# Didactics Transposition in Mathematics Learning that Facilitates Students' Statistical Literacy

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**Abstract.** Didactic transposition is the process of transferring knowledge from scientific sources to experts, which is then used by teachers in the learning process in educational units. This study aims to describe the use of didactic transposition as a means of student learning and mathematics learning that facilitates students' statistical literacy. This type of research is qualitative research with the summative content analysis method. The data source used comes from literature studies indexed by Scopus, both journals and international conference proceedings. The data analysis technique uses four stages, namely: selecting, comparing, combining, and sorting until relevant meanings are found in knowledge related to didactic transposition and statistical literacy. The results of the study of the literature of relevant Scopus-indexed journals stated that the use of didactic transposition as a means of learning for students that facilitates their statistical literacy can increase enthusiasm in learning mathematics and have an impact on the ease of students understanding what is conveyed by the teacher.

## INTRODUCTION

Learning activities by integrating the approach with the concept of didactic transposition are very important because the systematic process of knowledge transfer [1] can be used to develop and analyze teaching materials [2]. Didactic transposition allows researchers to analyze the teaching materials presented in teaching modules and other learning resources. The analysis will reveal whether the teaching materials taught by teachers in the classroom are oriented to learning objectives or not, whether they are appropriate or not when reviewed from the learning design [3], student conditions, curriculum, and students' mathematical scholarly knowledge [4].

The concept of didactic transposition has the term noosphere which can be interpreted as the space of human knowledge. A group of human beings is semantically referred to as society and the composition of the association which together consists of human beings, namely teachers and students. The existence of the society is a forum for developing teaching materials that can facilitate statistical literacy for students through the concept of didactic transposition, namely building bridges on *scholarly knowledge* [5] and *knowledge to be taught* with *taught knowledge* [6] . This can provide space for teachers to develop strategies to overcome the gap, which is further known as *learning obstacles* , so that they can improve the quality of learning.

Through didactic transposition, it is also used to analyze teachers' knowledge of teaching materials based on the principles of scientific knowledge conceptually (Arzarello, et.all., 2004). If the mathematical knowledge possessed by students and teachers is in accordance with scientific knowledge conceptually and the curriculum that is the reference for learning [7], then the teaching and learning process activities between teachers and students can reduce student learning obstacles caused by teaching materials (Jamilah, et.all., 2020).

According to Chevallard, didactic transposition is a process of changing from original knowledge, for example, science at the university level to an easy form to teach for students [8]. This didactic transposition process involves several accompanying processes, such as adaptation, simplification, and reorganization of knowledge from subject matter that has been adapted to the needs and cognitive development of students and learning objectives (Brosseau, 1997; Bergsten et al., 2010). The process of transferring knowledge that is scientific or created by experts to knowledge applied by teachers to the learning process is known as didactic transposition (Brosseau, 1997; Chevallard, 1989). Figure 1 presents the didactic transposition process that occurs for a teacher.

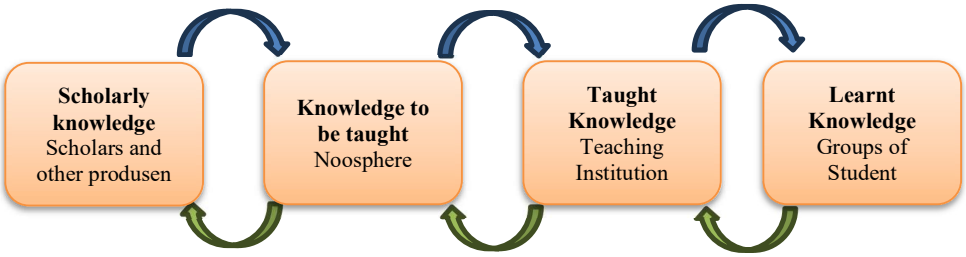


Figure 1. The process of didactic transposition

Figure 1 explains that there are several stages in the didactic transposition process which are described as follows.

a. *Scholarly knowledge* (scientific knowledge) is knowledge that comes from experts and researchers in their fields, for example mathematicians. This scientific knowledge is academic and tends not to be easily understood by students at the school level [11].
b. *Knowledge to be taught* (knowledge to be taught). In this step, the scientific knowledge that has been selected and determined, then adapted and modified to be suitable for teaching [3]. This process goes through steps of simplification, the use of relevant examples, and the reorganization of the material to make it easy for students to understand.
c. *Taught knowledge* (knowledge taught). At this stage, the knowledge that has been adapted and modified is then used by teachers to carry out the learning process in certain educational institutions (schools, universities, or others) [3]. The existence of a curriculum that regulates the needs of how the process of teaching knowledge to be taught, the use of teaching methods, and interaction between teachers and students are also some of the factors that affect how the knowledge is received by students.

