soulé H, Warrick T. Defining 21st century readiness for all students: What we know and how to get there. Psychology of Aesthetics, Creativity, and the Arts. 2015;**9**(2):178

[6] Chalkiadaki A. A systematic literature review of 21st century skills and competencies in primary education. International Journal of Instruction. 2018;**11**(3):1-16

[7] Granone F, Reikerås EKL. Preschoolers learning by playing with technology. In: Education in Childhood. London, UK: IntechOpen; 2021

[8] Pollarolo E, Størksen I, Skarstein TH, Kucirkova N. Children's critical thinking skills: Perceptions of Norwegian early childhood educators. European Early Childhood Education Research Journal. 2022:1-13

[9] Kunnskapsdepartementet. Rammeplan for Barnehagen: Forskrift om Rammeplan for Barnehagens Innhold og Oppgaver. Oslo: Udir; 2017

[10] Regjeringen. Overordnet del–Verdier og Prinsipper for Grunnopplæringen. Oslo: Utdanningsdirektoratet; 2017

[11] Wing JM. Computational thinking. Communications of the ACM. 2006;**49**(3):33-35

[12] Wing JM. Computational thinking and thinking about computing. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. 1881;**2008**(366):3717-3725

[13] Voskoglou MG, Buckley S. Problem solving and computational thinking in a learning environment. Egyptian Computer Science Journal. 2012;**36**(4):28-46. Retrieved from: http://arxiv. org/abs/1212.0750

[14] Bloom BS, Englehart MD, Furst EJ, Hill WH, Krathwohl DR. Taxonomy of Educational Objectives: Handbook I. Cognitive domain. New York: David McKay; 1956

[15] Anderson LW, Krathwohl DR. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman; 2021

[16] Jewitt C. Multimodal methods for researching digital technologies. In: The SAGE Handbook of Digital Technology Research. 2013. pp. 250-265

[17] Rahbarnia F, Hamedian S, Radmehr F. A study on the relationship between multiple intelligences and mathematical problem solving based on revised Bloom taxonomy. Journal of Interdisciplinary Mathematics. 2014;**17**(2):109-134

[18] Bissell AN, Lemons PP. A new method for assessing critical thinking in the classroom. Bioscience. 2006;**56**(1):66-72

[19] Golding C. Educating for critical thinking: Thought-encouraging questions in a community of inquiry. Higher Education Research and Development. 2011;**30**(3):357-370

[20] Jouppila K. Supporting the Development of Critical Thinking in Early Childhood Education. 2021. Retrieved from: https://www.google.com/ url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjV5uq62bn3AhWthv0HHUH6AYMQFnoECAgQAQ&url=https%3A%2F%2Fwww. theseus.fi%2Fbitstream%2Fhandle%2F10024%2F502597%2FCritical%2520Thinking%2520in%2520Early%2520Childhood.pdf%3Fsequence%3D2&usg=AOvVaw2RPhZ2crskIaBK9Ik80OZO

[21] Davies C, Gibson SP, Hendry A, Archer N, McGillion M, Gonzalez-Gomez N. Early Childhood Education and Care (ECEC) Had Sustained Benefits for Young children's Vocabulary, Communication, Problem Solving, and Personal-Social Development during COVID-19, Particularly for those from Socioeconomically Disadvantaged Backgrounds. 2022

[22] Bers MU, Strawhacker A, Sullivan A. The State of the Field of Computational Thinking in Early Childhood Education. 2022

[23] Stanic G, Kilpatrick J. Historical perspectives on problem solving in the mathematics curriculum. The Teaching and Assessing of Mathematical Problem Solving. 1989;**3**:1-22

[24] Liljedahl P, Cai J. Empirical research on problem solving and problem posing: A look at the state of the art. ZDM Mathematics Education. 2021;**53**(4):723-735

[25] Simamora RE, Saragih S. Improving students' mathematical problem solving ability and self-efficacy through guided discovery learning in local culture context. International Electronic Journal of Mathematics Education. 2019;**14**(1):61-72

[26] Yayuk E, Husamah H. The difficulties of prospective elementary school teachers in item problem solving for mathematics: Polya's steps. Journal for the Education of Gifted Young Scientists. 2020;**8**(1):361-368

[27] Güner P, Erbay HN. Prospective mathematics teachers' thinking styles and problem-solving skills. Thinking Skills and Creativity. 2021;**40**:100827

[28] Lossius MH, Lundhaug T, editors. Mathematical problem-solving visualised in outdoor activities. In: Mathematics Education in the Early Years: Results from the POEM4 Conference. 2018. pp. 127-141

[29] Brijlall D. Exploring the stages of Polya's problem-solving model during collaborative learning: A case of fractions. International Journal of Educational Sciences. 2015;**11**(3):291-299

[30] Voskoglou MG. Problem solving from Polya to nowadays: A review and future perspectives. Progress in Education. 2011;**22**(4):65-82

[31] Polya G. How to Solve it: A New Aspect of Mathematical Method. NJ: Princeton University Press; 1971

[32] Schoenfeld AH. Teaching problem-solving skills. The American Mathematical Monthly. 1980;**87**(10):794-805

[33] Carlson MP, Bloom I. The cyclic nature of problem solving: An emergent multidimensional problem-solving framework. Educational Studies in Mathematics. 2005;**58**:45-75

[34] Lai ER. Critical thinking: A literature review. Pearson's Research Reports. 2011;**6**(1):40-41

[35] Mayer RE, Wittrock MC. Problem solving. In: Handbook of Educational Psychology. 2006. pp. 287-303

[36] Association AP. Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. ERIC document ED. 1990;**315**:423

