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ARTICLE

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Pre-appropriation of games about the first-degree equation proposed in textbooks

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Abstract: This article results from a master's thesis developed in the Postgraduate Program in Science Teaching, whose objective was to analyze the pre-appropriation of games for teaching first-degree equations by mathematics teachers, proposed in textbooks approved by the National Program of the Textbook. The research was guided by the model of appropriation of a new resource, structured in three phases (pre-appropriation, original appropriation, and reappropriation), and the reflective methodology was used based on the Documental Approach to Didactics. This article is limited to analyzing the pre-appropriation phase of the games. Two mathematics teachers from the final years of the elementary school in the municipal network of Recife, Pernambuco, participated in the research. The results highlight the influence of mathematical knowledge for teaching in the instrumentalization process of the games and the different types of planned instrumental orchestrations, in particular, for the use of the equivalent equations game in the classroom.
Keywords: Appropriation model of a new resource. Math games. First-degree Equation. Documental Approach to Didactics.

Pré-apropriação de jogos sobre equação do 1º grau propostos em livros didáticos

Resumo: Este artigo é fruto de uma dissertação, desenvolvida no Programa de Pós-Graduação em Ensino das Ciências (PPGEC). Tomamos por objetivo analisar a pré-apropriação por professores de matemática de jogos para o ensino de equação do 1º Grau, propostos em livros didáticos aprovados no Programa Nacional do Livro Didático. Norteamos esta pesquisa no modelo de apropriação de um novo recurso, estruturado em três fases: pré-apropriação, apropriação original e reapropriação. Utilizamos a metodologia reflexiva, tecida na Abordagem Documental do Didático. No presente trabalho, limitamo-nos a analisar a fase de pré-apropriação desses jogos. Participaram da pesquisa dois professores de matemática dos anos finais do ensino fundamental da rede municipal do Recife -PE. Sobre os resultados, destacamos a influência do conhecimento matemático para o ensino no processo de instrumentalização dos jogos e os diferentes tipos de orquestrações instrumentais previstas, em particular, para a utilização do jogo das equações equivalentes em sala de aula.
Palavras-chave: Modelo de apropriação de um novo recurso. Jogos matemáticos. Equação do 1º Grau. Abordagem documental do didático.

Preapropiación de juegos sobre la ecuación de 1er grado propuestos en los libros de texto

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Resumen: Este artículo es el resultado de una disertación, desarrollada en el Programa de Posgrado en Enseñanza de las Ciencias (PPGEC). Nuestro objetivo fue analizar la preapropiación por parte de profesores de matemáticas de juegos para la enseñanza de ecuaciones en 1º grado, propuestos en libros de texto aprobados por el Programa Nacional do Livro Didático. Guiamos esta investigación en el modelo de apropiación de un nuevo recurso, estructurado en tres fases: preapropiación, apropiación original y reapropiación. Utilizamos la metodología reflexiva, tejida en el Enfoque Documental de la Didáctica. En el presente trabajo nos limitamos a analizar la fase de preapropiación de estos juegos. Participaron de la investigación dos profesores de matemáticas de los últimos años de la enseñanza fundamental de la red municipal de Recife -PE. De los resultados, destacamos la influencia del conocimiento matemático para la enseñanza en el proceso de instrumentación de los juegos y los diferentes tipos de orquestaciones instrumentales previstas, en particular, para el uso del juego de ecuaciones equivalentes en el aula.
Palabras clave: Modelo de apropiación de un nuevo recurso. juegos de matematicas Ecuación de 1er grado. Aproximación documental a la didáctica.

Introduction

This article results from a master's thesis (LIRA, 2022) developed in the Graduate Program in Science Teaching (PPGEC) at the Federal Rural University of Pernambuco[1]. This article presents the bases of the *appropriation model of a new resource*, proposed by Trgalová and Rousson (2017), which was the reference to analyze the pre-appropriation by mathematics teachers of games presented in 7th-grade textbooks approved by the National Textbook Program (in Portuguese, Programa Nacional do Livro Didático, PNLD) (BRASIL, 2020). Therefore, it discusses the scenario of the first contact of teachers with these games.

The research is anchored in the reflective investigation methodology (GUEUDET; TROUCHE, 2010), which presupposes the teacher's reflexivity in the data construction process on their work mediated by/with resources. The following definition guides the analysis of the results: *an appropriate resource = an instrumentalized resource + instrumental orchestrations* (TRGALOVÁ; ROUSSON, 2017).

This article seeks to analyze the influence of games on teachers' activity (instrumentation) and modifications of games by teachers to use them according to their contexts and knowledge (instrumentalization), as well as the instrumental orchestrations foreseen for their use in the classroom (TROUCHE, 2004). In addition, the identification of

[1] The research had funding from the Foundation for the Support of Science and Technology of the State of Pernambuco (FACEPE).

didactic moments is proposed according to the sense attributed to the Anthropological Theory of Didactics (CHEVALLARD, 1999) related to instrumental orchestrations.

From the appropriation model of a new resource, it is considered that teachers appropriate the same resource differently. The instrumentation and instrumentalization processes can be more or less developed, depending on the teachers. However, similarities can be observed in the same way, and the orchestrations elaborated by the teachers can present similarities and differences, as can be seen in the case of the collaborating professors of this research.

Appropriation model for a new resource

As shown in Figure 1, the appropriation process of a new resource is timely delimited into three phases: 1. pre-appropriation, which refers to the teacher's first interactions with the resource, 2. original appropriation, which is the first implementation of the resource in the classroom, and 3. reappropriation, which is related to the review of the resource eventually adapted to new uses.

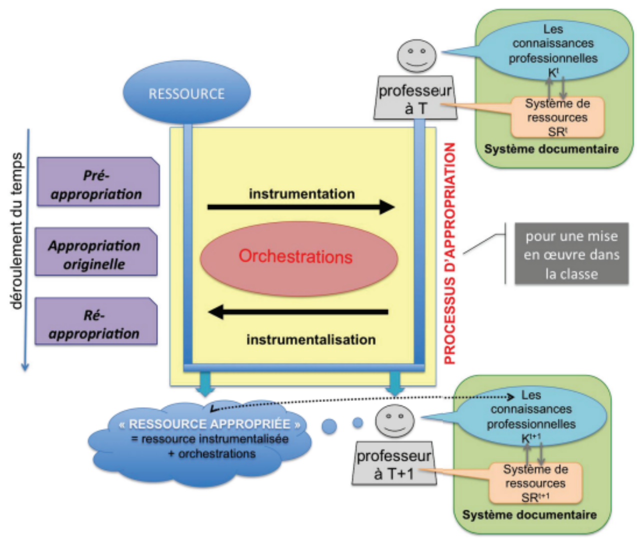

Figure 1: Appropriation model for a new resource (TRGALOVÁ; ROUSSON, 2017, p. 68).

