

TEACHERS' PROFESSIONAL KNOWLEDGE IN IMPLEMENTING TEACHING SCENARIOS ON THE PRINCIPLE OF PULLEY SYSTEMS IN SECONDARY SCHOOLS

Ahodegnon Zéphyrin Magloire DOGNON *

Institute of Mathematics and Physical Sciences, Laboratory of Didactics of Disciplines, University of Abomey-Calavi.

* Corresponding Author

ORCID Details

Ahodegnon Zéphyrin Magloire DOGNON: <https://orcid.org/0009-0008-1744-9193>

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ABSTRACT

This article examines the teaching and learning of pulley systems at Benin Secondary School. It is a case study whose main objective is to analyze the professional knowledge of physics teachers in order to identify barriers to learning and draw the necessary conclusions. The research is based on semi-structured interviews conducted with two physics teachers, drawing on the typology of professional knowledge proposed by Shulman (1986, 1987, 2007), adopted by Grossman (1990) and expanded upon by Magnusson, Krajcik and Borko (2012), which enables the identification of the knowledge that teachers must draw upon in order to teach a given scientific subject effectively: subject-specific content knowledge (CC), general pedagogical knowledge (CP) and content-specific pedagogical knowledge (PCK). The results primarily highlight a partial mastery of subject-specific content relating to pulleys and limited use of experimental approaches, which are likely to restrict pupils' understanding. The discussion highlights the need to incorporate more practical activities, even those using recycled materials, to reinforce learning. The study concludes that initial and continuing professional development for physics teachers on the epistemology of subject-specific content is important, and proposes ways to improve the teaching of pulleys in the Beninese context.

Keywords: Teaching and learning, Pulleys, Science pedagogy, Professional knowledge, Experimentation

1 INTRODUCTION

The teaching of physical sciences at secondary school level, and more specifically mechanics, is a key challenge for pupils' scientific education. Among the topics covered, pulley systems occupy a special place, as they enable the integration of fundamental concepts such as force, mechanical work and Newton's laws, whilst providing a fertile ground for experimentation. However, numerous studies in the didactics of physics have shown that learning these concepts remains challenging, due to persistent preconceptions amongst pupils and teaching practices that are often limited by a lack of experimental equipment (Viennot, 1979; Maarouf & Kouhila, 2001; Ahouassa, 2023). In the Beninese context, the teaching and learning of pulleys is included in the official curriculum from Year 8 onwards, but field observations reveal recurring obstacles linked to teachers' partial mastery of the subject content and the lack of

practical resources. This clinical study is set within this framework and aims to analyze the professional knowledge drawn upon by physics teachers in order to identify the difficulties encountered and propose avenues for improvement. It draws on Shulman's model (1986, 1987, 2007), further developed by Grossman (1990) and Magnusson, Krajcik and Borko (2012), which distinguishes between disciplinary knowledge, general pedagogical knowledge, contextual knowledge and content-related pedagogical knowledge. The aim is to understand how these different dimensions influence the implementation of teaching situations relating to the combination of pulleys and to draw inferences about teachers' actual practices.

1.1 Institutional framework for the teaching and learning of pulley systems

1.1.1 A brief history of chickens

Since ancient times, the pulley has established itself as one of the earliest inventions designed to reduce the physical effort required to move and lift loads. The earliest evidence dates back to Ancient Egypt (around 1991–1802 BC) and Mesopotamia in the early second millennium BC, where it was used to guide ropes in a rudimentary manner. The real turning point came in the 3rd century BC with Archimedes, who formalized the principle of mechanical advantage and devised the block and tackle. Plutarch, moreover, recounts a famous scene in which Archimedes, using a system of compound pulleys, managed to pull a fully laden ship towards him as if it were gliding on the water, thereby demonstrating the effectiveness of this device. Under the Roman Empire, pulleys were incorporated into large-scale constructions, and Heron of Alexandria (c. 10–70 CE) identified them as one of the six simple machines, capable of providing a decisive mechanical advantage. They also found practical applications in agriculture, well-digging and construction work. In the Middle Ages, they became widespread in everyday life, particularly in mills and shipping. The Renaissance marked a scientific milestone with Galileo, who demonstrated the principle of the conservation of mechanical work. In the modern era, pulleys evolved into more complex systems: blocks and tackles for lifting, as well as belts and chains for transmitting power between rotating shafts. The Industrial Revolution made them a central component of production machinery and lifting equipment. Today, they are ubiquitous in lifts, robots, fitness equipment and industrial systems, bearing witness to a long history in which a simple invention has become a universal tool of mechanics.