*Learnt Knowledge* (Knowledge learned). The final stage of the didactic transposition process, students internalize knowledge from what has been taught by the teacher [11]. The knowledge internalized by these students can be in the form of skills, concepts, or values obtained during the learning process.

Based on the important role of didactic transposition, this study describes the process of didactic transposition in mathematics learning for students that facilitates the development of their statistical literacy. In addition, by looking at the learning obstacles experienced by students in learning mathematics caused by teaching materials or inappropriate concept delivery structures, it is necessary to conduct an in-depth study related to the preparation of efficient teaching material systematics so that it can make the design in the learning process more effective. In addition, teachers need to pay attention to *the learning trajectory* process of students so that it can be designed in learning tools in designing learning.

## METHOD

This type of research is qualitative research with the summative content analysis method. Content analysis is used to produce an objective and systematic description of the content contained in the text media. Content analysis is also interpreted as a systematic technique to analyze the meaning of a message and how to express a message. Initially, content analysis developed in the realm of communication and health sciences, but in its development it is now used in various fields of science. The content analysis has objectives including: 1) describing the tendency of the content of communication/messages, 2) tracking the development of knowledge, 3) detecting the existence of propaganda or hidden ideology, 4) identifying the intention and nature of communicators/writers. The essence of a content analysis is to find out the content and intent of a text. Descriptive studies in this case are needed to find out the content, while to find out the meaning of the text is carried out by making inferences and interpretations based on the analytical construct that is built.

The steps used in this content analysis method are presented in the following figure 2.


Figure 2. Stages of content analysis research

1. Identify the research question: develop research questions that are appropriate to the research theme and topic
2. Define the population: at this stage, the researcher looks at the population used so that it can be used to make references to all members.
3. Select the research design: There are several steps taken at this stage, namely: selecting literature with analysis that is appropriate to the research question, creating a coding scheme, developing a coding system.
4. Gather data: Data collection is carried out by selecting, comparing, combining, and sorting information that is appropriate to the research question. Researchers must try
5. avoid personal subjectivity.

Interpreting and reporting: This stage requires checking all the data obtained and combining the appropriate information to answer the research questions. The result of this interpreting stage is a comprehensive report with a focus on understanding didactic transposition and mathematics learning in statistics material and can be a recommendation for further research topics and potential improvements in mathematics teaching that facilitates students' statistical literacy.

## RESULT AND DISCUSSION

### Result

The results of this analysis content research produced an analysis of various 8 studies indexed by Scopus by comparing the research objectives, samples and research designs used in the study, which are presented in the following table 1.

**Table 1**. Comparison of research objectives, samples, and design

| Title of Paper | Objective | Sample | Reseach Design |
|---|---|---|---|
| The faculty development model of the University of MilanBicocca: towards an integration of general and disciplinary didactics [12] | Describe the training structure of the faculty development program at the University of Milan-Bicocca through large classroom teaching workshops | More than 200 professors, data taken since June 2017 | Qualitative research, case studies, use participatory evaluation and feedback from participants. |
| The process of proof in the geometric workspace: Initial training teachers [13] | Learn how beginner teachers relate their knowledge of the process of proofing in geometry between high school and university contexts. | 19 teaching practice students and 25 first-year students who failed in the Geometry course. | Qualitative research using interviews, questionnaires, surveys, and document analysis |
| Initial training in the teaching master: Reflections around the implementation of a didactic proposal for a reading and literary education [14] | Analyze the impact of the master of education program (MAES) on the formation of student teaching practices | One MAES student, a 3rd grade high school student, a tutor and a practice supervisor | Qualitative research, case studies, using questionnaires, field journals, direct observations, and discussions with practice tutors. |