In the appropriation model of a new resource (Figure 1), the notions of instrumentation and instrumentalization are based on Rabardel's Instrumental Approach (1995) and the theoretical developments of these notions in the Documental Approach to Didactics (DAD)

(GUEUDET; TROUCHE, 2008). The instrumentation process is related to the characteristics of a resource that influence the teachers' practice, and the instrumentation process concerns the habits and knowledge of the teachers that guide their choices and the transformation processes of different resources.

Concerning professional knowledge, these are considered essential to the analysis of the relationship between teacher and resource(s). In this case, they were approached by the model of Ball, Thames, and Phelps (2008): Mathematical Knowledge for Teaching (MKT). In this model, Mathematical Knowledge for Teaching is distinguished into two poles: Content Knowledge (Common Content Knowledge, Specialized Content Knowledge, and Content Horizon Knowledge) and Pedagogical Content Knowledge (Knowledge of Content and Teaching, Knowledge of Content and Students, and Knowledge of Content and Curriculum).

In the appropriation model of a new resource (Figure 1), it is considered that the set formed by the resources used by the teacher is called a resource system. "These resources are associated with schemes of usage, forming documents (the same resource can intervene in several documents). The documents developed by a teacher also form a system, called the document system of the teacher" (TROUCHE et al., 2020, p. 5). In the DAD, the teacher develops new professional knowledge and changes his resource and document systems based on the appropriation of new resources.

The notion of Instrumental Orchestration (IO), according to Trouche (2004), enables the study and guidance on the use of artifacts for educational purposes by teachers and students. In this sense, instrumental orchestration has three components: didactic configuration, mode of execution, and didactic performance. This study is limited to the first two components in the pre-appropriation phase.

The didactic configuration is related to the organization of the classroom and to the didactic choices made by the teacher regarding the "mathematical task, the resources to be made available, the functions of the individuals involved, among other aspects" (LUCENA, GITIRANA; TROUCHE, 2016, p. 3). The mode of execution is the operationalization of the didactic configuration previously developed by the teacher with a focus on the instrumental genesis (instrumentation and instrumentalization) of the students. According to Igliori and Almeida (2019, p. 236-237):

> It is relevant to highlight that there are as many types of orchestrations as teachers can think of for their class, and likewise, the ways to execute a mathematical task with digital resources or others. Teachers orchestrate their classes by defining didactic configurations and ways of executing a mathematical situation as they consider most appropriate.

The IO can be distinguished according to the task asked of the students in two broad categories: 1. Collective (IOC) - the students of the whole class have time to exchange with each other and the teacher; 2. Individual (IOI) - students work individually, in pairs, or in groups to solve a given task (DRIJVERS et. al., 2010; ROUSSON, 2017). The categorization and analysis of orchestrations are relevant to the study of the appropriation of a resource. It makes it possible to identify the teacher's planning for use in the classroom (forecast IO), in the implementation of the resource (effective IO), and to observe its evolution over time. It makes it possible to distinguish phenomena that occurred in the phases of pre-appropriation, original appropriation, and reappropriation of a resource.

It was necessary to resort to the didactic moments introduced by Chevallard (1999) in the Anthropological Theory of Didactic (ATD) and its correlation with the teacher's families of activities (GUEUDET; TROUCHE, 2010) to group the orchestrations by sessions, based on Rousson (2017). Chevallard (1999) argues in the ATD that every regularly performed human activity can be described by a model designated as a praxeology. As a result, learning or teaching mathematics as human actions can be described according to a mathematical or didactic praxeological model. Regarding the latter, Rousson (2017) considers the following moments: 1. a first encounter with the task, 2. an exploration of the type of task and development of a resolution technique, 3. work with the resolution technique, and 4. evaluation.

Based on the above, the following procedures were developed, in light of the Reflective Investigation Methodology (GUEUDET; TROUCHE, 2010).

Methodology

Based on the principles of the Reflective Investigation Methodology (GUEUDET; TROUCHE, 2010), an analysis was carried out on the appropriation of games about 1st Degree Equations by two teachers (with the codenames Luzia and José) working in the final years of

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elementary school, of the Municipal Network of Recife, in Pernambuco. The reflective research methodology:

> It stems from the understanding that research on teaching work with its resources, from a systemic perspective, must include the analysis of a significant period for the production of resources. This production can be observed wherever it occurs (both in different work environments and outside of it) (IGNÁCIO, 2018, p. 64).

The principles of reflective inquiry are 1. monitoring the teacher's work for a significant period; 2. the monitoring occurs inside and outside the classroom; 3. the extensive collection of resources used and produced in the documentation work, throughout the follow-up, and 4. the reflective follow-up of the documentation work by the teacher himself.

On the principle of *monitoring the activities of teachers for a significant period*, in this case, the construction of data occurred from July to October of the 2021 school year. During this period, teachers were working in the remote education modality. As for *monitoring the teacher's documentary work inside and outside the classroom*, it happens in several places (at the teacher's home, school, and in the classroom, among others) (BELLEMAIN; TROUCHE, 2019). Thus, interviews were conducted with Luzia and José through Google Meet when they were at home.

Regarding the broad *collection of material resources used and produced in the documentation work*, it is understood that in the teacher's documental work, they use a variety of resources, being necessary to have access to these resources in the best possible way. On the principle of *reflective follow-up of the documentation work*, an attempt was made to actively involve Luzia and José in the analysis of the games in such a way that their active involvement would lead to a reflexive posture about their documentary work.

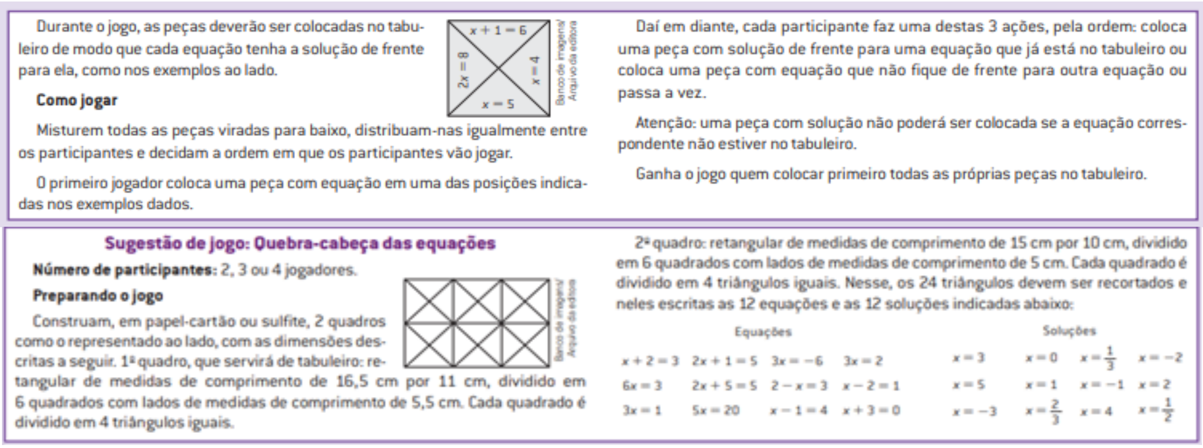
In the light of the mentioned principles, for the study of the **pre-appropriation phase**, an interview with the teachers was proposed (recorded on Google Meet), centered on the presentation of the four games on Equation of the 1st degree, previously identified in the textbooks. It should be noted that the games were identified in only two of the 11 collections approved by the PNLD (BRASIL, 2020). Teláris collection (DANTE, 2018) presents the Equations Game, the Equivalent Equations Game, and the Equations Puzzle, and the Araribá Mais Matemática (Araribá More Math) collection (GAY; SILVA, 2018) presents the Equation Game. The interview sought to identify aspects of the instrumentation and instrumentalization processes and the types of teaching knowledge on the scene. Thus, as each game was presented, questions were proposed, such as What did you think of the game? Would you use this game in the classroom? Would you make any adaptations to this game to use it in the classroom? Which game did you like best? Why?

