Sociedade Brasileira de Educação Matemática

RIPEM

Potential of an inquiry-based teaching sequence for improving the level of knowledge about diabetes and statistics

Marta da Silva Simões
Universidade Estadual de Santa Cruz
Coaraci, BA — Brasil
✉ martasimoes381@gmail.com
0000-0002-9708-2908

Irene Mauricio Cazorla
Universidade Estadual de Santa Cruz
Itabuna, BA — Brasil
✉ icazorla@uol.com.br
0000-0003-3028-5513

Miriam Cardoso Utsumi
Universidad Estadual de Campinas
Paulínia, SP — Brasil
✉ mutsumi@unicamp.br
0000-0001-7738-0513

2238-0345 ISSN

10.37001/ripem.v14i3.3807 doi

Received • 26/02/2024
Approved • 15/05/2024
Published • 20/08/2024

Editor • Gilberto Januario

Abstract: In this study, we explored the effectiveness of a pedagogical intervention based on investigative teaching to improve students' understanding of diabetes and statistical concepts. The intervention involved 26 third-grade high school students from a public school. During the intervention, the students actively participated in the investigation, discussed the topic with a nutritionist and analyzed their data in groups. The results suggest that the intervention was effective. The students improved their conceptions of diabetes, expressed intentions to change their eating and physical activity habits and developed an awareness of their role in diabetes prevention. Regarding statistical knowledge, the students could handle the data in a list, satisfactorily organizing it in frequency distribution tables and graphs. However, we identified some gaps in their treatment of decimal numbers and rounding.

Keywords: Teaching Statistics. Inquiry-Based Science Teaching. Likert Scale. Conceptual Variables.

Posibles contribuciones de una secuencia didáctica basada en la investigación para mejorar el nivel de conocimiento sobre diabetes y estadística

Resumen: En este estudio, exploramos la efectividad de una intervención pedagógica basada en la enseñanza investigativa para mejorar la comprensión de los estudiantes sobre la diabetes y los conceptos estadísticos. La intervención involucró a 26 estudiantes de tercer grado de secundaria de una escuela pública. Durante la intervención, los estudiantes participaron activamente en la investigación, discutieron el tema con un nutricionista, y analizaron sus datos en grupo. Los resultados sugieren que la intervención fue efectiva. Los estudiantes mejoraron sus concepciones sobre la diabetes, expresaron intenciones de cambiar sus hábitos alimentarios y de actividad física y desarrollaron conciencia sobre su papel en la prevención de la diabetes. En cuanto a los conocimientos estadísticos, los estudiantes pudieron manejar los datos en una lista, organizándolos satisfactoriamente en tablas de distribución de frecuencias y gráficas. Sin embargo, identificamos algunas lagunas en el tratamiento de los números decimales y el redondeo.

Palabras clave: Enseñanza de Estadística. Enseñanza de Ciencias Basada en la Investigación. Escala Likert. Variables Conceptuales.

Potencialidades de uma sequência de ensino por investigação para o aprimoramento do nível de conhecimento sobre o diabetes e estatística

Resumo: Neste estudo exploramos a eficácia de uma intervenção pedagógica baseada em ensino investigativo para melhorar o entendimento dos alunos sobre o diabetes e conceitos estatísticos. A intervenção envolveu 26 alunos do 3° ano do ensino médio de uma escola pública. Durante a intervenção, os alunos participaram ativamente da investigação, debateram o tema com um nutricionista e analisaram seus dados em grupo. Os resultados sugerem que a intervenção foi eficaz. Os alunos melhoraram suas concepções sobre o diabetes, expressaram intenções de mudar seus hábitos alimentares e de atividade física, e desenvolveram uma consciência sobre seu papel na prevenção do diabetes. No que diz respeito aos conhecimentos estatísticos, os alunos foram capazes de tratar os dados contidos em uma lista, organizando-os em tabelas de distribuição de frequência e gráficos de maneira satisfatória. No entanto, identificamos algumas lacunas no tratamento de números decimais e arredondamentos.

Palavras-chave: Ensino de Estatística. Ensino de Ciências por Investigação. Escala de Likert. Variáveis Conceituais.

1 Introduction

The change in people's eating patterns, with the consumption of high sodium, sugar and saturated fat content and the lack of physical activity, has contributed to the alarming increase in obesity and diabetes inside and outside Brazil.