1.1.2 Teaching and learning about pulleys in secondary school

The analysis of knowledge relating to the teaching and learning of pulleys in secondary education in Benin is based on the official guidelines set out in the Physics, Chemistry and Technology Curriculum (P.E., Year 4, 2020, p. 97) and the Curriculum Guide (GPE Year 4, 2020, p. 15-17). In Year 4, the combination of pulleys is studied under the theme 'Verification of pulley combinations', with a view to developing the scientific and experimental approach, in accordance with the competence-based approach inspired by constructivism and socioconstructivism. The prescribed conceptual content includes mechanical interactions and forces (Newton's law of action and reaction, use of a dynamometer, examples of forces), the resultant of forces, the calibration of a spring, and the study of pulleys and hoists. The GPE further specifies the benefits and limitations of simple pulleys, as well as the use of the experimental approach to establish the general relationship between the magnitude of forces and displacements in a block and tackle with n pulleys.

In terms of competences, the teaching targets disciplinary competence No. 1 as defined by the GPE: 'To develop an explanation for a fact or phenomenon in one's natural or built environment by applying the modes of reasoning specific to physics, chemistry and technology' (GPE 4th edition, 2020). This competence is broken down into specific abilities and skills: expressing one's initial perception of a situation or problem, discussing and establishing links with other situations, defining the problem by identifying and correlating data, proposing an explanation through data collection and analysis, formulating provisional hypotheses, and selecting the most plausible explanation. Testing the explanation involves planning and carrying out experimental tasks, comparing the results with the hypotheses, and then formulating the final explanation. Objectifying the knowledge acquired involves identifying successes and difficulties, pinpointing possible improvements and implementing them. Finally, pupils are required to apply what they have learnt to everyday situations.

2 THE ISSUE

The issue of teaching and learning about pulley systems in lower secondary schools in Benin is based on several institutional, scientific and local observations. At an institutional level, the study of pulleys is included in the official curriculum from Year 4 onwards (PE 4^e, 2015; GPE 4^e, 2007), where it forms an essential stage in the teaching of mechanics and electricity, drawing on fundamental concepts such as voltage, current and resistance. However, the literature on physics pedagogy emphasises that teaching the associated concepts, particularly force and the application of Newton's second law, remains particularly challenging. The pioneering work of Viennot (1979, 1989) showed that pupils spontaneously associate force with motion, which hinders their understanding of the principle of inertia. Ménigaux (1986) and Brasquet (1999) identified recurring errors in the modelling of interactions and the balance of

forces, whilst Maarouf and Kouhila (2001) analysed learners' tendency to incorrectly reduce forces to a single force aligned with the trajectory. More recently, Ahouassa (2023) highlighted the limitations of traditional teaching when dealing with the abstraction of the concept of force, advocating for explicit modelling activities. Following the same line of reasoning, Dognon, Kaffon, Oké and Ahodekon (2025) demonstrated that the teaching methods used to teach Newton's second law in the final year of the science stream do not facilitate pupils' transition between the real and theoretical worlds, resulting in conceptual inconsistencies and a lack of interconceptual connections. At a local level, classroom observations reveal that pupils encounter difficulties in solving exercises on the combination of pulleys, that teachers often work without experimental support, and that large class sizes complicate individualized support. These findings fully justify targeted educational research, as the study of the combination of pulleys appears to be both scientifically fruitful and pedagogically necessary. The aim of this research is to understand current teaching practices in order to gather sufficient information to enable Year 4 pupils to correctly apply the principles of pulley systems. The research question formulated is as follows: 'What characterizes teachers' practical epistemology regarding pulley systems in Year 4 classes?', a question which enables us to explore the subject-specific, pedagogical and contextual knowledge drawn upon by teachers and to draw inferences about their actual teaching practices.

3 THEORETICAL AND METHODOLOGICAL APPROACH

The methodology of this research is based on Shulman's model (1986, 1987, 2007), enriched by the work of Grossman (1990) and extended to include that of Magnusson, Krajcik and Borko (2012), which distinguishes four categories of knowledge drawn upon by science teachers: - subject-specific content knowledge (SSCK): this refers to the knowledge that the teacher is responsible for teaching pupils; however, their subject-specific knowledge is not limited to what they are required to teach. For example, *Q19: What do you know about Atwood's machine?* - general pedagogical knowledge (GPK): this refers to the teacher's general knowledge about teaching, without being linked to any specific subject content. For example, this includes the knowledge the teacher draws upon when they wish to restore calm in the classroom. For example, *Q9: What types of activities do you usually plan for lessons on pulley systems?*