[37] Sternberg RJ. Critical thinking: Its nature, measurement, and improvement. In: Link FR, editor. Essays on the Intellect. Alexandria, VA: Association for Supervision and Curriculum Development. 1985. pp. 45-65

[38] Lewis A, Smith D. Defining higher order thinking. Theory Into Practice. 1993;**32**(3):131-137

[39] Willingham DT. Critical thinking: Why is it so hard to teach? Arts Education Policy Review. 2008;**109**(4):21-32

[40] Forehand M. Bloom's taxonomy: Original and revised. In: Emerging Perspectives on Learning, Teaching, and Technology. Vol. 8. 2005. pp. 41-44

[41] Angeli C, Voogt J, Fluck A, Webb M, Cox M, Malyn-Smith J, et al. A K-6 computational thinking curriculum framework: Implications for teacher knowledge. Journal of Educational Technology & Society. 2016;**19**(3):47-57

[42] Bers MU, Flannery L, Kazakoff ER, Sullivan A. Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. Computers & Education. 2014;**72**:145-157

[43] Selby C, Woollard J. Computational Thinking: The Developing Definition. 2013. pp. 74-77

[44] Bengtsson M. How to plan and perform a qualitative study using content analysis. NursingPlus Open. 2016;**2**:8-14

[45] Krathwohl DR, Anderson LW, Merlin C. Wittrock and the revision of Bloom's taxonomy. Educational Psychologist. 2010;**45**(1):64-65

Chapter 5

Physical Education in the Academy – Learning Takes Body

Chiara Gentilozzi, Antonio Cuccaro and Filippo Gomez Paloma

Abstract

This contribution, starting from the scientific framework of the Embodiment phenomenon, wants to focus on the specific issue of university education aimed at students from an Embodied Cognition-based (EC-based) perspective. For several years now, European educational policies have required member states to create programmes to increase the educational level of the population and to give more importance to the training of key competences in order to guarantee continuous learning for all citizens. At the same time, the importance of promoting meaningful learning processes is emphasised, where the individual is able to actively construct the meaning of what is presented and to transfer their knowledge and skills. It is from these considerations that the research expressed in this paper takes shape, analysing the application and outcomes of the EC-based approach in the educational pathway of the students of the Physical Education course enrolled in the Primary Education degree course at the University of Macerata during the 2022/23 academic year.

Keywords: embodied cognition, training, motor education, workshop, academic teaching

1. Introduction

This contribution, starting from the scientific framework of the Embodiment phenomenon (edited by Gomez Paloma [1]), intends to focus on the specific issue of university education aimed at students from an Embodied Cognition-based (EC-based) perspective [2–4].

It is necessary, therefore, to focus attention on some fundamental aspects that characterise the educational process understood as the practice of human training, in a narrative and context-oriented perspective [5, 6], namely, the centrality of the body in learning processes [7], the places in which these processes are implemented [8], the workshop activity as a teaching methodology and search for meaning [9]. We cannot but start from the primary place where every learning dynamic is implemented and, contextually, located.

As an interpretative lens of corporeality as the nodal point of every cognitive acquisition of the human being, as well as the meeting point between subjectivity and intersubjectivity, we use the scientific paradigm of Embodied Cognitive Science, with particular reference to the Embodied Cognition approach [7]:

> *A human body is never given for itself, but in relation to others. Bodies near and far, touching or looking at each other, dancing together, building worlds. Bodies that evoke, reflect feelings and knowledge, tell lived stories and prefigure future ones ([8], p. 111).*

In this dynamic of continuous relationship with itself and the environment, the body shapes its knowledge of the world, overcoming the scientific conception that would have it as a mere object of evaluation to ultimately acquire the dignity of a *subject of cognition* [10]. For some time now, various authors have contributed to highlighting how complex phenomena require a complex, non-linear view, open to plurality, more representative of the variety and unpredictability of evolutionary and educational dynamics and outcomes [11–14]. On the basis of this evidence, the phenomenon of knowledge does not only require the participation of the brain and the body but also that of the environment in which it is immersed: an interesting constructive dialogue between Pedagogy and Architecture has been open for more than a decade [1, 15]. Learning environments, as an extension of the human mind [16], therefore, play a fundamental role in the interconnectedness of cognitive processes. As Merleau-Ponty [17] reminds us:

> *The influx of information from sensory organs and the continuous interaction with the environment then determine how the brain takes shape.*