According to the World Obesity Federation (WOF, 2022), obesity is a chronic disease characterized by the accumulation of body fat at levels that can cause harm to health. Individuals are classified as obese when their body mass index (BMI) reaches or exceeds 30 kg/m². Obesity has the potential to trigger a series of other non-communicable diseases (NCDs), such as stroke, heart attack, high blood pressure and diabetes.

A survey by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE, 2020) showed that 61.7% of the adult Brazilian population was overweight in the year the study was carried out. Corroborating this estimate, the World Obesity Federation (WOF, 2022) warns that around one billion people worldwide will live with obesity by 2030.

According to the World Health Organization (WHO, 2016), diabetes mellitus (DM) is a chronic disease in which inadequate functioning of the pancreas results in insufficient insulin production to synthesize glucose or when the body is unable to use the insulin produced. According to the International Diabetes Federation (IDF, 2021), in 2014, there were approximately 422 million adult people with DM on the planet and estimates indicate that by 2030, this number will reach more than 643 million. In 2021, Brazil had 15.7 million adults with DM and by 2030, this number is estimated at 19.2 million, making it the third country in the world that spends the most on DM.

The IDF celebrates World Diabetes Day every year on November 14th. In 2023, its slogan campaign, "Know your risk, know your response" (Figure 1), focused on the importance of knowing the risk of developing type-2 diabetes and highlighted the importance of seeking information about appropriate care to manage complications related to the disease

and prevent it. To this end, it made the Findrisc test available on its platform (https://worlddiabetesday.org/type-2-diabetes-risk-assessment/po/).

Findrisc comprises eight risk factors that contribute to the development of diabetes: 1) Age; 2) Body Mass Index (BMI); 3) Abdominal Circumference (AC); 4) Practicing less than 30 minutes of physical activity daily; 5) Frequency of consumption of vegetables, fruits or grains; 6) Taking medication for high blood pressure regularly; 7) Presence of high blood glucose and 8) Family history of DM (type 1 or type 2).

The participant just needs to answer questions about the eight risk factors and the platform provides a score and the probability of the person developing type-2 diabetes in the next ten years.

Figure 1: World Diabetes Day 2023 Campaign

Source: International Diabetes Federation (2023)

As we can see, this topic has become highly relevant and, in this sense, the development of studies on obesity and diabetes in basic education schools became crucial since students spend considerable time in these institutions, where they often eat (snacks and lunch) and practice physical activities in the Physical Education curriculum component. Thus, they can be great allies in preventing these diseases at school and in their communities.

In this context, we could ask ourselves how to work on a topic of such social relevance in mathematics classes, using statistics to help students understand the world around us, forming readers and producers of statistical information to understand how data is generated, transformed and what is most important: that they become aware of the meaning of the results and, based on these results, make decisions that can impact their personal development and that of their communities.

The use of instruments such as Findrisc in contextualizing the topic allows for a rich discussion about the nature of statistical variables, bringing to mathematics classes the dilemma of how to build instruments to "measure" habits, perceptions, conceptions and opinions, among others, called theoretical or conceptual variables (Cazorla & Oliveira, 2010), which necessarily demands interdisciplinary knowledge and a transversal approach in mathematics classes. The big challenge is working from this perspective in the classroom and school realities.

In this sense, we found that several researchers have focused on statistics teaching in basic education as a tool for understanding the phenomena/problems that affect students' reality by implementing teaching sequences through the investigative cycle, in which students reflect on the problem, collect data, analyze the data using summaries, tables and statistical graphs and take a stand considering the results.

For example, Cazorla, Silva-Junior and Santana (2018) and Utsumi, Anjos and Couto (2024) used a Likert-type scale to investigate the eating habits of elementary school students in the 8th and 5th grades, respectively. In both works, students signaled changes in their habits toward healthier eating. Silva, Souza and Cazorla (2021) also used a Likert scale to assess high school students' perceptions of the impact of the use of pesticides.

Almeida, Souza and Cazorla (2021) developed a statistics teaching sequence in which high school students analyzed the relationship between their study habits and performance in the Mathematics curriculum component; Lobo and Cazorla (2019) implemented a teaching sequence using data from students' vaccination cards; and Nascimento, Jerônimo and Santos (2020) addressed the reuse of cooking oil.

These works had the investigative cycle and statistical literacy as their theoretical-methodological framework. In this work, we expanded the framework for inquiry-based science teaching, as it allows us to detail the research process in the classroom.