After teachers Luzia and José had already chosen the Equivalent Equations Game as the most favorable to be used in the classroom, another interview occurred to clarify the role and articulation of this game with other resources used in the teaching about 1st Degree Equations. In particular, for the analysis of the predicted IO, a specific interview was carried out about the planning of a lesson to implement this game in the classroom in 9th and 7th-grade classes, respectively indicated by Luzia and José. For further identification and discussion of didactic configurations and modes of execution, Rousson's (2017) adaptation was used on the proposition of IO related to different didactic moments (CHEVALLARD, 1999): 1. a first encounter with the task; 2. an exploration of the type of task and development of a resolution technique; 3. work with the resolution technique; and 4. evaluation.

Luzia and José's pre-appropriation of games proposed in textbooks

It is important to remember that an "*appropriate resource = an instrumented resource + instrumental orchestrations*." The pre-appropriation phase concerns the first interactions of the teacher with a resource and its initial interpretations. That is, it is considered that as the teachers have their first contact with a resource, they begin to make predictions about how they can use it or not in the classroom.

Given the above, will be discussed the pre-appropriation of the game *Equations Puzzle* (Figure 2) by teachers Luzia and José, followed by the pre-appropriation of the Equivalent Equations Game, Equations Game, and Equations Game.



Durante o jogo, as peças deverão ser colocadas no tabuleiro de modo que cada equação tenha a solução de frente para ela, como nos exemplos ao lado.

Como jogar

Misturem todas as peças viradas para baixo, distribuam-nas igualmente entre os participantes e decidam a ordem em que os participantes vão jogar.

O primeiro jogador coloca uma peça com equação em uma das posições indicadas nos exemplos dados.

Daí em diante, cada participante faz uma destas 3 ações, pela ordem: coloca uma peça com solução de frente para uma equação que já está no tabuleiro ou coloca uma peça com equação que não fique de frente para outra equação ou passa a vez.

Atenção: uma peça com solução não poderá ser colocada se a equação correspondente não estiver no tabuleiro.

Ganha o jogo quem colocar primeiro todas as próprias peças no tabuleiro.

Sugestão de jogo: Quebra-cabeça das equações

Número de participantes: 2, 3 ou 4 jogadores.

Preparando o jogo

Construam, em papel-cartão ou sulfite, 2 quadros como o representado ao lado, com as dimensões descritas a seguir. 1º quadro, que servirá de tabuleiro: retangular de medidas de comprimento de 16,5 cm por 11 cm, dividido em 6 quadrados com lados de medidas de comprimento de 5,5 cm. Cada quadrado é dividido em 4 triângulos iguais.

2º quadro: retangular de medidas de comprimento de 15 cm por 10 cm, dividido em 6 quadrados com lados de medidas de comprimento de 5 cm. Cada quadrado é dividido em 4 triângulos iguais. Nesse, os 24 triângulos devem ser recortados e neles escritas as 12 equações e as 12 soluções indicadas abaixo:

Equações				Soluções			
$x + 2 = 3$	$2x + 1 = 5$	$3x = -6$	$3x = 2$	$x = 3$	$x = 0$	$x = \frac{1}{3}$	$x = -2$
$6x = 3$	$2x + 5 = 5$	$2 - x = 3$	$x - 2 = 1$	$x = 5$	$x = 1$	$x = -1$	$x = 2$
$3x = 1$	$5x = 20$	$x - 1 = 4$	$x + 3 = 0$	$x = -3$	$x = \frac{2}{3}$	$x = 4$	$x = \frac{1}{2}$

Figure 2: Puzzle of Equations (DANTE, 2018, p. 119-120).

For teacher Luzia, the game Puzzle of Equations (Figure 2) proved to be confusing and laborious in terms of making it.

> **Luzia**: *To structure the pieces in this rectangular format, we would have to build a mold for the students to overlap the pieces. I guess I understand the game, we have to cut the 24 triangles. If it's the triangles, you can do it, but if it's square? I've seen a game like this before, but the teacher had already assembled it. Here we have to mount this rectangle. Does the relationship between the equation and answer have to match on both sides of the square formed by the fit? This is confusing. We have to have time to test it beforehand.*

As for José, he associated the Puzzle of Equations with a "domino," commenting: "*I thought it was cool. It is like a domino. We need to find the root of the equation and join the equation piece with its respective root piece*." He stated that he could use it in the classroom to work on solving equations but also indicated that making the game is laborious.

The lack of practicality for making the pieces and precision regarding the rules of the Puzzle of Equations impacted the pre-appropriation phase by the teachers, that is, their instrumentation process. Based on Knowledge of Content and Teaching, the correlation that teachers visualized between the equations and their solutions is evident. However, the instrumentalization process and the elaboration of the IO were compromised, considering their desire to carry out its effective use in the classroom was not identified, that is, to make it evolve into an original appropriation.

Regarding the Game of Equations (Figure 3), Luzia liked it. It is highlighted in the instrumentation process: "*I understood that the answer roulette wheel is turned, and as for the* *other roulette wheel, the student needs to solve the equation, and the answer has to correspond with what he turned before. I liked it*!" José, on the other hand, did not quite understand how to make the roulette wheel for the game (Figure 3) and commented: "*How do we build this roulette wheel, and how are the students going to spin the roulette wheel in practice?*".

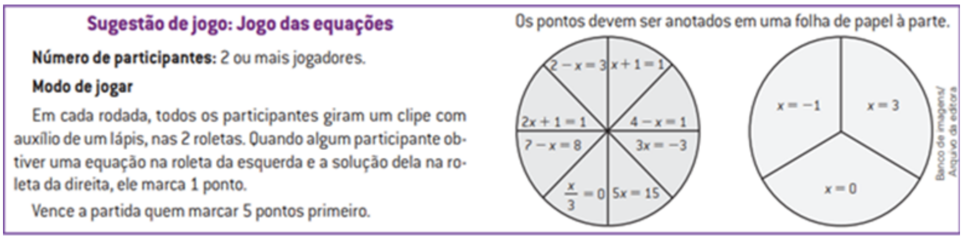


Figure 3: Game of Equations (DANTE, 2018, p. 117).