2. Scientific framework: neurobiological bases of learning and educational implications

The realisation that cognition is embodied and that it depends on bodily characteristics, in particular our perceptual and motor systems should therefore be acquired by all those working in education. Numerous neuroscience studies, moreover, have shown how at the moment we receive information or a stimulus from the environment, there is an activation of neural circuits in our brain/body that are expressed in mental processes, processes that would not take place without the neural circuit activation of areas of the brain and not primarily dedicated to perception [18–20], action and emotions; the same happens when these mental processes activate response reactions, i.e. neural circuits that manifest themselves in the lived environment through behaviour [21, 22]. The body becomes a situated device of cognitive action as, in addition to being embodied, it is also situated in a context that defines it. Perceptual and motor systems, therefore, are of fundamental importance in the formation of structures from which 'global functions' arise, that is, those activities that give rise to categorisation, memory and learning [23]. In this complex process, a very significant role is played by emotions, which represent the main 'spark' through which the brain processes the value to be attributed to the information coming from sensory channels [24]. As soon as the input information is relevant, an emotional circuit is activated that can lead to the execution of automatic responses, or the planning of the response, by virtue of previous experience or the result of decisions elaborated in contingent contexts [25]. Thus, following a stimulus, our output responses are influenced by prior experiences that have been formed throughout our lives during the interactions we have activated with the world around us: the way we speak, reason, and construct concepts are the result of a continuous exchange between the perceived and the experience gained from embodied perceptions. Study, learning, and training contribute substantially to neural stimulation, to the possibility of the constitution of new synapses and thus from synaptogenesis generate the possibility of the construction of new patterns [26]. Taking up Kandel's [27] theories, it is possible to clearly outline the meaning of neuroplasticity: it is not neurons that change over time, but rather synaptic connections through continuous interaction with the environment. Studying and understanding the neuroscience that explains the neurobiological mechanisms, the nervous system and the functioning related to the mental and social processes that are activated in a person allows us to understand what complex system is involved in the functioning of a person and how these processes have come to be configured over time based on experiences, allowing for a true anatomical and physiological modification of the nervous system [28]. Our individual experiences and behaviour are rooted in the interaction between genes and environment that shapes our brain (epigenetics) [29, 30]. Knowledge of these basic constructs is also essential for understanding how knowledge construction processes are substantiated and is of fundamental relevance for teachers who aim to implement meaningful teaching, through which students can be enabled to construct authentic learning [31]. As teachers, it is necessary to offer as much room for expression as possible through the practical and lived experience of the pupils; if we want to form a solid foundation for their creative activity, we have to make them experience school actively because the more they are explored, experienced through the senses and assimilated, the more fertile their imaginative capacity will be [32]. The brain, if not appropriately stimulated also from an emotional point of view, will tend to construct mechanical learning that will be recorded in short-term memory and that will not leave a strong, felt mnemonic trace. Take, for example, the function of the amygdala, which is crucial in its ability to bring to consciousness an emotional stimulus, albeit a latent one, by returning feedback to the primary sensory cortices, such as to influence perceptual processing itself [33]. It is therefore necessary to offer a methodological approach that goes in the direction of multisensory involvement, for a non-standardised didactic in which all subjectivity is eliminated, a model that therefore goes towards personalisation for all [34]. It is necessary to recognise to 'all' teachers the burden and honour of constituting themselves as levers of change [35] by promoting inclusive paths where the context acts as facilitator of the subject's functioning in terms of activity and participation [36]. To do this, one must not leave aside the human relationships established between teacher and student: the majority of school experiences focus on the acquisition of skills and knowledge related to the contents of various disciplines, but personal well-being and prosocial behaviour require the cultivation of the ability to understand oneself and be empathetic from an early age, qualities that emerge when one acquires an awareness of the value of being reflective [37].

3. An embodied cognition-based training model

The EC-based approach assumes and promotes a multi-perspective view that recognises and enhances the existing circular dialogue, in learning processes, in order to outline more effective training paths in the three pivotal dimensions of embodied theory - cognitive, bodily and emotional [7, 18, 19, 38, 39] - that jointly and significantly determine the teacher's teaching actions [40].

In recent years, a number of preliminary exploratory studies [4, 29, 41] have been conducted in which the structuring of the constituent elements of the EC-based integrated training approach was gradually defined.

This contribution, starting from the EC-based approach, illustrates the academic experience conducted with the students of the LM-85bis Primary Education Degree Course at the University of Macerata. This training, accompanied by a qualitative-quantitative research design, had as its pedagogical focus Physical Education understood not so much as a discipline in the primary school curriculum, but as a methodological glue, a cultural and anthropological hinge with which to intervene professionally in teaching interaction.

3.1 Structure and design of training interventions

The EC-based approach is defined as integrated in that it envisages the articulation of three non-hierarchical phases: theoretical training, practical-experiential workshop and final discussion. Each of them aims at influencing and, in turn, being influenced by the others, through reflexive practices [42] aimed at activating metacognition, also fostering relational group dynamics, where emotions and empathy are declined as interdisciplinary constructs for the understanding and educational management of indifference, a pathology of our time [43]. In this sense, a training structured according to the Embodied Cognition theory stands as a possible model capable of meeting the training, educational and didactic challenges of teachers of our time.

The theoretical phase occupies the first part of each meeting and consists of a discussion of subject-specific content placed in continuity with the training principles. Theoretical training aims to stimulate meaningful learning [44] through continuous references to prior learning and systematic reflections that relate the contents and experiences of the learners or situations in real contexts; all with the aim of linking learning to the learners' training needs.

The second phase of the meetings are the *practical-experiential workshops*, which represent the *core of* the EC-based approach. These consist of situations of *role playing*, problem posing, problem solving, project-based learning, E.A.S. (Situated Learning Experiences), storytelling, writing and reading, outdoor education, small group *cooperation* activities in the co-construction of artefacts; *games involving the* active involvement of the body; *peer to peer* situations in practical experiences of 'observing' students in the classroom context, with *the* mediation of the trainer [45]. The observation of complex real-life experiences enables the simulation of situations and fosters the identification and active participation of teachers/learners, bridging the gap between theory and practice [46, 47]. These activities succeed in engaging the teachers'/learners' bodily, emotional, cognitive and motivational dimensions from a multisensory and emotionally meaningful point of view, activating situations of perception through vision and, consistent with the mirror system construct, favouring immediate referral to action, stimulating the ability to analyse, predict and choose possible strategies. Each day of academic training concludes with a *final discussion,* in which the lecturers invite the group to report their views on their experiences. Confirming the extent to which teaching professionalism is composed of identity, personal and value elements, reflection on one's *core qualities is* useful in the literature.

The sharing of personal perceptions respects the observation of certain rules of communication, such as respecting one's own and others' speaking time, suspending judgement, practising active listening and exercising positive *feedback*: this is in order to refine each teacher's empathic and relational skills and derive appropriate reflections on communication with and between students. Therefore, reflexivity and narration, action, sharing and self-evaluation are, in short, the strategic principles and guidelines capable of guiding the construction of training experiences consistent with the theory of Embodied Cognition, in a recursive process that emphasises the developments and interconnections that human communication is capable of generating.