In this context, this article aims to analyze the possible contributions of an inquiry-based teaching sequence to improving the level of knowledge about diabetes and statistics among students in a high school class. We emphasize that this article is an excerpt from a master's thesis focused on the contributions to the level of knowledge assessed by the scale developed by Shiferaw et al. (2020) and adapted by Cazorla et al. (2023) for use in basic education. It also intended to raise students' awareness about their eating and physical activity habits, indications for changes to healthier habits and proactive signs for preventing these diseases.

In the next section, we present work on obesity and diabetes carried out in basic education and the instruments to assess students' level of knowledge about diabetes.

2 Studies on obesity and diabetes in basic education

Observing the alarming data on the advancement of obesity and diabetes, many researchers believe that schools have an important role in their prevention and have carried out research in schools addressing various aspects related to the topic, as we report below.

Ciaccia et al. (2018) developed a survey with 580 adolescents enrolled in elementary school in Santos, SP, to map overweight and obesity occurrence and identify factors associated with these conditions. The researchers observed that 19.97% of students were overweight, while 19.85% were obese. These results showed a high prevalence of overweight and obesity in a very young population.

Almeida's (2016) survey evaluated the perceptions of obesity of high school first graders before and after an educational intervention aimed at the benefits of a healthy lifestyle. Ninety students participated in the research before and 92 after the development of the educational intervention. The researcher observed that terms used by students to conceptualize obesity changed after the intervention, indicating a change in understanding the concept of obesity. Furthermore, other terms such as "prevention," "lack of exercise," "illness," and "death" were mentioned more by the students after the intervention, which

showed that the participants began to have a clearer understanding of the consequences of this disease in people's lives.

To prevent type-2 DM in adolescents who had at least one risk factor for developing the disease, Silva et al. (2011) analyzed two educational approaches: one individual approach, in which students received an informative leaflet with brief explanations about this content and the other group, which prioritized student active participation, addressing beliefs, opinions and learning needs, as well as researcher-student interaction. Ninety students from a public school in Fortaleza participated in the research. They filled out a questionnaire to assess their level of knowledge about type-2 DM before, one day after and 60 days after the educational intervention. Although the results showed no significant difference between the two approaches regarding the level of knowledge, the researchers highlighted that the educational interventions used at school have the potential to help spread measures to prevent type-2 DM.

These studies show the importance of working on these topics at school, which can be an ally in preventing and treating obesity and diabetes, offering students a more detailed view of these diseases. Furthermore, if someone already has any of these diseases, students must know that there are strategies to control the situation and promote a healthier lifestyle.

Finally, Cazorla, Utsumi and Simões (2023) carried out a literature review on the construction and validation of instruments to assess the level of knowledge of DM. At a national level, they found a review of instruments and scales related to DM, adapted and validated for Brazilian culture, carried out by Curcio, Lima and Alexandre (2011), which, in general, focuses on diabetics and the knowledge they should have to control their disease. In the international context, the authors found Shiferaw et al.'s (2020) study, which assessed knowledge and perceptions about DM and associated factors of people in Debre Berhan, northeastern Ethiopia, using a Likert-type scale. Given that this scale seemed appropriate for teaching, the authors translated and adapted it for use in an investigation proposed in the classroom with master's degree teachers and got consistent results with those of Shiferaw et al. (2020).

Thus, we adopted this scale to work on this investigation, the results of which will be compared with those found by the researchers. The following section presents the theoretical framework used in this work.

3 Theoretical framework

The statistical literacy model proposed by Gal (2002) and the assumptions of inquiry-based science teaching (IBST) (Sasseron, 2018; Carvalho, 2018) supported the construction of the investigative teaching sequence (ITS) developed in the present study.

Gal (2002) developed a statistical literacy model, considering that a citizen literate in statistics can critically evaluate statistical information and relate the data to the context in which they were derived.

People "live" with statistics in their daily lives, whether reading the news, reading product labels, or watching the newspaper and sometimes, they do not realize that they are statistics. This may happen because individuals are not statistically literate. Therefore, integrating statistics at school can help students understand and interpret data effectively, developing their statistical literacy.

Gal (2002) proposed a model that considers knowledge and disposition elements. The elements of knowledge include literacy, mathematical knowledge, statistical knowledge,

context knowledge and the ability to elaborate critical questions. The dispositional element is formed by beliefs, attitudes and a critical stance.