As for the instrumentalization process of the Game of Equations (Figure 3), it is possible to identify in Luzia the influence of *Horizon Knowledge of Equation Content* of the 1st grade. Because, for her, the level of resolution of the equations proposed in the game was "very basic" for a class in the 9th or 7th grade of Elementary School.

> **Luzia:** *This is a very suggestive game, then we can make variations. It could involve an Equation of the 2nd degree, thinking about the 9th grade. For the 7th year, I would add other equations and increase the number of equations. I would not leave the answers straight away. I would give the students a little work to solve them. I would put some with exponentiation, and it would give the game a higher level of difficulty.*

Teacher José commented: "*I find it interesting, but it would be good if this roulette wheel on the right had more values, not just 3. If it had a greater number of values, it would be better*." Regarding his instrumentalization process, a possible change is found —to add more solutions to the second roulette wheel, which would also imply changing the first roulette wheel with other equations. This statement reveals his Knowledge of Content and Students, given that the equations to be proposed by him would "*depend on the level of the class*."

Luzia pointed out a possible didactic configuration and mode of execution for using the Game of Equations: "*I would use the game made up of two giant roulette wheels exposed on the whiteboard and thus be able to interact, at the same time, with all the students in the class*." On the other hand, José did not assume a prior IO for using the game. Roughly speaking, in both cases, it is clear that there was not much interest in using this game in the classroom, either because of its didactic potential or because of the work involved in making it.

Concerning the Game of Equations (Figure 4), it should be highlighted, in the instrumentation process, the impact on the teacher of the proposal of the textbook's author in proposing the elaboration of the equations of the game by the students and the resolution of equations by mental calculation. In instrumentalization emerged the Knowledge of Content and Student of Luzia, when commenting on students "*inventing 1st-degree equations*": "*I would be calmer for them to solve it, but for them to elaborate the equations? They could even do the most basic ones. So, I think for them to build the game, it would be more complex*." And she added: "*I would be careful with the stages of the game because if we use basic equations, we can use mental calculation, but if we use more difficult equations, we cannot*."

Jogo de equações

Material necessário

- Duas folhas de cartolina, uma branca e outra amarela, por equipe.
- Canetas hidrográficas.

Participantes

- Equipes com quatro alunos.

Objetivo

- Agrupar o maior número de pares de cartas.

Regras

- Cada grupo deverá confeccionar 20 cartas brancas e 20 cartas amarelas com as cartolinas. O grupo deverá inventar equações do 1º grau e escrever uma equação em cada carta branca. A solução correspondente a cada equação deverá ser escrita em uma carta amarela. Para que sejam resolvidas por meio de cálculo mental, as equações criadas não podem ser complexas.
- Depois de confeccionadas, as cartas deverão ser trocadas com outro grupo.
- Para iniciar o jogo, cada grupo deverá embaralhar as cartas, separando as amarelas em um monte. Esse monte terá as faces com as soluções viradas para baixo e ficará no centro da mesa.
- As cartas brancas deverão ser distribuídas igualmente entre os componentes do grupo. Cada aluno observará as equações descritas nas cartas brancas, mas não deixará os demais componentes do grupo observarem suas cartas.
- Uma a uma, as cartas amarelas serão viradas no centro da mesa. Os jogadores vão observar suas cartas e verificar se há alguma equação cuja solução seja a indicada pela carta amarela exposta. Caso isso ocorra, o jogador deverá pegar a carta amarela e formar o par equação-solução, separando-o em um monte.
- Se houver dois jogadores com equações que tenham a mesma solução indicada na carta virada, ficará com a carta amarela quem a pegar primeiro.
- Ganhará a rodada o jogador que formar primeiro os cinco pares equação-solução.

Modelo para confecção das cartas

Branca (equação)	Amarela (solução)	Branca (equação)	Amarela (solução)
$x+3=7$	A solução é o número 4.	$3k+7=16$	A solução é o número 3.
$2x+5=13$	A solução é o número 4.	$e+10=13$	A solução é o número 3.
$5x+20=30$	A solução é o número 2.	$8t-2=54$	A solução é o número 7.
$y+3=5$	A solução é o número 2.	$5w+6=41$	A solução é o número 7.
$2z+6=28$	A solução é o número 11.	$3x+6=6$	A solução é o número 0.
$2w+4=26$	A solução é o número 11.	$\frac{3}{4w}=0$	A solução é o número 0.
$2s-23=-21$	A solução é o número 1.	$\frac{1}{2f}-5=13$	A solução é o número 36.
$3k+7=10$	A solução é o número 1.	$\frac{1}{3}j-6=6$	A solução é o número 36.
$2y-9=1$	A solução é o número 5.	$5t+4=-6$	A solução é o número −2.
$6q-23=7$	A solução é o número 5.	$4j+12=4$	A solução é o número −2.

Figure 4: Equations Game (GAY; SILVA, 2018, LI).

According to Luzia, the equations with fractions proposed in the card model (Figure 4) are more difficult but necessary. But without the resolution by mental calculation. From the above, it was possible to identify aspects of her Knowledge of Content and Teaching, visible in her positioning in working with equation-solving techniques: "neutralization of terms" or "transposition of terms" (ARAÚJO, 2009), excluding the technique of mental calculation and the elaboration of equations by the students. In contrast, José adhered to the proposal for the students to make the cards themselves. He stated:

> **José:** *I understood that each group has to make 20 white and 20 yellow cards and then exchange them with another group. I think it would work. I would do it that way. But we need some time to explain the rules and make them very clear to the students, doing a kind of 'pilot' application. It also depends on the type of equation we will*

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> *propose for them to make the cards. I have not worked on equations with fractions yet.*

The instrumentalization of the Equation Game made by José (Figure 4) is influenced by his Knowledge of Content and Students due to: proposing equations already studied by the students to the detriment of making cards with equations involving fractions. Furthermore, he predicted an IO:

> **José:** *Now, I would bring the cards ready (already cut) for them, so they would only create the equations because if we were to ask them to make the material, they would spend the whole class just making it. And another thing I would do is not let this confection be done with the help of the notebook, so they don't copy equations.*

In a way, the adherence of teachers to the students' elaboration of equations related to their Knowledge of Content and Curriculum. Because, in the 7th year, the Brazilian National Common Core Curriculum (BNCC) (EF07MA18) foresees solving and elaborating problems that can be represented by 1st-degree polynomial equations reducible to the form ax + b = c, making use of the properties of equality (BRASIL, 2018, p. 307). José was favorable to the elaboration of problems by the students, even about other contents.