3.2 Research design

This contribution illustrates the perceptions and experiences of students who attended the subject course in Physical Education using the ECS-based approach.

In order to obtain useful data for research from a qualitative point of view, a question was posed during the opening lecture through Mentimeter, an online platform that allows students to create interactive presentations and obtain feedback with elements such as questions, surveys, word clouds, reactions and more. Students can use their smartphones to view the presentations and interact by answering questions or surveys while guaranteeing their anonymity. An open question was designed at the beginning of the course that allowed students to express themselves freely: 'What do you expect from this course?'. The subsequent meetings followed the design shown in **Table 1**. *Finally*, during the last of the training days, a *final restitution was* carried out by means of a digital artefact [48], again constructed with Mentimeter, which was followed by a discussion in the form of a narrative restitution. The guidelines for this restitution were created by the trainer in such a way that the various key themes emerging from the training experiences could be opened up to the horizons of the discussion. All this is also in order to return to the teachers/learners the effectiveness of their commitment as well as, in an indirect and recursive manner, to operate a form of metacognitive processing of the experience, [49] as a means of recognition, taking charge of the individuality of each person and personalisation of the training paths. In this sense, it is noted that adequate training on Feedback Literacy, for both teachers and students, can foster the ability to understand feedback effectively, attribute meaning to the information received, manage it adequately also from a relational point of view and exploit it to improve and regulate one's own learning, taking into account one's active role and co-responsibility with the teacher and classmates. Conceptualised in a socio-constructivist dimension, as a bilateral flow of information, in reality, feedback is an active process, based on dialogue and interaction, which enables those who receive it to 'acquire information about their own work and to identify its greater or lesser compliance with a given standard, as well as the quality of the work itself, in order to produce better work' ([50], p. 6).

Getting to the heart of the matter, the qualitative analysis of the responses was based on the interpretation of the answers provided by the sample to the open-ended questions with the aim of reducing the complexity and breadth of the information collected, against which the answers considered useful for research were considered. This type of analysis allows texts to be deconstructed into a limited number of categories through the use of analytical decomposition, classification and coding procedures [51]. The open-ended questions were intended to explore the perceived effectiveness of the approach, leaving the opportunity to justify the answers in order to broaden the reflections on its strengths or weaknesses.

Specifically, the following operations were conducted:

- manual content analysis of the first type [52];
- occurrence count;

ARGUMENT	TOPIC	ECS-BASED ACTIVITIES
ECS: Embodied Cognitive Science foundations and theoretical models	Educational implications of neuroscience; From perceptual to cognitive processes; Intersubjectivity; Capability approach; ECS contribution to inclusive education.	Dramatisation by the students of the main cognitive and biological processes through the use of body and speech, creating original 'scripts' structured from the theoretical awareness acquired.
Body, environment, relationship	Perceptual neurophenomenology; Mechanisms of environmental conditioning; Body/brain-mind-environment relationship; Space/time/relationship design.	The students took part in a theatrical-assisted workshop, through which they were able to experience the main dynamics involved in the construction of the educational setting, in the awareness and management of their own bodies, and in the ability to verbally and in writing return their experience by exposing it to the group in narrative form
Anatomical-functional aspects	Anatomy and physiology; Systems and apparatuses; Motor skills and abilities; Modes of task organisation; Assistance and equipment.	The students took part in a mindfulness course in the search for greater awareness of their own bodies and breathing; afterwards, the various theoretical constructs were presented based on the reflections gained from the experience.
Theoretical models	Representation in body format; Somatic Marker; Mirror Neurons and Embodied Simulation.	The students were stimulated to experiment with alternative learning modes: the construction of knowledge in accordance with the Morinian construction of knowledge (Chaos Theory) and from the perspective of a Gadamerian-derived hermeneutics of knowledge.
Motor skills and abilities	Motor skills and abilities; Ways of organising the task; Assistance and tools.	The students took part in a workshop course where coarse and fine motor skills were experimented with in ways of organising the task with increasing difficulty and using specific equipment.
Educational planning and inclusion	Corporeality as a mediator between neuroscience and didactics; Innovative teaching models and methodologies; Embodied Cognitive Design: learning environments; Didactics for competences; International Classification of Functioning (ICF); Technologies for inclusion	The students were divided into small groups. Each group designed motor activities for primary school students, taking into account real contexts and specific situations. Each group reported on their work and submitted it for collegial discussion

Table 1.
Proposed EC-based topics and activities.

- decomposition of texts into a limited number of categories;
- analytical decomposition, classification and coding procedures [51].

The research design also envisaged the collection of quantitative data collected at the end of the workshop activities through Google forms (questions with quantitative measurement on a Likert scale from 1 to 10, where 1 corresponds to 'not spendable' and 10 corresponds to 'fully spendable').

3.3 Statistical survey

The sample of the present research is represented by the students of the Physical Education course - enrolled in the Primary Education Degree Course held at the University of Macerata in the year 2022–2023; during the first semester they attended 48 hours of teaching, without compulsory attendance, and 10 hours of laboratory with compulsory attendance, for a total of 157 students, 11 of whom were males and 146 females.

82.8% of the students are enrolled in the first year, 6.4% in the second year, 5.1% in the third year, 2.5% in the fourth year, 0.6% in the fifth year and 2.5% of students enrolled out of course.

The students who attended both curricular lessons and the workshop in presence were 58.6% of the sample and 7.0% in e-learning mode. 17.8% stated that they occasionally attended curricular lectures, while 16.6% did not attend any of the curricular lectures.

The constitution of the sample by age is shown in **Table 2**, by educational qualification in **Table 3**.