| Title of Paper | Objective | Sample | Reseach Design |
|---|---|---|---|
| Evolution of Didacticians' meta-didactical Praxeologies and Documentation Work [15] | Understand the relationship between lecturers' meta-didactic praxeology to design and execute teacher professional development (PD) programs and their documentation work for the program itself | Two lecturers and 17 junior high school mathematics teachers. | Instrumental case studies using data from worksheets, slides, video transcripts, and teacher protocols |
| Resources and Praxeologies Involved in Teachers' Design of an Interdisciplinary STEAM Activity [16] | Examine the collaborative design of interdisciplinary STEAM activities conducted by junior high school teachers from various disciplines | 4 teachers (art, music, technology, and math/science ) | Case studies involving semi-structured oral interviews; data analysis using a combination of Documentation on Didactic and Meta-Didactic Transposition |
| Consistency between the teaching strategies and the curricular beliefs of teachers second cycle from educational activities [17] | Descriptively reveal the coherence/incoherence between didactic strategies and curricular beliefs in senior teachers. | 16 Primary School Teachers | Descriptive qualitative research with a hermeneutic approach |

In addition, the next stage of research is to analyze the content based on the results and limitations of the research presented in table 2 below. (The order of content analysis has been adjusted to the order in table 1 above)

**Table 2.** Comparison of results and limitations of the study

| Result | Limitation |
|---|---|
| Inter- and transdisciplinary approaches are important for the interlinkage of the three principles of training development design in the faculty. Dialogue between disciplines supports the development of didactic skills. Workshops encourage self-reflection and teaching practice. The program has been expanded [12]. | A single case study limits generalizations. It does not discuss the evaluation of the success of the program. Focus on the lecturer's perspective |
| Students of teaching practice show instability in understanding proof, often switching between paradigms. Visualization affects their reasoning. There is a mismatch between how proof is treated in universities and high schools. Students often rely on pragmatic evidence [13]. | Small sample sizes limit generalizations. Focus on geometry, findings may not be transferable to other domains. It does not discuss the practical implications for teacher education program design. |
| The implementation of didactic units has succeeded in increasing student interest and engagement. Feedback from practice tutors emphasized the importance of early session management, task follow-up, innovative strategies, and diverse assessments. Students enjoy activities, especially those involving group work, creativity, and technology [14]. | It is theoretical and does not involve empirical research with teachers or students. It would be beneficial to include concrete examples of how these principles can be implemented in a variety of learning contexts. |
| The documentation work of lecturers is closely related to their meta-didactic praxeology and reflects the goals of the PD program. Lecturer praxeology and documentation evolve over time, influenced by changes in program objectives. 'Help cards' appear as an important element in task design. This research proposes an interpretive model for lecturers' work [15]. | A single case study may have limitations in terms of generalization. The main focus is on the lecturer's perspective. The research does not address in detail how interpretive models can be applied to other contexts or disciplines. |

| Result | Limitation |
|---|---|
| The documentation work of each teacher is influenced by their expertise and goals, related to the discipline being taught, and based on a variety of resources with a specific utilization scheme. Teachers develop meta-didactic praxeology together, emphasizing hands-on experience before the formalization of mathematics. Mathematics is recognized as a lens through which to interpret the world [16]. | There are difficulties in managing the time to collaborate together in one time and one place. |
| High level of coherence between didactic strategies and teachers' curricular beliefs. Some inconsistencies were found, mainly due to teachers' beliefs about didactic strategies. Teachers show a diverse understanding of didactic concepts. Various didactic strategies and resources are used. Some teachers point out inconsistencies in distinguishing between strategies and resources [17]. | Small sample sizes limit generalizations. Focus on the second cycle of teachers. It does not discuss how teachers' beliefs are formed or how they can be changed. |

## Discussion

Based on the research stage that has been carried out, namely, determining research questions that are in accordance with the researcher's research topic, finding the population and sample, as well as the research design, and the results of the research, then, the researcher then looks for a new knowledge (insight) that can be a novelty in the researcher's research theme, namely didactic transposition for mathematics learning that facilitates students' static literacy. The following results of content analysis to find insights are presented in the following table.