As reported in the results, all these elements were contemplated in the construction of the ITS. Below, we present the IBST assumptions that were also the foundations for the final format of the ITS.

According to Sasseron (2015), IBST is a didactic approach in which students, advised by the teacher, carry out the research. According to Almeida and Sasseron (2013), this approach guides students to practice the scientific method, helping them solve the proposed challenges autonomously and interact with the class while the teacher plays the role of a planner and a mediator.

In this context, students may be able to recognize problematic issues while being encouraged to become actors in possible transformations in their environment, making decisions supported by scientific knowledge.

One way to implement this approach is to use an investigative teaching sequence (ITS). Carvalho (2018) defines an ITS as a didactic proposal that explores and develops activities with scientific themes that can assist students in their learning process.

Furthermore, Carvalho (2011) emphasizes that there are four pillars to support ITS planning to create conditions in the classroom for the construction of scientific knowledge: a) the existence of a problem for the beginning of knowledge; b) the presence of a manipulative action that favors intellectual action; c) the importance of becoming aware of one's actions for the construction of knowledge; and d) the different stages of scientific explanations.

To build the ITS, Carvalho (2011) proposes eight points to guide its planning: 1) active student participation; 2) the importance of student-student interaction; 3) the teacher's role as a question creator; 4) creating an encouraging environment; 5) teaching based on the knowledge that students bring to the classroom; 6) the content (problem) must be significant for students; 7) the relationship between science, technology and society; and 8) the transition from everyday language to scientific language, highlighting the importance of developing argumentative capacity, using the mother tongue, mathematical expressions and graphic representations.

To involve students in the entire statistical investigation process so that they became aware of their eating habits and physical activities as potential risk/prevention factors for these diseases, we used the investigative cycle PPDAC, in which students could actively participate in all statistical surveys, process their own data and draw conclusions from the results.

In this way, we incorporate the four pillars that underpin the planning of an ITS and note that when we work with the statistical method to map conceptions and levels of knowledge about diabetes, we are working with conceptual and not empirical, variables (Cazorla & Oliveira, 2010), typical of problems/situations/phenomena in the areas of applied human and social sciences.

The next section presents the PPDAC and details the methodological procedures used to carry out the research and the ITS developed.

4 Methodological procedures

Our approach in this research is qualitative-quantitative. At the same time as we wanted to evaluate ITS's contributions to students' level of knowledge about DM and obesity,

the leading researcher conducted on-site studies and followed the entire ITS development process.

The research is of the pedagogical intervention type, which, according to Damiani et al. (2013), is applied research that aims to contribute to the solution of practical, real-world problems, as it is carried out on and with people outside the protected environment of a laboratory, warning about the distance between academic production in the area of education and its effects on the practice of professionals working in educational institutions. This type of research has the potential to support decision-making about changes in educational practices, promote improvements in existing education systems, or evaluate innovations.

To guide students' involvement in the statistical research process, we use the investigative cycle (PPDAC) proposed by Wild and Pfannkuch (1999), which aims to promote the development of statistical thinking. In this proposal, the individual actively participates in the process from problem formulation (P), planning (P) and data collection (D), to analysis of collected data (A) and conclusions (C).

In this research, students participated in contextualizing the problem through guided reading of reports and interaction with the guest nutritionist; they were encouraged to create questions to be answered based on the data. They collected and analyzed their personal data on eating habits and physical activities and, finally, drew conclusions from the results found in the simple and double-entry Frequency Distribution Table (FDT) and the bar/column graph they constructed.

As we can see, while the investigative cycle (PPDAC) is more oriented to the phases of the statistical research process in a more global way, IBST magnifies the construction of the process, focusing on how activities can be carried out to promote scientific knowledge involved in the most global statistical research process.

We emphasize that the scientific knowledge involved in this ITS was of two types: the first related to diabetes (what it is, what the risk factors are, its symptomsand the forms of treatment, controland prevention); the second refers to the statistical knowledge involved in a statistical investigation, as well as the processing of data and its transformation into tables, graphsand statistical measures.

The research was conducted in a state public school, with 26 high school third graders aged between 17 and 19 years old, with a mean of 17.56 and a standard deviation of 0.57 years old. This research is an excerpt from the first author's master's thesis, approved by the Ethics and Research Committee on Human Beings (CAAE: 65904222.3.0000.5526).