- Contextual knowledge (CC): This encompasses the teacher's knowledge of their pupils' backgrounds (social class, etc.) and the type of school in which they teach, which they take into account in their teaching. For example, *Q02: Could you very briefly describe the context of teaching and learning physics, chemistry and technology at your school?*
- Pedagogical Content Knowledge (PCK): this refers to the knowledge that a teacher develops to help pupils understand and learn a particular subject area. For example, *Q06: What is the statement of the subject-specific competence targeted by the teaching and learning of pulley systems in Year 8?* This theoretical framework provides a structure for analyzing teachers' professional competences relating to the teaching of pulley systems in Year 8. Data collection took place in two general secondary schools in the municipality of Porto-Novo. Two physics teachers, both Trainee Teachers (AME), took part in the study: one with eight years' experience, seven of which were spent teaching Year 8 science classes, and the other with eleven years' experience, ten of which were spent teaching the same year group. The method chosen was the semi-structured interview, selected for its flexibility and its ability to elicit teachers' perceptions and practices with a high degree of authenticity. The interviews were conducted separately, recorded and led by a colleague from the same school in order to minimize bias related to status.

The interview guide, comprising around twenty questions, explores the four types of knowledge identified by the theoretical framework. The distribution of questions focuses on CCD and PCK, which are considered the most relevant for analyzing teachers' ability to teach the principle of pulley systems. Consequently, sixteen questions (seven relating to CCD and nine to PCK) were devoted to exploring subject-specific knowledge and its didactic application. Data processing and analysis were based on the full verbatim transcription of the interviews, in accordance with conventions recognized by the scientific community. The information extracted was organized into a two-way table, enabling the types of knowledge drawn upon by each teacher to be correlated.

This analytical approach aims to draw inferences about teachers' professional competences by identifying convergences and divergences in the teaching of pulley systems in Year 8 classes

4 PRESENTATION AND ANALYSIS OF DATA AND RESULTS

4.1 Presentation of the data

In the table below, we have compiled all the findings drawn from the interviews we conducted with each of the two teachers. For each category of a teacher's core knowledge, we estimate the average score by assigning a score of 0 to any statement deemed not to conform to the reasonably expected answer, and a score of 1 to any response from the

teacher that is sufficiently close to what might be expected from a specialist in the teaching and learning of physical sciences.

In the following table, we present a compilation of the results obtained

Table 1: Summary of teachers' responses by type of knowledge

Profs	The GPK		The SSCK					The CK				
	Q9	%	Q17	Q18	Q19	Q20	%	Q1	Q2	Q12	Q13	%
P1	1	100%	1	0	0	0	25%	1	1	1	0	75%
P2	1	100%	1	0	0	0	25%	1	1	1	0	75%
The PCK												
Q3	Q4	Q5	Q6	Q7	Q8	Q10	Q11	Q14	Q15	Q16	%	
0	1	1	1	0	0	0	0	1	0	1	45%	
0	1	1	1	1	1	1	0	1	0	1	73%	