*Article 1*

Didactic transposition begins with the scholarly knowledge stage which provides material sources from experts. The idea of developing didactic transposition research based on the results of the research in this article includes the didactic position at the university level involving the adaptation of teaching content and methodologies [11]to meet the specific needs of students and disciplines. In addition, an interdisciplinary approach can facilitate the development of didactic skills by guiding didactic transposition and educational reconstruction [5].

*Article 2*

The results of the research and the limitations of the research found in this article provide an overview of how to conduct research related to didactic transposition involving prospective teacher students. In addition, there are several things related to the content of the material that should be used by educators so that it does not become a conceptual error in didactic transposition [10]. Some of the things that were found as insights in the next didactic transposition research are that the didactic position that is not explicit about proof in universities creates difficulties for prospective teachers in bridging the gap between the practice of proof [3] at the university and high school levels.

More so, including explicit training on proofing and didactic transposition in teacher education programs is important to prepare them to teach mathematical concepts effectively [18].

*Article 3*

The results of the research mentioned show that there is an opportunity in the development of research related to didactic transposition, which he said, is that the didactic position is needed to bridge the gap between the academic knowledge of prospective teachers and the knowledge needed to teach effectively [19]. In addition, the importance of connecting theory with practice through hands-on experience in the classroom during teacher training [20].

*Article 4*

In this article, the researcher obtained things related to praxeology for lecturers, namely educators at universities so that they are expected to be able to initiate prospective teachers through their lectures. Some of the findings in the development of research ideas on didactic transposition are: 1) the meta-didactic phenology of lecturers and their documentation work develops over time, influenced by the goals of professional development programs and collaboration with teachers and 2) didactic transposition is a dynamic process that involves continuous adaptation of teaching materials and approaches [21].

*Article 5*

The researcher found things that support the novelty of the researcher's research related to didactic transposition, namely: 1) the collaborative design of STEAM activities by teachers involves the use of various resources and special utilization schemes; 2) the meta-didactic praxeology together guides the teacher's documentation work and emphasizes hands-on experience before the formalization of mathematics; 3) mathematics serves as a unifying tool in STEAM activities, interpreting real-world phenomena studied in various disciplines [22].

*Article 6*

The insights obtained include 1) teachers' beliefs about the curriculum and teaching strategies can affect their practice in the classroom and student learning outcomes; 2) the importance of alignment between teaching strategies and curricular beliefs for effective teaching; 3) the need for further research on how teachers' beliefs are formed and how they can be changed to improve alignment with teaching strategies [23].

Based on the content of the analysis, it can be concluded that there is an important role of teachers who teach and are student-centered, both at the school and university levels. The importance of adapting content and teaching methods that are in accordance with the specific context at the elementary school level to university and cross-cultural education. This is in line with the idea that complex mathematical knowledge needs to be transformed into a form that is more accessible and understood by students ([24];[25]). In the context of statistical literacy, this means presenting statistical concepts in a way that is relevant and meaningful to students [26], relating them to their previous experience and knowledge.

Some articles distinguish between external didactic transposition (the transformation of scientific knowledge into knowledge to be taught) and internal didactic transposition (the transformation of knowledge to be taught into knowledge to be taught in the classroom) (Pound, 2006; Bulut Atalar et al., 2018). These two stages are important in developing students' statistical literacy. External transposition ensures that the math curriculum includes relevant statistical concepts, while internal transposition ensures that those concepts are taught in a way that is appropriate to the student's level of understanding and learning objectives.

In succeeding in the performance of students in mastering statistical literacy, it is inseparable from collaboration between teachers, students and lecturers. This can be done in the form of collaboration and self-reflection by teachers because it is very important for continuous development and improvement in improving the quality of teaching practices and materials presented to students (Pocalana & Robutti, 2023; Aldon et al., 2013). In the context of statistical literacy, reflection and collaboration can help teachers identify student misconceptions, develop innovative teaching strategies, and create a learning environment that supports the development of statistical literacy.

In addition to teachers, lecturers also have an important role in the didactic transposition stage as an introduction to the understanding of scholarly knowledge. Mathematics teachers and lecturers play a central role in bridging the gap between formal mathematical knowledge and student understanding (Montoya Delgadillo, 2014; Aldon et al., 2013). This shows that teachers and lecturers need to have strong didactic knowledge related to mathematical content including statistics so that they can carry out didactic transposition effectively. Mathematics learning carried out with the concept of didactic transposition which is student-centered can indirectly facilitate students' statistical literacy. This provides opportunities for students to take an active role in their learning based on their interests and abilities.