3.4 Results

The number of open-ended responses that students actually uploaded onto the Mentimiter system during the first curricular lesson was 87, while 157 responses were recorded upon completion of the workshop training cycle, via Google forms.

An initial observation of the preliminary analysis of occurrences, which is currently in progress, about the first question on initial expectations, shows the most frequent use of content/disciplinary terms such as 'motor schemes', 'functioning of the human body', 'anatomy' and 'motor skills' and methodological terms on how to construct a Physical education lesson such as 'psychomotor exercises'.

A preliminary analysis of the occurrences on the answers given as final feedback during the last lesson of the course to the question 'Were the expectations you had, with respect to this teaching, fulfilled? Justify your answer'. the words of satisfaction

18–24	25–39	40–50
77,07%	19,11%	3,82%

Table 2.
Sample age groups.

Higher Education Diploma	Degree	Other/Unspecified
69.4%	26.08%	3.8%

Table 3.
Qualification.

emerged for 'non-frontal lessons', 'reflection', 'connection between theory and practice', 'emotionally involving' and also thanks to the answers to the second feedback question proposed immediately after 'What impressed you most about this course' the words emerged are in line with the satisfaction of the initial expectations and with the answers given to the first question, with a greater attention to the relational aspect. In fact, we note the recurrence of 'interaction and participation', 'involvement', 'human relationship' and 'enthusiasm'.

From the preliminary survey of occurrences, the words 'body' and 'mind' 'emotions' are most frequently used, confirming the centrality of the active involvement of the body in the training approach and its ability to guide cognitive content as well.

The responses collected at the end of the workshop activities through Google forms revealed the following data.

1. 'How spendable do you think the skills acquired during this workshop will be in the professional field?', 77% answered in a range between 8 and 10 points, expressing a high perceived spendability, while 21% between 6 and 7, thus indicating a sufficient spendability and finally 1.9% attributed 5 points, noting a spendability below sufficient (see **Figure 1**).

2. 'How much do you think this workshop further clarified the concepts illustrated during the teaching and facilitated their understanding?', 49% of the participants expressed a score in the range 8–10, 28.7% expressed a score between 6 and 7, while 21% expressed a score between 4 and 5. Finally, 1.3% expressed a score of 2 (see **Figure 2**).

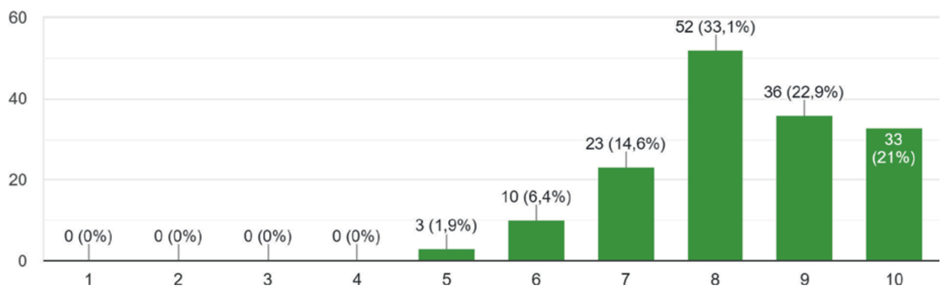


Figure 1.
Percentage of answers of the students on the level of marketability in the professional field of the skills acquired during the workshop.

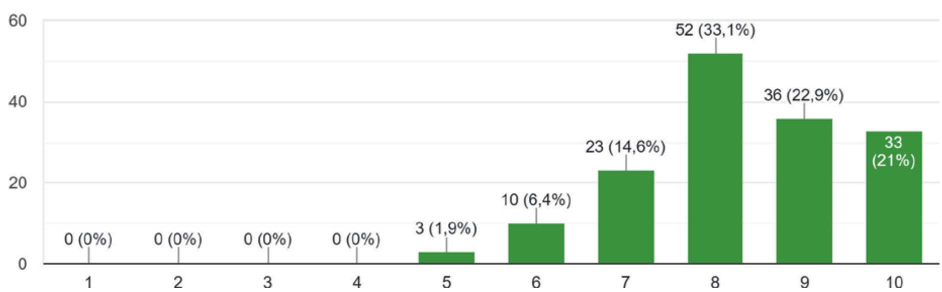


Figure 2.
Percentage of answers of the students on the level of impact of the workshop on the understanding and clarification of the concepts illustrated during the teaching.

4. Discussion

Here are some extracts from the most significant open-ended responses: '…I thought it would be a frontal lesson, but dialogue, debates and questions have positively developed each lesson', 'I actually expected the usual frontal lessons with content, so, it was a pleasant discovery that above all has made me reflect a lot on how I want to shape my teaching', 'yes (expectations were met), because I found that involvement, that passion, that stimulation of curiosity and emotion that I expected. Thank you for this Physical education course, which was also a life course and an incentive to improve ourselves', 'yes *(expectations were met, Editor's note)*, because I was able to better understand everything that lies behind the world of Physical education, which until now I only associated with the two hours of gymnastics', 'it was an interactive course, in which many of us actively participated with questions, group work. The lessons were never boring'; 'yes *(expectations were fulfilled, Ed.)*,) because teaching Physical education in a purely notional way would have been extremely boring both for the teachers/colleagues and of course for us students. Instead, the brilliant idea was to involve them emotionally as well,' the expectations I had were quite different…. I am happy that the professor aimed above all to make us construct our own thinking', 'from this course I didn't know what to expect clearly and even now that it is over I couldn't really describe what it left me, but certainly positive traces. I think the fruits of this course I will reap and understand over time'.

Finally, a deconstruction of the texts into a limited number of categories was carried out, which made it possible to trace back the words used, through a conceptual map and subsequent categorisation, to the constructs underlying the approach.