To assess students' level of knowledge about diabetes, we used a Likert-type scale adapted by Cazorla et al. (2023), with 22 items divided into four domains: conceptualization of diabetes mellitus (DM); risk factors for the disease; signs and symptoms of DM; and ways to control and treat the disease. Each item has three possible answers: Yes (Correct), Noand I don't know. Each hit (Yes) received one point. Thus, the scale score can vary from zero to 22 pointsand scores greater than or equal to 11 points (the midpoint of the scale) indicate that the person has adequate knowledge about the disease.

A Likert-type scale was also used to assess eating and physical activity habits, with four items and five points involving the frequency of consumption of industrialized sweets, sugary drinks, carbohydratesand physical activities. Each frequency was scored from 0 to 4, with zero corresponding to unhealthy habits and 4 to healthy habits. The total scale score ranges from 0 to 16and this score was again categorized into "not healthy" to "very healthy" habits.

The statistical variables generated by this scale were treated statistically by the students throughout the development of the ITSand this choice was purposeful. We wanted students to realize that the results were about their behavior and thus become aware of the risks a diet rich in sugar derivatives, ultra-processed carbohydratesand a tendency to be sedentary bring to health.

To complement the data, we used a questionnaire to map the conceptions and risk factors of obesity and diabetes and collected anthropometric data to calculate BMI, waist circumference (WC)and family history of DM.

The ITS was developed in seven two-hour meetings/classes. At the first meeting, we presented the research to the students and collected signatures on the participation terms of consent and assent. In the second meeting, students filled out the instruments: the diabetes knowledge questionnaire, the DM knowledge level scaleand the eating habits and physical activity scale, after which they performed guided readings of parts of reports on the topics that were later worked on in groups. In the third meeting, we promoted a conversation with a nutritionist and with the active participation of students, who interacted and clarified their doubts about the topics.

The fourth meeting was used to fill out the anthropometric measurement instrument so that they could calculate their BMI and WC. At the fifth meeting, at the class teacher's request, a new conversation was held about diabetes, obesityand related topics. In the sixth meeting, students processed the data initially collected using an activity guide and a database. Finally, the seventh meeting was dedicated to completing the instruments after developing the ITS.

To carry out data processing, we chose eight statistical variables that were distributed to eight groups as follows: G1-Frequency of consumption of industrialized sweets; G2-Frequency of consumption of industrialized sugary drinks; G3-Frequency of consumption of industrialized carbohydrates derived from wheat flour; G4-Frequency of physical exercise; G5-Eating and physical activity habits; G6-Excessive thirst; G7-Excessive hunger and G8-Family history of DM.

Each group received a database with 27 lines and 10 columns. The first line contained the student code, genderand eight variables; the remaining 26 lines contained the 26 students' answers.

To guide data processing, we created an activity guide in which students had to create a research question that could be answered with the data from the variable under their responsibility, then fill out the simple FDT and convert the FDT data to the graph of bars/columns. With these results, the groups needed to answer the research question created at the beginning, drawing a conclusion based on the results contained in the FDT and the graph constructed.

Furthermore, students had to construct the double-entry FDT relating their variable to the gender variable, formulate a research questionand answer it based on these results. Finally, the groups were requested to answer the question: "How is the class regarding the risk factors or symptoms related to DM?" Based on this answer, they should prepare advice for the class regarding the risk factors or symptoms analyzed.

A database was created to treat quantitative data with all variables collected and entered into an electronic spreadsheet. The answers to the open questions were grouped into categories, generally characterized by keywords on the subject.

We used the Statistical Package for the Social Sciences (SPSS) to statistically analyze the categorical quantitative and qualitative variables. To analyze the relationship between scores on the knowledge scale before and after the intervention, we used regression analysis and the Student's paired t-test. The level of significance was 5%.

In the following section, we present the results of this research.

5 Results and discussion

This section is divided into two subsections. The first is dedicated to the quantitative results presented in the knowledge scaleand the second is to the qualitative analysis of the ITS implementation process.

5.1 Level of knowledge about diabetes

Table 1 presents the 26 participants' answers to the 22 items on the scale. In the first dimension of the scale, about what DM is/are, 92.3% of students indicated that DM is a condition of high blood sugar leveland then 76.9% indicated that it is an uncurable disease. However, this knowledge dropped to 57.7% for insufficient insulin productionand only 15.4% indicated that it was insulin resistance; that is, knowledge about insulin production and resistance was not yet well established.

