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APPLICATION OF ANTHROPOLOGICAL THEORY OF DIDACTIC IN TEACHING OF MATHEMATICS

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Abstract. The anthropological theory of didactic is a new theory in the field of mathematics education, which was presented by a French mathematician named Chevellard in 1991. The main focus of the anthropological theory of didactic is on human interactions in the teaching-learning process. According to the framework of the Anthropological Theory of the Didactic (ATD), the goal of education is to elucidate the mechanism through which knowledge within an institution I is transmitted to individuals x in society $\widehat{S}$. Chevellard identified two aspects of human mathematical activity, which includes a practical part (Praxis) and a knowledge part (Logos). The Anthropological Theory of the Didactic (ATD) introduces praxeology as a tool for analyzing mathematical activities by considering their constituent components and the conditions present within educational institutions. Praxeology is a central concept and a key instrument in ATD. The aim of ATD is to provide a theory about human actions, and praxeology serves as the core concept for describing these actions. The practical part and the knowledge part are the components of praxeology (behavioral science). The practical part includes tasks and techniques. The knowledge part includes technology that explains the practical part. Also, the knowledge section contains a theory that justifies the technology used. The four elements of the anthropological theory of didactic (tasks, techniques, technology, and theory) are interconnected. In this article, after introducing the anthropological theory of didactic, the relationship between this theory and the theory of didactical situations (TDS) is stated. Then, the application of this theory in two mathematical examples from the school mathematics curriculum has been examined in detail. The article ends with the idea that the application of the anthropological theory of didactic can lead to a paradigm shift in the process of teaching and learning mathematics at school.

Keywords: Anthropological theory of didactic, Praxeology, school mathematics education, educational situations.

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1. Introduction

The Anthropological Theory of Didactics (ATD) is a theoretical framework developed by Yves Chevallard in 1991 to analyze and understand the processes of teaching and learning mathematics [3]. ATD focuses on the interactions between humans and knowledge within educational institutions, emphasizing the social and cultural dimensions of mathematics education. The theory is rooted in the idea that mathematical knowledge is not static but is shaped by the practices and norms of the institutions in which it is taught and learned [6]. ATD provides a comprehensive model for analyzing the didactic transposition of knowledge, which refers to the process by which scholarly knowledge is transformed into teachable content in educational settings [7].

One of the key contributions of ATD is the concept of praxeology, which refers to the combination of practical and theoretical knowledge in human activities. Praxeology is divided into two main components: the practical block, which includes problems and techniques, and the knowledge block, which includes technology and theory [8]. These four elements problems, techniques, technology, and theory are interconnected and form the basis for analyzing mathematical activities in educational contexts [9].

This article aims to explore the application of ATD in mathematics teaching, particularly in the context of school mathematics. We begin by introducing the theoretical foundations of ATD and its key concepts, including praxeology and didactic transposition. We then examine the relationship between ATD and the Theory of Didactical Situations (TDS), another influential framework in mathematics education [16]. Finally, we present three detailed examples from the school mathematics curriculum to illustrate how ATD can be used to analyze and improve the teaching and learning of mathematics.

2. Main Results

The Anthropological Theory of Didactics (ATD) is based on the idea that mathematical knowledge is not an isolated entity but is deeply embedded in social and institutional practices [17]. According to Chevallard, the process of teaching and learning mathematics involves the didactic transposition of knowledge, which refers to the transformation of scholarly knowledge into teachable content [13]. This process is influenced by the norms, values, and constraints of the educational institution in which it takes place [1].

ATD posits that any activity related to the production, dissemination, or acquisition of knowledge must be interpreted as a normative human activity. It then proposes a general model of human activity constructed through the idea of praxeology [7]. The similarities and differences between an educational system (referred to as an institution) in ATD can be understood and specified based on the conditions and constraints of the knowledge it utilizes ([3, 7, 8]). For every triplet consisting of a type of problem T, a technique τ, and a technology θ, there will be an associated theory Θ.

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ATD introduces the concept of praxeology as a tool for analyzing mathematical activities. Praxeology consists of four interconnected elements [2]:

(1) Problems (T): These are the tasks or questions that students are asked to solve.
(2) Techniques (τ): These are the methods or procedures used to solve the problems.
(3) Technology (θ): This refers to the explanations or justifications for the techniques.
(4) Theory (Θ): This is the broader framework of knowledge that justifies the technology.

The Anthropological Theory of Didactics (ATD) is defined as a theory for observing mathematical activities through epistemological models of mathematical knowledge. One of the reasons for using the term "anthropological" is that ATD situates mathematical activities, and consequently the study of mathematics, within the realm of human activities and social institutions [10].

Indeed, the theoretical component $\Lambda = [\theta/\Theta]$, which is typically associated with the practical component $\Pi = [T/\tau]$, merges with it to form a praxeology, as illustrated here:

$$\Pi \oplus \Lambda = [T/\tau] \oplus [\theta/\Theta] = [T/\tau/\theta/\Theta] \tag{2.1}$$

The quadruple $[T/\tau/\theta/\Theta]$ is called a **praxeology**. Praxeology is a central concept and a key tool in the Anthropological Theory of Didactics (ATD). The aim of ATD is to provide a theory about human practices, and praxeology is the core concept for describing human actions. A praxeology is an ordered pair $(\Pi; \Lambda)$, where Π is also an ordered pair $(T; \tau)$ and Λ is an ordered pair $(\theta; \Theta)$.
Here, **θ** represents the **technology**, which serves explanatory statements. It is the part of human action that justifies the use of the technique τ to solve problems of type T. The purpose of the technology θ is to make the technique τ understandable, explainable, justifiable, and provable within a specific institution [7, 5]). To solve a mathematical problem, θ depends on $(T; \tau)$. In fact, one of the roles of technology is to establish such connections among types of problems and techniques. However, the technology θ must (or may) also be justified at a higher level, where it is typically connected to other technologies. This higher-level justification is Θ, which is called the **theoretical component** of the praxeology. Θ relates to θ as well as to other technologies. The ordered pair $(\theta; \Theta)$ is called the **logos component** of the praxeology, which operates essentially at the level of reasoning and proof and can justify and make understandable a given technology or set of technologies. The theory Θ may consist of propositions such as definitions, principles, lemmas, theorems, and results to explain and justify the technology θ [19].