As can be seen from **Table 4**, the ability of integrated training to influence the personal dimension and morphology of the teacher emerged as a common element among the open-ended responses: to engage the three embodied dimensions in an integrated manner by offering the opportunity for a holistic training experience; to motivate and activate participation and leave significant traces of the experience; to establish a relationship of trust with the teacher; to establish a bridge between theory and practice through direct perception experiences that fostered constant reference; to promote metacognition.

This element offers the opportunity to emphasise how experiential theoretical-practical training is deliberately declined within university didactic lessons, and not merely relegated to laboratory hours, as a 'bridge' connecting theory and practice to offer an opportunity to reinforce the theoretical and specific training content that is indispensable.

With regard to the quantitative data, it is interesting to reflect on a few points. First of all, comparing these data with the answers to the question on the frequency of both teaching and laboratory (where 16.6% of the sample declared that they did not

Relational dimension	Motivational dimension	Theory-practice connection dimension
Future teacher	Dialogue	Active participation
Personal growth	Openness of mind	Reflection
Passion	Involvement	Metacognition

Table 4.
Main categories of the teacher's personal dimensions and professional morphology emerged as recurrences expressed in the open answers of the students.

attend the curricular course), it is evident that participation in the curricular part is a fundamental factor in answering the question. On the other hand, it is possible to infer that the perception of laboratory activities as a necessary, integrative and interacting part of the curricular course remains high, making the laboratory an essential component for the construction of a meaningful learning pathway.

With regard to the expendability of the training experience in real teaching contexts, 77% of the students involved noted a very high possibility (between 8 and 10) of being able to use the knowledge and skills acquired during the training in practice. In this sense, the participants note that activities structured with an ECS-based approach allow not only a co-construction of the learning phenomena and the necessary content knowledge but also a recursive relationship between theory and practice that increases the perceived expendability in real contexts. 21% of the participants noted a sufficient possibility, while a very low percentage (1.9%) did not point to a direct link between ECS-based approach and spendability. Precisely with regard to the desirable recursiveness between theory and practice, it is possible to note that the non-compulsory nature of the curricular didactic course, as opposed to the compulsory nature of the laboratory course, created a discrepancy for at least 16.6% of the students who did not attend any of the curricular lessons, making the laboratory experience the only didactic experience they tried out. At the same time, this percentage of students is precluded from comparing the two components of the experience. In fact, 49% of the students expressed the perception of a greater clarity of the contents exposed in the curricular didactic part thanks to the laboratory practice, to which we can add - in the perspective of an all in all positive perception - the 28.7% of the students who identify as sufficient the perception of integration between didactic activity tout court and laboratory practice. 21% of the students noted an unsatisfactory perception of the experience: in this percentage, it is possible to infer that the part of the students who did not take part in the teaching activities and only participated in the laboratory experience (16.6%) is involved. Finally, only 1.3% noted a substantial didactic non-usefulness of the laboratory part compared to the curricular teaching component of the training course.

5. Conclusions

On the basis of the results outlined above, it is possible to note that one of the substantial elements of the university training pathway for primary cycle school teachers is the recursiveness between teaching theory and practice, emphasising the need to actively construct one's own training pathway, participating in the construction of meanings and activating oneself in order to effectively connect what has been learnt in one's own study pathway and what has been physically experienced. It is possible to note that, taking into account the different cultural backgrounds of the students participating in the training project and the different age ranges to which they belong, it is necessary to promote ongoing and continuous training courses that take these elements into account. In this sense, for several years now, European educational policies have required member states to create programmes to increase the educational level of the population and give greater importance to the training of key competences in order to guarantee continuous learning for all citizens [53, 54]. With regard to the expendability of acquired knowledge and skills in real-life contexts, the importance of promoting meaningful learning processes is emphasised, where the individual is able to actively construct the meaning of what is presented and to transfer his or her knowledge and skills. For this reason, the research focused on the promotion of self-determination and self-regulation in school and vocational learning. The high percentage of satisfaction found with the ECS-based approach to didactics makes it possible to emphasise the importance of a substantial reconstruction of didactic and training logics useful for rethinking and problematising in such a way that the complexity and unity of the elements at play in learning processes, i.e. body-mind-environment, can be recognised. The ECS-based approach enabled students to become the protagonists of their own learning process and not just the subjects of the educational intervention. From the qualitative elements found in the research (**Table 4**), it can be seen that at least three fundamental dimensions characterising the training process, i.e. the relational, motivational and theory-practice connection dimensions, come together. If the occurrences underline a deep rootedness with respect to the perception of oneself in the perspective of personal and professional growth, identifying one's own path as directed towards the construction of the figure of the future teacher, passion turns out to be an equally important element. It therefore becomes necessary to recognise and accept that emotions represent significant and indispensable elements in the learning process. It is precisely emotions, in fact, that attribute meaning and significance to cognition, making it permanent and usable even in different contexts [55]. The results emerging from the research lead us to recognise the value of the motivational dimension in an academic training process. In this sense, the concepts of dialogue, open-mindedness and involvement assume relevant value and significance. In this sense, pedagogical reflection on the trainer's didactic actions must necessarily take these elements into account, preparing the setting in a shrewd and targeted manner, addressing not so much a passive audience as an audience to be understood as active, alive, relationally connected. The open-mindedness, the non-preclusion of one's own training space to the other and to the idea of the other, creates the prerequisites for a greater involvement to be implemented through a substantial and not merely formal perception of a dialogic syntony. A syntony that can be built by taking into account the human, emotional and personal elements present in each of the students, understanding them not as mere users of an investment in didactic terms but as a human group in training, profoundly interrelated, the subject of complex dynamics, positively interdependent. It is, therefore, necessary to implement an educational transformation that operationally recognises the value of the community [56] as an integrating background on which to build customisation processes.