Participants presented a good percentage of knowledge regarding risk factors, genetic history, inadequate eating habits, obesityand sedentary lifestyles –only age as a risk factor needed to be better clarified for these students.

They recognized two signs and symptoms well: "High blood sugar" and "Wounds that take time to heal." The other factors were less highlighted. Regarding the control and treatment dimension, "Insulin Injection" and "Healthy Eating" were well stressed, but the remaining three were not. These answers show that the students had good prior knowledge but that it could still be more accurate.

Table 1: Participants' knowledge about DM before the intervention (%)

	Items	Yes	No	Does not know	Total
What is/are DM	DM is a condition of insufficient insulin production	57.7	11.5	30.8	100.0
	DM is a condition of the body that presents insulin resistance	15.4	42.3	42.3	100.0
	DM is a condition of high blood sugar	**92.3**	0.0	7.7	100.0
	DM is incurable	**76.9**	7.7	15.4	100.0
Risk factors	Age	57.7	7.7	34.6	100.0
	Genetic or family history of DM	**92.3**	0.0	7.7	100.0
	Sedentary life	**80.8**	0.0	19.2	100.0
	Poor eating habits	**92.3**	0.0	7.7	100.0
	Being overweight (obesity)	**80.8**	0.0	19.2	100.0
Signs and symptoms	Urge to urinate all the time	53.8	3.8	42.3	100.0
	Excessive thirst	57.7	0.0	42.3	100.0
	Excessive hunger	30.8	15.4	53.8	100.0
	Weight loss	50.0	15.4	34.6	100.0
	High blood sugar	**88.5**	3.8	7.7	100.0

	Blurred vision	73.1	0.0	26.9	100.0
	Wounds that take a long time to heal	**92.3**	3.8	3.8	100.0
	Feeling of weakness	61.5	3.8	34.6	100.0
Control and treatment	Insulin injection	**84.6**	0.0	15.4	100.0
	Tablets and pills	50.0	0.0	50.0	100.0
	Regular physical exercise	65.4	7.7	26.9	100.0
	Healthy eating	**92.3**	0.0	7.7	100.0
	Overweight control	73.1	0.0	26.9	100.0

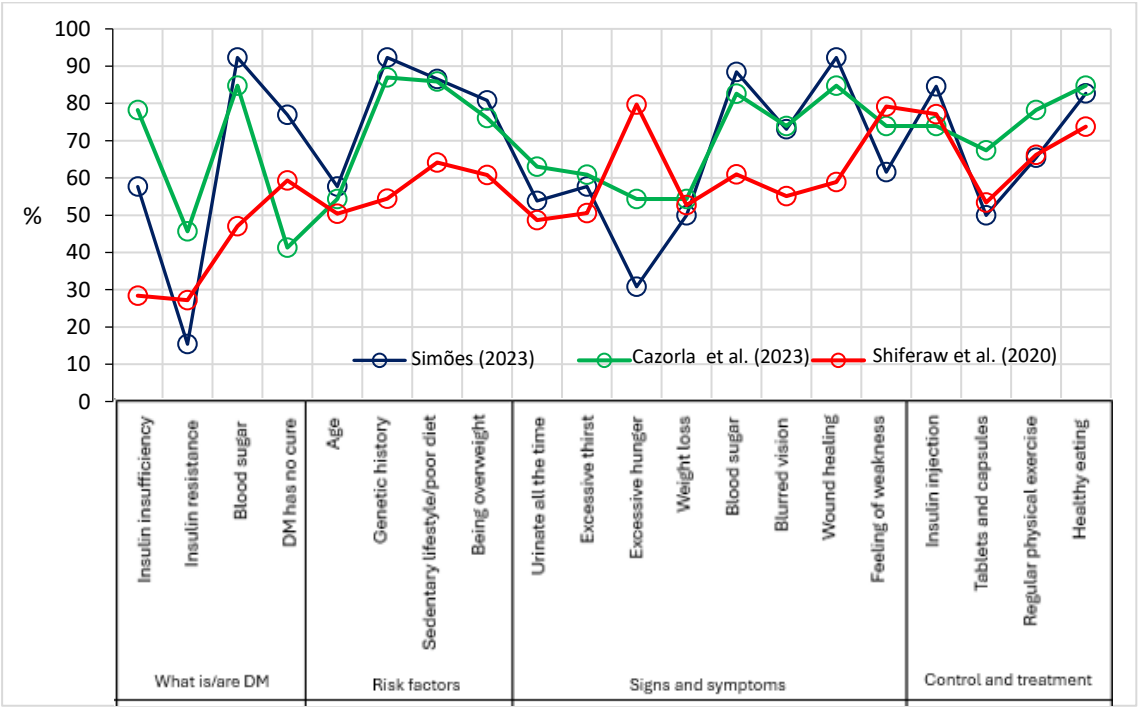
Source: Simões (2023)