These four elements form the basis of praxeology, which can be used to analyze both the practical and theoretical aspects of mathematical activities. ATD also emphasizes the importance of institutional constraints, which are the norms and rules that shape the teaching and learning of mathematics within a particular institution [11].

The Theory of Didactical Situations (TDS), developed by Guy Brousseau, is another influential framework in mathematics education [18]. TDS focuses on the design of learning situations that promote the construction of mathematical knowledge by students. While TDS is primarily concerned with the cognitive and psychological aspects of learning, ATD takes a broader perspective by considering the social and institutional dimensions of mathematics education [12].

Despite their differences, ATD and TDS share some common ground. Both theories emphasize the importance of analyzing the interactions between teachers, students, and mathematical content [4]. However, ATD goes further by considering the role of institutional constraints and the didactic transposition of knowledge. In this article, we explore how ATD can complement TDS by providing a more comprehensive framework for analyzing the teaching and learning of mathematics.

To illustrate the application of ATD in school mathematics, we present three detailed examples from the mathematics curriculum. Each example is analyzed using the praxeological model, which allows us to examine both the practical and theoretical aspects of the mathematical activities.

Example 2.1 (Drawing Tangents to a Circle)**.** *The first example involves a geometry problem from the 9th-grade curriculum. Students are asked to draw two tangents from an external point to a circle and determine whether the lengths of these tangents are equal* [14]*. This problem is analyzed using the praxeological model as follows:*

- *Problems (T): The task is to draw two tangents from an external point to a circle and determine if they are equal in length.*
- *Techniques (τ): Students use geometric constructions and properties of tangents to solve the problem.*
- *Technology (θ): The technology involves the use of dynamic geometry software (e.g., GeoGebra) to visualize and justify the geometric constructions.*
- *Theory (Θ): The theoretical basis for this problem lies in the properties of congruent triangles and the perpendicularity of the radius to the tangent at the point of contact.*

This example demonstrates how ATD can be used to analyze the practical and theoretical aspects of a geometry problem, providing insights into the teaching and learning process.

Example 2.2 (Calculating the Area of a Triangle Using the Law of Sines)**.** *The second example is a trigonometry problem from the 10th-grade curriculum. Students are asked to calculate the area of a triangle given two sides and the included angle* [15]*. This problem is analyzed as follows:*

- *Problems (T): The task is to calculate the area of a triangle using the Law of Sines.*
- *Techniques (τ): Students apply the formula for the area of a triangle using the Law of Sines.*
- *Technology (θ): The technology involves the use of dynamic geometry software to visualize the triangle and verify the calculations.*
- *Theory (Θ): The theoretical basis for this problem lies in the Law of Sines and the properties of trigonometric functions.*

This example highlights the importance of connecting practical techniques with theoretical knowledge in the teaching of trigonometry.

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Example 2.3 (Similarity of Triangles)**.** *The third example involves a problem on the similarity of triangles, taken from the Indonesian mathematics curriculum* [2]. *Students are asked to find the lengths of unknown sides in two similar triangles. This problem is analyzed as follows:*

- *Problems (T): The task is to find the lengths of unknown sides in two similar triangles.*
- *Techniques (τ): Students use the properties of similar triangles to set up and solve proportions.*
- *Technology (θ): The technology involves the use of dynamic geometry software to visualize the similar triangles and verify the solutions.*
- *Theory (Θ): The theoretical basis for this problem lies in the properties of similar triangles and the concept of proportionality.*

This example demonstrates how ATD can be applied to analyze problems involving geometric similarity, providing a deeper understanding of the teaching and learning process.

3. Conclusion

The present study aims to introduce the Anthropological Theory of the Didactic (ATD) as a research perspective in mathematics education and demonstrates how ATD, through the lens of praxeology, can serve as a framework for studying mathematical situations. ATD describes human practices, including the doing, teaching, and learning of mathematics, in terms of praxeologies composed of two complementary components: a practical component ("knowhow") consisting of types of problems and techniques for solving them, and a theoretical component that emerges as a body of discourse to describe, explain, and justify the practical component.

The Anthropological Theory of the Didactic is also connected to the theory of didactic situations, as both examine the processes of teaching and learning mathematics. However, the theory of didactic situations is primarily grounded in psychological and cognitive perspectives, whereas ATD draws on anthropological and sociological viewpoints. The empirical epistemology of the theory of didactic situations relies on the observation and analysis of classroom implementations. Thus, the primary focus is not on the cognitive subject, i.e., the student, but rather on the situations that organize the relationship between such subjects and mathematical knowledge, as well as the reasons for its existence.

Research on ATD offers the potential for a paradigm shift in the teaching and learning of mathematics. The theoretical framework of ATD, particularly its praxeological analytical tools, has been developed for application in any educational situation, regardless of the prevailing teaching and learning paradigm. In the field of mathematics education, ATD has been internationally studied due to the advancements it has demonstrated both in mathematics education research and in other domains. However, in the domestic research literature, this theoretical framework has not received significant attention. Therefore, it is suggested that ATD be utilized in national-level research in mathematics education to leverage its potential in enhancing teaching and learning processes.

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