The Equivalent Equations game (Figure 5) was the one that obtained the most favorable position for an original appropriation. Luzia revealed, in the instrumentation, the plausibility of the rules and material proposed by the game:

> **Luzia:** *From the moment I understand the idea of the game, I like to apply it like the original. I have this profile. Generally, I don't make changes before the application. If I see that I can use it in the classroom, first I do it, and, based on the feedback from students on how they interact, I see the adaptations that should be made.*

The only alteration Luzia proposed was to remove the answers in the presentation on the red cards (Figure 5), an effect of her instrumentalization due to her Knowledge of Content and Teaching related to the intention of getting all students to exercise solving 1st-degree equations.

Jogo das equações equivalentes

Com este jogo você vai aprimorar seus conhecimentos sobre equações equivalentes.

Orientações

Número de participantes: 3 ou 4 jogadores.
Material necessário: 2 folhas de papel de cores diferentes.

Preparação do jogo

Providenciem as 2 folhas de papel de cores diferentes; para exemplificar, usaremos as cores vermelho e azul.
Dividam cada folha em 12 partes iguais, escrevam as equações e recortem as 24 peças do jogo.

$3x = 6$ Solução: $x = 2$.	$4x = 2$ Solução: $x = \frac{1}{2}$.	$x + 5 = 3$ Solução: $x = -2$.	$3x = 15$ Solução: $x = 5$.
$x - 1 = 3$ Solução: $x = 4$.	$1 - x = 2$ Solução: $x = -1$.	$x + \frac{1}{3} = 1$ Solução: $x = \frac{2}{3}$.	$\frac{x}{5} = 1$ Solução: $x = 5$.
$2x - 1 = -7$ Solução: $x = -3$.	$3x = 1$ Solução: $x = \frac{1}{3}$.	$x + 4 = 4$ Solução: $x = 0$.	$6 + x = 2$ Solução: $x = -4$.

$3x + 5 = 11$	$10x = 5$	$x = -2$	$3x + 3 = 18$
$4x = 16$	$2 - 2x = 4$	$3x + 1 = 3$	$2x = 10$
$6x - 3 = -21$	$2x = \frac{2}{3}$	$2x + 5 = 5$	$2x = -8$

Como jogar

Antes de começarem a partida, misturem as peças vermelhas e distribuam igualmente entre os jogadores. As peças azuis devem ser empilhadas no centro da mesa, com as equações viradas para baixo.

A cada rodada, o jogador pega uma peça azul e verifica se nela há uma equação equivalente a alguma das equações das peças vermelhas que estão com ele. Se houver, então o jogador separa esse par de peças. Por exemplo:

$6 + x = 2$	$2x = -8$

Caso contrário, o jogador descarta a peça azul em uma pilha separada, também sobre a mesa. O próximo jogador pode escolher se quer pegar a peça azul descartada pelo jogador anterior ou uma peça azul nova.

Quando terminarem as peças azuis sobre a mesa, ganha a partida quem tiver formado mais pares de peças com equações equivalentes.

Figure 5: Equivalent Equations game (DANTE, 2018, p.112).

The teacher stated that the Equivalent Equations game could be an opportunity to explore the equivalence of equations provided for in the study plan proposed by the Department of Education for the 7th grade (RECIFE, 2021), which revealed his Knowledge of Content and Curriculum. José commented on the game (Figure 5): "*It is easy to play. I liked the game a lot. It is easy and straightforward*." About the game equations, he expressed his Knowledge of Content and Teaching:

> **José**: *When I am working on equations, I am careful to separate them into types. I have not worked with them yet on any equation with a fraction. For example, this equation of the red letter (x +⅓=1) would be difficult, but we could keep it because, on the other side, there may be an equation equivalent to this one more 'easy,' and they could associate. Does the student understand? I also think that proposing only equations they have already seen that they already know how to solve, is making the game a little less fun. This game is mixed. It has equations of various levels. So, I think the equations are cool in the way they are proposed.*

Unlike Luzia, José proposed changes to the game rules to use it in the classroom:

> **José:** *For me, each group of students can receive the 12 red and the 12 blue cards. Students must separate the blue cards on one side and the red cards on the other. All cards must be face up. Each student, in turn, must solve an equation on a blue card*

> *and find an equivalent equation on a red card. The group that forms the most pairs of equivalent equations wins.*

According to José, the proposal to keep all the cards (blue and red) face up "frees up" the formation of pairs of equivalent equations. Contrary to the proposal of the author of the game in the textbook (Figure 5), which advises that the equation cards must be turned face down. This form of instrumentalization, anchored in Knowledge of Content and Students, consequently, could lead the students to choose to solve the equations initially considered easier. But all cards would finally have to be related with equivalent equations, that is, with the same solution.

The planning of a class, based on the interviews with Luzia and José, to use the Equivalent Equations game revealed explicitly the orchestrations thought by each one of them and the role of this game in the sequence of teaching about 1st-degree equations.

- Lesson planning for the use of the Equivalent Equations Game by Luzia

According to her statement, during online classes, she followed the weekly study plan proposed by the Secretary of Education. First-degree equations were proposed in the second week of remote teaching (March 2021). Thus, it even implemented activities via electronic form on 1st-degree equations and only "brushed" the notion of equivalent equations.

> **Luzia**: *I had only done a review on 1st-degree equations. As it is a 9th-grade class, we work more from that perspective. I did that a few weeks ago. Due to the various difficulties of the students, I started reviewing integers, polynomials, and algebraic expressions.*

The teacher stated to have provided students with an exercise sheet for solving equations and others with problem situations. Figure 6 shows the exercise sheet supplied by the teacher and related to the game proposal. It was prepared about three years ago; it was available on internet sites (not recalled by the teacher) and had already been used in other classes. The presentation of equation resolution techniques can be seen in the sheet: "transposition of terms" and "neutralization of terms" (ARAÚJO, 2009). The presentation of these two techniques was justified by the importance of students knowing both.