Figure 2 compares students' initial level of knowledge in our study and the studies by Cazorla et al. (2023) and Shiferaw et al. (2020). Our data agree with those by Cazorla, Utsumiand Simões (2023), as Brazilian participants' answers showed a higher hit rate than the study by Shiferaw et al. (2020). This difference is observed in practically all items except four: "DM is uncurable," "Excessive hunger," "Feeling of weakness," and "Insulin injection."

The education of the participants in the compared studies may explain these differences. While Shiferaw et al. (2020) carried out a study with people from the community, the participants of this study and the study by Cazorla et al. (2023) were students, the last of whom were postgraduate students who, in theory, have greater access to information.

Simões (2023) demonstrated that participants' initial knowledge was between the rates of the other two studies; regarding "Insulin Injection," it surpassed the rates of other studies in the item "It is incurable" and was below other studies in the items "Insulin resistance," "Excessive hunger," and "Feeling of weakness."

Figure 2: Comparative study of the level of knowledge about DM



Source: Simões (2023)

In Figure 3, we present the positive (correct) response rates of the 25 students before and after the intervention (one student did not complete the scale after the intervention). Considering the 22 items, two dropped by 12% in the item "DM is incurable." In the item

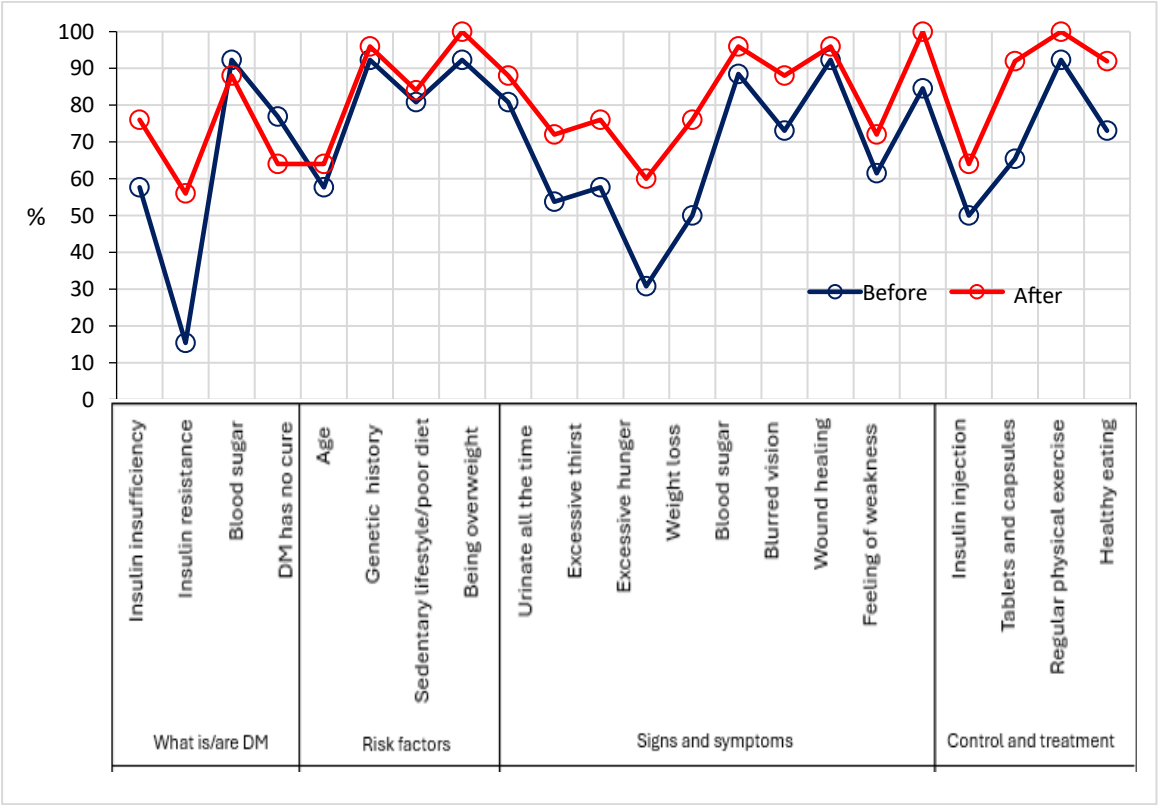
"High blood sugar level," the drop was 4.0%. The remaining 20 items improved, so in some, this improvement was substantial, such as the item related to "Insulin resistance," with a gain of 40%; "Excessive hunger," with 28.0%; "Weight loss," with 24.0%; and regularly doing physical activities, also with 24.0%.