Author details

Chiara Gentilozzi[1], Antonio Cuccaro[2] and Filippo Gomez Paloma[2†*]

1 Niccolò Cusano Net University, Rome, Italy

2 Department of Education Science, Cultural Heritage and Tourism, University of Macerata, Macerata, Italy

*Address all correspondence to: filippo.gomezpaloma@unimc.it

† The present research was conducted by the team of authors. Chiara Gentilozzi is responsible for the Introduction, the Scientific framework, the Analysis of results and the Conclusions. Antonio Cuccaro is responsible for the Methodological procedure. Filippo Gomez Paloma scientifically supervised the product.

References

[1] Gomez Paloma F, editor. Embodiment & School. Lecce: Pensa Multimedia; 2020

[2] Minghelli V, D'Anna C. Integrated teacher training embodied cognition based research data. Italian Journal of Health Education, Sport and Inclusive Education, Year. 2021;**5**(3):78-93

[3] Minghelli V, Damiani P. Embodied-based integrated training model for inclusive teacher competence enhancement. Mizar, Constellation of Thoughts. 2021;**15**:230-235

[4] Minghelli V, D'auria V, Gomez Paloma F. Integrated teacher training tools for the promotion of inclusive embedded competences. Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva. 2022;**6**(1):123-136

[5] Bruner J. The Meaning of Education. Roma: Armando Editore; 1990

[6] Smorti A. Il pensiero Narrativo. Costruzione di Storie e Sviluppo del Pensiero Sociale. Firenze: Giunti Editore; 1994

[7] Caruana F, Borghi AM. Embodied cognition: A new psychology. Giornale Italiano di Psicologia. 2013;**40**(1):23-48. DOI: 10.1421/73973

[8] Gamelli I. What body are we talking about? In: The Embedded Knowledge in Education and Care. Milan: Franco Angeli; 2012

[9] Sibilio M. Il corpo intelligente. L'interazione tra le intelligenze umane in un percorso laboratorio a carattere motorio. Napoli: Simone Editore; 2002

[10] Gomez Paloma F. Body Cognition, Integrated Skills and Teacher Training. Trento: Edizioni Erikson; 2015. p. 13

[11] Canevaro A. Inclusive Schooling and a Fairer World. Trento: Erikson; 2013

[12] Contini MG. Disalliances in Educational Contexts. Rome: Carocci; 2012

[13] Demetrio D. Pedagogy of memory. In: For oneself, with Others. Rome: Maltemi; 1998

[14] Kaneklin C, Scaratti G. Formazione e Narrazione. Milan: Raffaello Cortina editore; 1998

[15] Goldberg E. The Symphony of the Brain. (translation by C. Blum I. and Zago F.). Milan: Ponte alle Grazie Editore; 2011

[16] Clark A. Curing cognitive hiccups: A defence of extended mind. The Journal of Philosophy. 2007;**104**(4):163-192

[17] Merleau-Ponty M. Phénoménologie de la perception. Paris: Gallimard; 1965 (Original work published in 1945)

[18] Gallese V. Embodied simulation: From neurons to phenomenal experience. Phenomenology and Cognitive Science. 2005a;**4**:23-48

[19] Gallese V. Embodied simulation: From neurons to phenomenal experience. Phenomenology and the Cognitive Sciences. 2005b;**4**:23-48

[20] LeDoux J. The Synaptic Self. How our Brain Makes us Who we Are, (translated by Longoni M. and Ranieri A.). Milan: Raffaello Cortina Editore; 2002

[21] Gomez Paloma F, Damiani P. Handbook of ECS Schools. The Neuroeducational Approach. Brescia: Morcelliana; 2021

[22] Gomez Paloma F. Embodied Cognite Science, Embodied Acts of Education. Rome: Edizioni Nuova Cultura; 2013

[23] Frauenfelder E, Santoianni F. Le scienze bioeducative: prospettive di ricerca. Napoli: Liguori; 2002

[24] Damasio A. Emotion and Consciousness. Tr. it. Milan: AdelPhi; 1999

[25] Cristini C, Ghilardi A. Feeling and thinking. In: Emotions and Learning between Mind and Brain. Milan: Springer; 2008

[26] Shors TJ. Sfida ai Nuovi Neuroni. Milano: Rivista Le Scienze; Maggio 2009

[27] Kandel ER. In Search of Memory. The Story of a New Science of the Mind. Turin: Codex; 2007

[28] Ivry RB, Mangun GR. Cognitive Neuroscience: The Biology of the Mind. New York: Norton & Company; 2014

[29] Damiani P. Inclusion and epigenetic perspective. In: La Sperimentazione Della "Scuola ECS Based", Formazione & Insegnamento XVIII - 1. Lecce: Pensa Multimedia; 2020

[30] Gomez Paloma F, Buonanno E, Borrelli M. Innovative schools. In: L'Embodied Cognition Design come paradigma dei nuovi spazi educative. Rome: Edizioni Nuova Cultura; 2020

[31] Chandler P, Sweller J. Cognitive load theory and format of instruction. Cognition and Instruction. 1991;**8**:293-332

[32] Vygotsky LS. Imagination and Creativity in Childhood. Rome: Editori Riuniti; 1972

[33] Phelps EA. Emotion and cognition: Insights from studies of the human amygdala. Year. Rev. Psychol. 2006;**57**:27-53

[34] Ianes D. Bisogni Educativi Speciali e inclusione. Trento: Erickson; 2005

[35] Ainscow M. Developing inclusive education systems: What are the levers for change? Journal of Educational Change. 2005;**6**(2):109-124