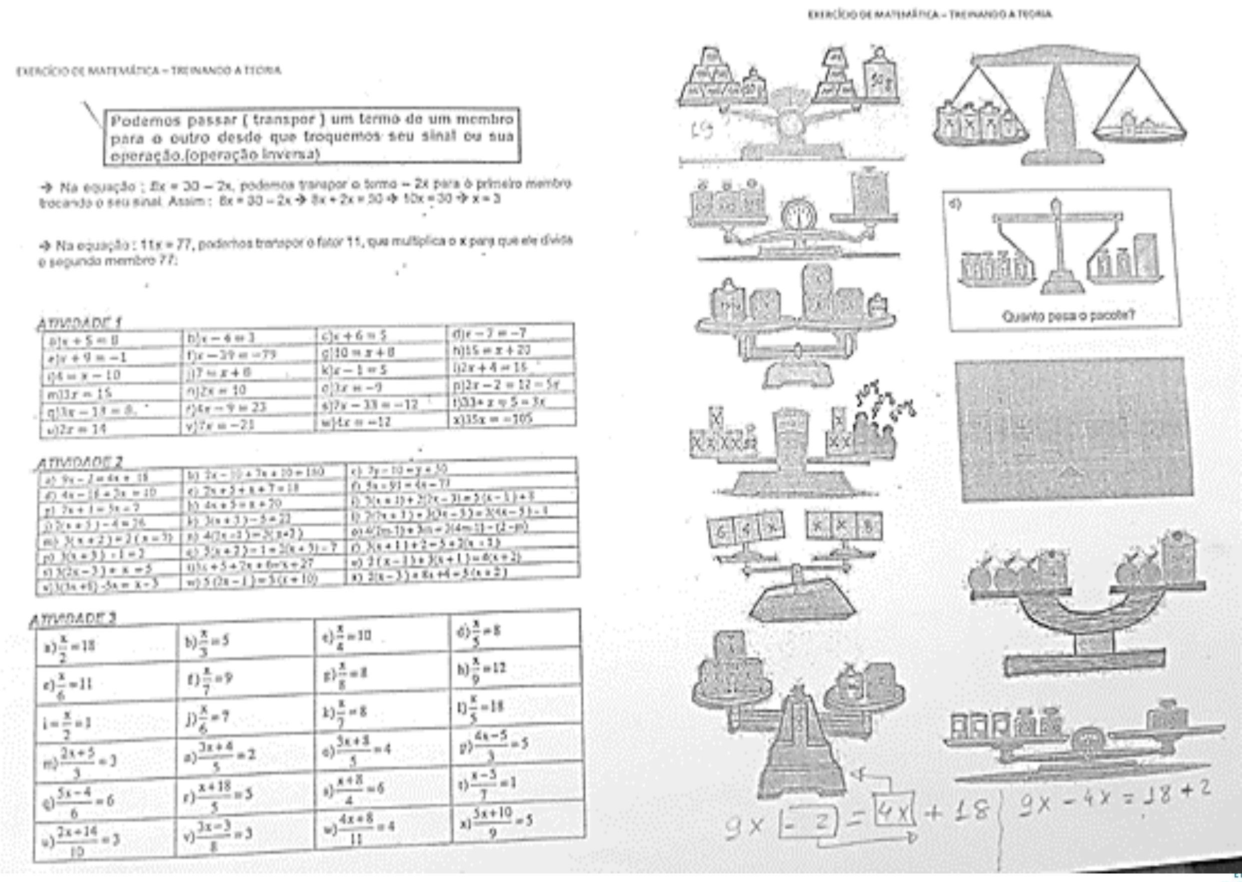


Figure 6: Proposed exercise sheet to review the theme – presential classes.

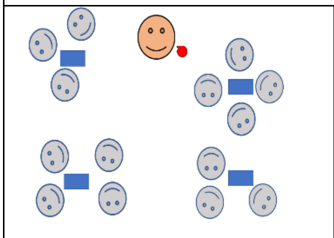
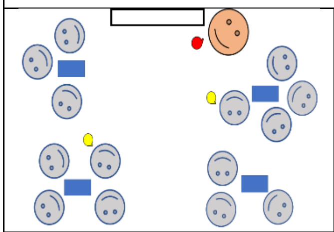
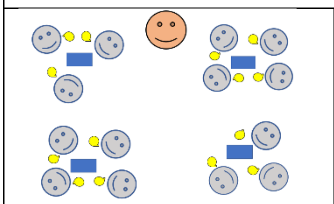
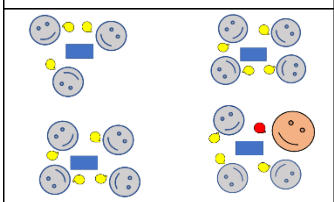
The exercise sheet (Figure 6) draws attention to the number of equations to be solved. About this, Luzia explained that several of them are similar and stated:

> **Luzia**: *So, what happens, is I usually work with very extensive exercise sheets, not only this one but others as well. If we look at activity 1, activity 2, and activity 3, they are of the same type. I do the correction by sampling. For example, from 30 questions, I ask them about 15 questions. I ask them to choose the most difficult ones, the ones they have doubts about, and I explain them.*

Given the above, it is noteworthy the influence of the Equivalent Equations Game, with its possibilities and limitations, on the activity (instrumentation) of the teacher and her adaptation of this resource, according to her school context, her needs, and her knowledge (instrumentalization). It is also worth mentioning the instrumentation. The objective presented by the author of the game was to “improve knowledge about equivalent equations” (DANTE, 2018), which reveals the effect of the resource on the teacher and her intention to review the resolution of equations, even before thought by her, without the exploration of this type of equations.

Luzia planned the application of the game for a 9th-grade class with 27 students whose attendance in presential classes was occurring in rotation. Thus, each week, 50% of the students attended alternately. Therefore, the participation of 14 students was estimated. The artifacts listed beforehand by the teacher were: four games, a notebook to record the resolution of equations, a whiteboard, and adequate desks for students to handle the game. The estimated class time was 60 minutes. Chart 1 presents the types of IO selected by the teacher before applying the game in the classroom related to her prediction of didactic moments around the task: solving 1st-degree equations and comparing those that are equivalent.

Chart 1: Didactic moments and IO foresaw in the pre-appropriation phase.

The first encounter with the task	
	*ICO - Technical Demonstration (TD)* The teacher introduces the game and explains its rules while the students remain silent and attentive to the explanation. *IOC - Explanation by the teacher (ET)* The teacher explains that the students must solve and compare the equations of the game to verify those that present the same result while they remain silent and attentive to the explanation.
Exploration of the task and elaboration of a resolution technique	
	*IOC - Guidance and Explanation by the teacher (GET)* The teacher reviews the concept of equivalent equations, proposing examples on the whiteboard so that students can compare the equations in the game. Some questions can be proposed to the students.
Work with the resolution technique	
	*ICO - Discussion between the actors (DA)* In each group, students discuss the game with each other and perform the task while the teacher watches them.
	*IOI - Work and monitoring (WM)* The groups of students solve the task in their notebooks, and the teacher circulates the classroom, checking or helping with the answers and following the game evolution.

Source: Elaborated by the author.

During the interview, Luzia commented that she would not previously inform the students about the application of the game. In particular, it was possible to perceive her concern about some students not remembering the concept of the equivalent equation, which made her choose to explain this theme before the start of the game. She mentioned that she would organize the students by the affinity between them, considering it essential that they feel at ease without worrying about someone "*knowing less or more*." As for expectations about the game implementation in the classroom, Luzia explained: "*This will serve to evaluate not only the students but also what I need to work on more. Let us say this game is 50% for assessment and 50% for work with exercises*".