4.2 Analyse des données recueillies

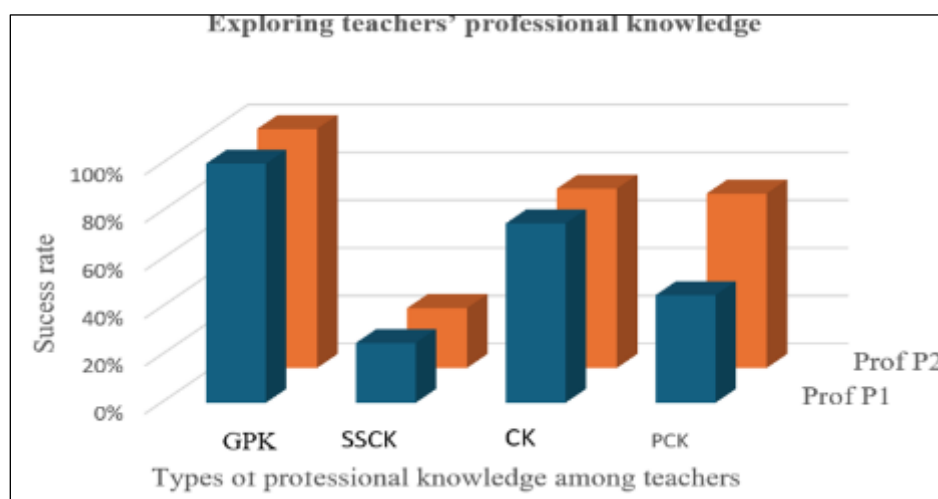


Figure 1: The professional knowledge of P1 and P2 teachers

4.3 Contextual knowledge (CK) of the teaching and learning of pulley systems

Analysis of the data collected shows that the teachers interviewed have a good understanding of the context of teaching and learning about pulley systems in Year 8 (a 75 per cent success rate for each teacher). They appear to have a good understanding of their pupils' social circumstances as well as the specific characteristics of the schools where they work, and state that they take these into account when delivering their lessons. With regard to the difficulties they frequently observe among pupils when solving problems involving pulley systems, the teachers highlight challenges linked to the specific conditions of the school in which they work. Among these, they mention the steady decline in learners' language proficiency, the overcrowded classes they are responsible for, and their school's glaring shortage of teaching materials needed to conduct practical experiments as part of the lesson on pulley systems. With regard to conceptual difficulties, the teachers mention that pupils encounter mathematical difficulties and are unable to make the connection between the different forces at play when using different types of pulleys. However, neither teacher was able to provide any details whatsoever regarding the socio-demographic conditions and/or characteristics of their pupils that might impact their learning. Knowledge of these factors would enable the teaching methods used to be adapted to support the pupils' learning.

4.4 Teachers' subject-specific knowledge (SSK) relating to the use of pulleys

An analysis of the responses provided by the two physics teachers in our sample reveals that they demonstrate only a very limited grasp of the specific content relating to the use of pulleys (a 25 per cent success rate on the questions asked). Indeed, the teachers make no connection between universal gravitation and the use of pulleys. Originally, in 1784 (Van Biezen, 2013), Atwood designed the simple machine that bears his name to study free fall. The advantage of

the invention lies in circumventing the short duration of the fall by reducing the acceleration of the masses, thereby enabling the elapsed time to be measured far more accurately than with the inclined planes previously tested by Galileo. From an educational perspective, Atwood's machine has often been used to enable pupils to verify Newton's second law and/or the conservation of mechanical energy. Thus, if the masses of the pulley and the string are negligible compared with the sum of the suspended masses, if the frictional forces are negligible compared with the difference in their weights, and if the elasticity of the string is neglected, we see that the heavier mass m_2 falls with the reduced acceleration a :

$$a = \frac{m_2 - m_1}{m_1 + m_2}g$$

equality from which it can easily be concluded that $a < g$. Although both teachers were able to describe the practical uses of pulley systems, they were unable to provide a brief history of pulleys to establish a link with the law of universal gravitation, which will be the subject of extensive teaching and learning from Year 9 onwards (the relationship between weight and mass, Newton's second law, the law of conservation of momentum, etc.). A teacher's knowledge of the subject content relating to the use of pulleys is not limited to what they are required to teach. This knowledge must extend to a much higher cognitive level to enable the teacher to better ground their teaching in a forward-looking perspective within the framework of the curriculum across the various school years. It is easier to understand why learners experience conceptual difficulties with regard to scientific knowledge.

4.5 An exploration of the pedagogical knowledge of physics teachers

The teachers were asked a single question to explore their pedagogical knowledge. Both teachers correctly explained to us that the learning strategy they implement in the classroom is based on the systematic use of individual work, followed by group work, to foster an interactive dynamic capable of leading to the joint production of scientific knowledge, before carrying out a collective task with the whole class with a view to institutionalizing this knowledge. We can therefore state, even though the single question asked is not particularly meaningful, that the two teachers in our sample demonstrate good teaching practices in the classroom.

4.6 An exploration of content-related pedagogical knowledge (PCK) concerning the use of pulleys

As PCK represents the professional knowledge that is crucial to a teacher's effectiveness in the classroom, we asked the teachers eleven (11) questions (out of the twenty questions in the interview guide) to explore the knowledge that a teacher develops to help learners understand and learn content relating to pulley systems. In this regard, the two teachers differed. P1 achieved a score of only 45 per cent, compared with 73 per cent for P2. For both P1 and P2, pulleys are only taught and learnt in Year 8 classes in general secondary schools. However, as discussed in the previous paragraph, pulleys feature in the curriculum for Year 9, Year 11 and, in particular, Year 13, where Newton's second law is covered. It is therefore understandable why neither teacher makes any connection between pulleys and Earth's gravity or universal gravitation. Furthermore, neither teacher was able to list the institutional guidelines relating to the teaching and learning of pulley systems. Thus, for example, unlike P1, P2 was unable to state the subject-specific competence targeted by the teaching and learning of pulley systems in Year 4. This raises questions about the training of teachers who are unable to readily present the knowledge to be developed with learners. It is interesting to note that P2 managed to describe the teaching and learning strategies to be implemented for the classroom teaching of pulley systems. This is not the case for P1, who confuses learning strategies (forms of work) with teaching and learning strategies, that is to say, the activities to be proposed to pupils to help them develop an understanding of pulley systems. The two teachers also differed on how to teach the pulley system in Year 8. On this point, P1 rightly suggests teaching the pulley system by following the experimental approach specific to the subject of Physics. As regards the organization of construction materials in the classroom for the pulley system, unlike P2, P1 was unable to provide a list of the minimum materials required. This highlights the fact that most teachers teach physics through the study of documents, as research in science education has already shown.