[36] Organizzazione Mondiale della Sanità. Classificazione Internazionale del Funzionamento, della Disabilità e della salute (ICF). Trento: Erickson; 2001

[37] Gomez Paloma F. Corporeality, Didactics and Learning. The New Neurosciences of Education. Italy: Edisud, Salerno; 2009

[38] Barsalou LW. Rooted cognition: Past, present and future. Topics in Cognitive Science. 2010;**2**(4):716-724

[39] Glenberg AM. Embodiment for education. In: Calvo P, Gomila A, editors. Handbook of Cognitive Sciences: An Embodied Approach. San Diego: Elsevier; 2008

[40] Rivoltella PC, Rossi PG. Acting Teaching. Handbook for the Teacher. Brescia: La Scuola; 2017

[41] Damiani P, Minghelli V, D'Anna C, Gomez Paloma F. The embodied cognition based approach in teacher education. A recursive training model for integrated teacher competencies, Online Annals of Teaching and of Teacher Education; 2021;**13**(21):106-128

[42] Schön DA. The Reflective Practitioner: For a New Epistemology of Practice. Bari: Dedalo; 1999

[43] Contini M, Fabbri M, Manuzzi P. Non di solo cervello - Educare alle

connessioni mente - corpo- significati - contexts. Milan: Raffaello Cortina; 2006

[44] Ausubel D. Educazione e processi cognitivi. Guida psicologica per gli insegnanti (Vol. 25). Milan: FrancoAngeli; 1968

[45] Damiano E. La mediazione didattica. Milan: Franco angeli; 2013

[46] Impedovo MA. Reflexive approach and alternating practice and theory in teacher education: A case study in France. Training and Teaching. 2018;**16**(1):279-287

[47] Kersting N. Using video clips of classroom mathematics lessons as suggestions for measuring teachers' knowledge of mathematics teaching. Educational and Psychological Measurement. 2008;**68**(5):845-861

[48] Simondon G. Entretien sur la mécanologie. Revue de Synthèse. 2009;**130**(1):103-132

[49] Rossi PG, Pentucci M, Fedeli L, Giannandrea L, Pennazio V. From informational feedback, to generative feedback. Education Sciences & Society. 2018;**9**(2):83-107

[50] Boud D, Molloy E. Rethinking models of feedback for learning: The challenge of design. Assessment & Evaluation in Higher Education. 2013;**38**(6):698-712

[51] Weber PR. Basic Content Analysis. (Vol. 49). Essay. California: SAGE Publications; 1990

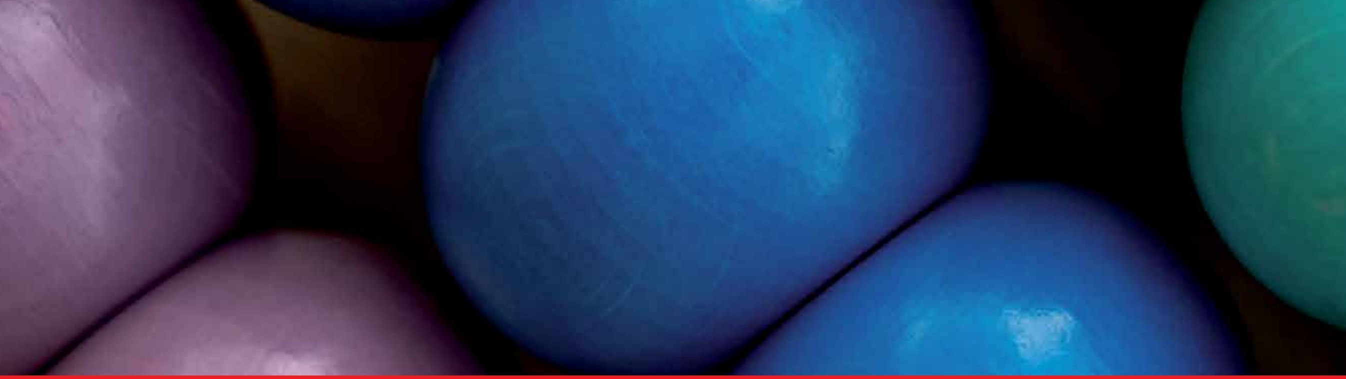
[52] Rositi F. Analisi del contenuto, in Rositi e Livolsi (a cura di) La ricerca sull'industria culturale. Roma: Nis; 1988. pp. 59-94

[53] Di Donato Flavia, La strategia di Lisbona nel campo dell'istruzione e della formazione. Roma: Anicia Edizioni; 2010

[54] Europe Strategy. 2023. Available from: https://www.invalsiopen.it/istruzione-formazione-framework-strategic-cooperation-europe-2020/

[55] Damasio A. Descartes' Error. Emotion, Reason and the Human Brain. Milan: Adelphi Editore; 1994

[56] Giaconi C, Caldin R. Pedagogia speciale, famiglie e territori. Sfide e prospettive. Milano: Franco Angeli Editore; 2021



Edited by Filippo Gomez Paloma

This book reviews the training and practice of teachers from several perspectives. The scientific quality and pedagogical richness of the contributions within make this book indispensable for training and enriching teaching professionalism and is useful for teachers in service as well. The interdisciplinarity that increasingly characterizes the educational and training environment clearly emerges, offering the reader a more articulated and less monotheistic vision. This vision, which at first might be more difficult to interpret and less functional to the educational impact of the text, instead offers the opportunity to build a new interpretative key of the complex educational–didactic and educational–professional phenomenon. Trying to govern a phenomenon rich in variables is a fundamental error; to operate with awareness and conscience, the best way is to go through the complexity of the phenomena and reading this book is, in our opinion, the best cultural weapon.

Published in London, UK

IntechOpen

ISBN 978-1-80356-910-9