About the Knowledge of Content and Student, it was possible to identify her strong intention to review the resolution of equations, especially with fractions and operations with whole numbers, without losing sight of the comparison between equations to identify equivalent ones.

- Lesson planning for the use of the Equivalent Equations Game by José

José explained that, in the 7th-grade class, he started working on the 1st-degree equations with the conversion of registers from mother language to algebraic language: "*I first worked on the idea of setting up the equation, then we went to solve it. When we started solving equations, I carefully separated them by cases, like equations that need to apply the distributive property, fractional equations, and equations like* $ax+b = k$." Figure 7 presents the tasks proposed in the exercise sheet used in the 7th grade.

EXERCÍCIOS DE INTRODUÇÃO

1 – Resolva:

a) $5x - 4 = 10$
b) $2x + 1 = 7$
c) $\frac{x}{4} - 1 = \frac{2}{3}$
d) $x - 1 + 8 = 6x$
e) $5x^2 - x - 4 = 8$
f) $\frac{1}{2}x - 4 + x = 9$

2 – Entre as equações do exercício 1, diga quais são do 1º grau.

3 – Dada a equação $7x - 3 + x = 5 - 2x$, responda:

a) Qual é o 1º membro?
b) Qual é o 2º membro?
c) Quais são os termos do 1º membro?
d) Quais são os termos do 2º membro?

4 – Qual é o número que colocado no lugar de x, torna verdadeira as sentenças?

a) $x + 9 = 13$
b) $x - 7 = 10$
c) $5x - 1 = 9$
d) $x - 3 = 8$

5 – Verifique se 1 é raiz da equação $4x + \frac{1}{2} = \frac{9}{2}$.

6 – Resolva as equações:

a) $x + 5 = 8$
b) $x - 4 = 3$
c) $x + 6 = 5$
d) $x - 7 = -7$
e) $x + 9 = -1$
f) $x + 28 = 11$
g) $x - 109 = 5$
h) $x - 39 = -79$
i) $10 = x + 8$
j) $15 = x + 20$
k) $4 = x - 10$
l) $7 = x + 8$
m) $0 = x + 12$
n) $-3 = x + 10$

7 – Resolva as seguintes equações:

a) $3x = 15$
b) $2x = 14$
c) $4x = -12$
d) $7x = -21$
e) $13x = 13$
f) $9x = -9$
g) $25x = 0$
h) $35x = -105$
i) $4x = 1$
j) $36x = 12$
k) $21 = 3x$
l) $84 = 6x$

8 - Resolva as equações:

a) $\frac{x}{3} = 7$
b) $\frac{x}{4} = -3$
c) $\frac{2x}{5} = 4$
d) $\frac{2x}{3} = -10$
e) $\frac{3x}{4} = 30$
f) $\frac{2x}{5} = -18$

9 - Resolva:

a) $-x = 9$
b) $-x = -2$
c) $-7x = 14$
d) $-3x = 10$
e) $-5x = -12$
f) $-4x = 8$
g) $-3x = -9$
h) $-5x = 15$
i) $-2x = -10$
j) $15 = -3x$
k) $-40 = -5x$

10 - Determine x:

a) $6x = 2x + 16$
b) $2x - 5 = x + 1$
c) $2x + 3 = x + 4$
d) $5x + 7 = 4x + 10$
e) $4x - 10 = 2x + 2$
f) $4x - 7 = 8x - 2$
g) $2x + 1 = 4x - 7$
h) $9x + 9 + 3x = 15$
i) $16x - 1 = 12x + 3$
j) $3x - 2 = 4x + 9$
k) $5x - 3 + x = 2x + 9$
l) $17x - 7x = x + 18$
m) $x + x - 4 = 17 - 2x + 1$
n) $x + 2x + 3 - 5x = 4x - 9$
o) $5x + 6x - 16 = 3x + 2x - 4$
p) $5x + 4 = 3x - 2x + 4$

11 - Resolva as equações:

a) $4x - 1 = 3(x - 1)$
b) $3(x - 2) = 2x - 4$
c) $2(x - 1) = 3x + 4$
d) $3(x - 1) - 7 = 15$
e) $7(x - 4) = 2x - 3$
f) $3(x - 2) = 4(3 - x)$
g) $3(3x - 1) = 2(3x + 2)$
h) $7(x - 2) = 5(x + 3)$
i) $3(2x - 1) = -2(x + 3)$
j) $5x - 3(x + 2) = 15$
k) $2x + 3x + 9 = 8(6 - x)$
l) $4(x + 10) - 2(x - 5) = 0$
m) $3(2x + 3) - 4(x - 1) = 3$
n) $7(x - 1) - 2(x - 5) = x - 5$
o) $2(3 - x) = 3(x - 4) + 15$
p) $3(5 - x) - 3(1 - 2x) = 42$
q) $(4x + 6) - 2x = (x - 6) + 10 + 14$
r) $(x - 3) - (x + 2) + 2(x - 1) - 5 = 0$
s) $3x - 2(4x - 3) = 2 - 3(x - 1)$
t) $3(x - 1) - (x - 3) + 5(x - 2) = 18$
u) $5(x - 3) - 4(x + 2) = 2 + 3(1 - 2x)$

Figure 7: Proposed exercise sheet to review the theme - presential classes (7º grade).

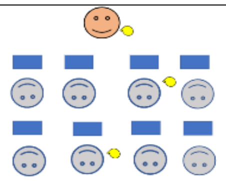
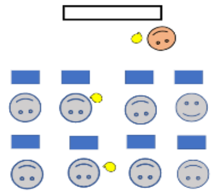
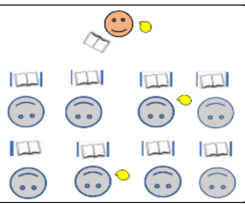
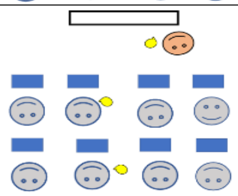
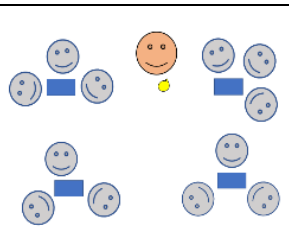
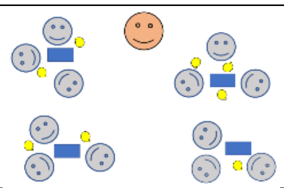
The exercise sheet (Figure 7) gave clues on the knowledge taught about 1st-degree equations in the 7th-grade class, that is, closer to the proposal of the Equivalent Equations Game: the resolution of equations centered on the mathematical context. While it was possible to follow the progress of the activity, the teacher worked on items 1 to 7.