Modern mathematics education, including the teaching of statistics, is increasingly oriented towards a student-centered approach to learning (Mara, 2017). The articles emphasize the importance of empowering students to take an active role in their own learning. Didactic transposition in this context should focus on presenting statistical concepts in a way that is relevant and meaningful to students, encouraging them to explore data, make guesses, and develop their own understanding of statistical concepts.

In addition, it is natural that all students have their own cultural values. Therefore, teachers are expected to be adaptive to cross-cultural issues that need to be considered specifically in order to be effective in the application of the concept of didactic transposition in the learning planning that will be presented.

Based on the content of the analysis above, the use of didactic transposition in mathematics learning that facilitates students' statistical literacy also has challenges and opportunities to be implemented effectively and

efficiently, including: 1) the gap between formal knowledge and student understanding, 2) the role of technology, 3) the importance of context, 4) cross-cultural considerations.

The challenge in bridging the gap between the formal mathematical knowledge that teachers have and the level of student understanding in teaching that facilitates statistical literacy. This means that the mathematics teaching presented by teachers needs to present complex statistical concepts in a way that is appropriate to the cognitive development of students (Montoya Delgadillo, 2014).

The potential of technology, such as computer algebra systems (CAS) and e-learning platforms, in supporting didactic transposition and improving mathematics learning, including statistical literacy (Gyöngyösi et al., to appear; Aldon et al., 2013) is a challenge as well as an opportunity in implementing didactic transposition. Technology can provide opportunities for students to visualize data, conduct simulations, and analyze large data sets, thereby improving their understanding of statistical concepts.

More than that, the importance of connecting mathematical concepts, including statistics, with real-world situations and authentic problems (Pocalana et al., 2024) is also a challenge for teachers to prepare for varied learning. This approach can help students see the relevance and usefulness of statistics in everyday life, thereby increasing their motivation and engagement in learning. In the context of statistical literacy, the understanding and interpretation of data can be influenced by the cultural context. Educators need to be sensitive to these cultural differences and adapt their teaching (Wang et al., 2023).

## CONCLUSION

The content analysis of the article reveals that didactic transposition is a crucial element in mathematics learning, especially in the context of developing students' statistical literacy. Didactic transposition is not just an adaptation of content, but also the transformation of complex mathematical knowledge into a form that is more accessible and understood by students. This involves adaptation of content and methodologies, the active role of teachers, student-centered learning approaches, collaboration, reflection, and consideration of cultural contexts. The implications of the results of this research are the importance of teacher professional development, responsive curriculum design, technology utilization, as well as collaboration and reflection, mathematics teachers need to continue to improve their didactic knowledge, especially in terms of statistical literacy.

Ongoing professional development programs can help teachers understand statistical concepts in depth, develop effective teaching strategies, and integrate technology in learning. The math curriculum needs to be designed with didactic transposition in mind, ensuring that statistical concepts are presented in a relevant and meaningful way for students. The curriculum also needs to accommodate the diversity of students and cultural contexts. Technology can play an important role in supporting didactic transposition and improving statistical literacy learning. Teachers need to be trained to use technology effectively in math learning. Collaboration between researchers, lecturers, and teachers, as well as self-reflection by teachers, is essential to improve teaching practices and develop effective learning materials in statistical literacy. Research opportunities that can be carried out in the future are related to the evaluation of the effectiveness of didactic transposition, the development of didactic transposition models, the use of technology in didactic transposition, and cross-cultural didactic transposition.

In carrying out this study, the researcher found limitations in the study, namely that some of the studies analyzed had limitations in terms of gseneralization of findings due to small sample sizes or focus on specific contexts, research focused on the teacher's perspective, while the student's perspective was also important to understand the didactic transposition process comprehensively, the research did not explicitly discuss the practical implications of their findings for curriculum development and teaching practice. Didactic transposition is a complex process and requires further attention and research, especially in the context of developing students' statistical literacy. By overcoming existing research limitations and exploring new research opportunities, it can improve understanding of didactic transposition and contribute to the development of more effective mathematics teaching practices to develop students' statistical literacy.

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