Overall, the teachers in our sample do not appear to possess a solid pedagogical understanding of the content relating to pulley systems, such that we might consider them capable of implementing it in the classroom in a way that enables pupils to develop a sound conceptual understanding. It seems that this is, at least in part, a consequence of their insufficient knowledge of the subject-specific content relating to pulleys.

5 CONCLUSION

Analysis of the data collected from the two physics teachers reveals a partial grasp of the subject content relating to pulleys and limited use of experimental approaches, which contributes to the pupils' conceptual difficulties. Whilst the teachers have a good understanding of the school context and report using interactive teaching strategies, their pedagogical knowledge of the subject matter appears insufficient to ensure effective management of pupils' learning regarding the combination of pulleys. These findings underscore the importance of initial and continuing professional

development focused on the epistemology of scientific content and on the integration of experimental set-ups, even simple ones or those made from recycled materials. The study calls for teachers to be better prepared to link subject-specific knowledge with teaching practices, in order to promote a better conceptual understanding of mechanics among pupils. It also opens up avenues for future research into the development of contextualized teaching sequences and the assessment of their impact on the learning of pulley systems in lower secondary school. Ultimately, the teaching of pulley systems appears to be a prime area for examining the training of science teachers and for promoting a teaching approach more firmly rooted in experimental practice and conceptual understanding.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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REFERENCES

- [1] Ahouassa, M. S. (2025). An exploration of the concept of strength in teaching practices in Benin. Doctoral thesis. University of Abomey-Calavi.
- [2] Dognon, A. Z. M., Kanffon, D. A. C., 1, OKE, S. E., et Sessou Ahodekon, C. C. (2025). Teaching Newton's second law in final year science classes: Exploring practical bridging-in-action. *World Journal of Advanced Research and Reviews*, Vol 28(02), pp.186-202. DOI: <https://doi.org/10.30574/wjarr.2025.28.2.3612>
- [3] ERASMUS & PROGRAMME OF EUROPEAN UNION (2022). The physics of pulleys. Steam builder. URL: https://www.steambuilders.eu/wp-content/uploads/2022/09/22.-Pedagogical_Sequence_Pulley_FINAL_FR.pdf
- [4] Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. Teachers College Press.
- [5] STUDY PROGRAMME GUIDE (2020). Physics, Chemistry and Technology, Year 4, revised edition. National Institute for Engineering Education and Trainer Capacity Building (INIFRCF)
- [6] Halloun, I. A., & Hestenes, D. (1985). Common sense concepts about motion. *American Journal of Physics*, 53(11), 1056–1065.
- [7] Maarouf, A., & Kouhila, M. (2001). Elementary dynamics in Moroccan primary education: An analysis of the difficulties in learning the concept of force. *Didaskalia*, (18), 41–59. https://www.persee.fr/doc/didas_1250-0739_2001_num_18_1_1110
- [8] Magnusson, S., Krajcik, J. et Borko, H. (2012). Nature, Sources, and Development of Pedagogical Content Knowledge for Science Teaching. In book: *Examining Pedagogical Content Knowledge*, pp.95-132. DOI:10.1007/0-306-47217-1_4
- [9] Pulley. (n.d.). Energy Education. URL : <https://energyeducation.ca/encyclopedia/Pulley>
- [10] Shulman, L. S. (1986). Those who understand : knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.
- [11] Shulman, L. S. (1987). Knowledge and teaching : foundation for a new reform. *Harvard Educational Review*, 51(1), 1-22.
- [12] Shulman; L. S. (2007). Those who understand: the development of knowledge in education. *Education et didactique*, 1(1), 97-114.
- [13] Van Biezen, M. (2013). Physics - Mechanics: The Pulley (1 of 2). YouTube. <https://www.youtube.com/watch?v=kvCnjVSpuv0VIENNOT>, L. (1978). Spontaneous reasoning in elementary dynamics. *Revue française de pédagogie*, 45(1), 16–24. https://www.persee.fr/doc/rfp_0556-7807_1978_num_45_1_1688
- [14] Viennot, L. (1979). *Le raisonnement spontané en dynamique élémentaire*. Éditions Hermann. Iennot, L. (1996). *Raisonner en physique : La part du sens commun*. De Boeck Université.