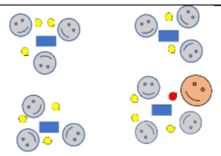
> **José**: *Whenever I start [to teach] equations, and this class is no different, I talk about the idea of the scale, but since I don't have concrete material (scales) to show them, it gets a little complicated. So, when I start teaching equations, I write x+2=7, and I ask them what is that unknown value that is being represented by x, then they say 5. Then I ask: what can we do with the 7 and 2 to get to 5? Then they say: you have to calculate less. They don't say subtraction, they say less. So, I'm careful, for example, when I say 2x=20, that they don't write x = 20-2. [They have to] be careful about using the inverse operation, so basically, that's what I do.*

Given the above, it is essential to know aspects of the teaching sequence on the subject in question to understand the pre-appropriation process of the Equivalent Equations game. The teacher adopted the Equivalent Equations game, although strongly influenced by the possibility of inserting it in an introductory class on the equivalence of equations, as an opportunity of getting students to exercise, once again, the resolution of 1st-degree equations.

Teacher José planned to apply the game to a 7th-grade class with the same attendance modality as Luzia (50% of students). It was expected that 12 students participate. The artifacts listed beforehand were: four games, a notebook to record the resolution of equations, a textbook, a whiteboard, and adequate desks for students to handle the game. There was 60 min scheduled for class. Chart 2 presents the types of IO predicted by José.

Chart 2: Didactic moments and IO foresaw in the pre-appropriation phase.

The first encounter with the task	
	*IOC - Guidance and Explanation by the teacher (OEP)* The teacher introduces the concept of equivalent equations and presents some questions to the students.
	*IOC - Guidance and Explanation by the teacher (OEP)* The teacher presents the concept of equivalent equations on the whiteboard and suggests some questions to the students.
Exploration of the task and elaboration of a resolution technique	
	*IOC - Guidance and Explanation by the teacher (OEP)* The teacher proposes examples of equivalent equations using the textbook and some questions to the students.
	*IOC - Guidance and Explanation by the teacher (OEP)* The teacher presents examples on the whiteboard so that the students can compare the equivalent equations and proposes some questions to the students.
Work with the resolution technique	
	*ICO - Technical Demonstration (DT)* The teacher introduces the game and explains its rules while the students remain silent and attentive to the explanation. *IOC - Explanation by the teacher (EP)* The teacher explains that the students must solve and compare the equations of the game to verify those that present the same result while they remain silent and attentive to the explanation.
	*ICO - Discussion between the actors (DA)* In each group, students discuss the game with each other and perform the task while the teacher watches them.

	*IOI - Work and monitoring (TA)* The groups of students solve the task in their notebooks, and the teacher circulates the room, checking or helping with the answers and following the game evolution.

Source: Elaborated by the author.

During the interview to discuss the lesson planning to implement the game of equivalent equations in the classroom, his Knowledge of Content and Teaching was perceived in the expected sequence when José stated that "*before using this game, I have to talk about equivalent equations or I could put it like this: in the game, we need to find equations with the same root, which have the same solution*," referring to the model: definition, examples, and exercises. As for expectations about the game implementation in the classroom, the teacher explained: "*For me, this game serves several things: introducing the content of equivalent equations, which I have not worked on yet. Also, to work collaboratively. Thus, students with more difficulty can learn from those who have less [difficulty]*."

About the group of 7th-grade students that the teacher selected to apply the Equivalent Equations game, he explained: "*They have been my students since 6th grade*." Thus, the teacher expressed his Knowledge of the Content and Students concerning their learning difficulties on 1st-degree equations.

> **José**: *They do not know how to switch from their mother language to algebraic language, and many do not know how to read a text and figure out the equation in that text. In addition to the difficulties with sign rules, division, and the unknown, when we put a letter to represent a number, they are always anxious to know the value of x, so that gives me a lot of work.*

The teacher also commented on using the textbook adopted at the school during the scheduled class: "*What I look for in it are theory and application. So, I will briefly explain the subject using the textbook that students usually take to Mathematics classes*."

It should be noted that, concerning the differences between the knowledge that influenced the instrumentation and instrumental orchestrations of the game, for example, the Knowledge of Content and Student of José had already been developed since the 6th grade, since he taught students who were in the 7th year. As for Luzia, she was aware of some because they were not her students and also because they were absent from remote teaching classes. It is also underlined on Knowledge of Content and Students, the different purposes of the class using the game. Luzia inserted the game in the teaching sequence to review equivalent equations while José introduced the theme. Both sought to review the resolution of 1st-degree equations. Both demonstrated Knowledge of Content and Curriculum, given their intentions to meet the curricular demands of the Municipal Department of Education.

Final considerations

Through the appropriation model of a new resource (TRAGALOVA; ROUSSON, 2017), it was possible to investigate the first contact of teachers with games about 1st-degree equations proposed in textbooks. Although these games are easily accessible, as those presented in the Teláris collection, which is well known by teachers for being a collection approved in several editions of the PNLD, it was found that they were not attracted to analyzing them for possible use in the classroom. It is possible to affirm that both teachers were driven by this study to conduct the analysis.

The interviews with the teachers showed their difficulty in understanding specific rules, and the work in making the material for the games in the textbooks reveals that the ergonomic factor influences the choice of a game to use in the classroom. It is inferred that textbook authors could better provide the game pieces to teachers in a more accessible way.

The teachers revealed clues to how the instrumentation and instrumentalization processes can occur differently according to each professional knowledge and how these processes can be developed. For example, in the pre-appropriation phase, teacher José (7th grade) changed the rules of the Equivalent Equations game, while teacher Luzia (9th grade) did not do this. In this article, Mathematical Knowledge for Teaching (BALL; THAMES; PHELPS, 2008) was a reference to analyze the process of instrumentalization and IO. Depending on the nature of the resource, a researcher can choose the most appropriate professional knowledge to analyze its appropriation (The Mathematics Teacher's Specialised Knowledge – MTSK, CARRILLHO et al., 2014 or Technological Pedagogical and Content Knowledge – TPAK, KOEHLER; MISHRA, 2008).

From the exercise sheets used by the teachers, it is possible to get an idea that the equations proposed in the games were not far from what they had already taught the students. From what it was possible to access about the sequence of teaching 1st-degree equations, this follow-up in other investigations is essential to understanding the game appropriation by the teachers. It helped to understand their preferences about a particular game (the Equivalent Equations game) and the best way to use it in the classroom. Furthermore, it is crucial to identify the instrumental orchestrations foreseen in the preparation of the class for the use of the game. Because it is not possible to understand what happens in the effective orchestrations and what happens in the classroom in which the game is applied without having this moment of analysis of the foreseen orchestrations. That is, through this procedure, it is possible to observe what happens inside or outside what is expected by the teachers.

It is expected that this study may raise further investigations on the appropriation of resources by Mathematics teachers. As perspectives for future research, there is: to analyze other games appropriation or other resources by teachers based on the analysis of the phases of original appropriation and reappropriation by teachers (after a specific time). Finally, it is expected that this study will serve as an inspiration for other research based on the appropriation model of a new resource aimed at teaching Mathematics.

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