In three items, 100% of students hit/recognized the characteristic "bad eating habits" as a risk factorand "insulin injection" and "healthy eating" as control and prevention methods.

Table 2 illustrates that, before the intervention, the score on the scale ranged from 0 to 21and after the intervention, this score had a considerable increase, varying from 12 to 22; that is, all students scored above the average point, which is 11. The average score went from 15.56 (SD = 4.805) to 18.00 (SD 2.769), which is a higher average and a less variable score distribution (Figure 4a). This shows that the gain was good, especially among students who started with a low level of knowledge (Figure 4b). The paired t-test results show this gain was significant at the 5% level.

Figure 4a shows the score boxplot at both moments. We can see that after the intervention, the score is higher than before, while the dispersion is smaller, as already verified in Table 2. In Figure 4b, we present the relationship between the scores obtained by the 25 students, whose correlation was 0.611. The adjusted line presents an angular coefficient lower than 1, which confirms that the most significant gains occurred among students who started the intervention with little knowledge.

Figure 3: Level of knowledge about diabetes before and after the intervention



Source: Simões (2023)

In this way, it seems that ITS contributed to improving students' level of knowledge about diabetes.

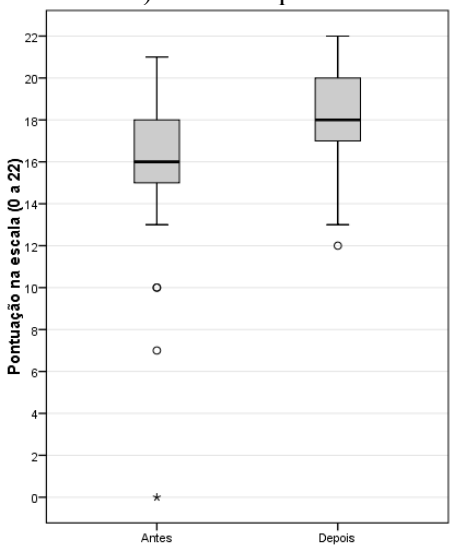
Table 2: Score statistics on the knowledge level scale before and after

Intervention	Statistics					Student's t-test	
	n	Minimum	Maximum	Average	SD	t-statistics	p-value
Before	25	0	21	15.56	4.805	$t_{(24)} = -3.203$	0.004
After	25	12	22	18.00	2.769		

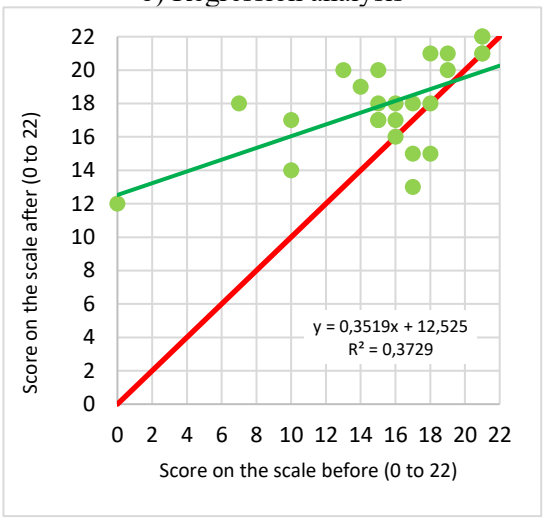
Source: Simões (2023)

Figure 4: Score on the scale before and after the intervention

a) Score boxplot



b) Regression analysis



Source: Simões (2023)

5.2 Qualitative analysis of the ITS development process

Below, we explain how the eight points suggested by Carvalho (2011) and the components of statistical literacy suggested by Gal (2002) were included in the development of the sequence.

The first point deals with students' active participation throughout the research process. As mentioned previously, in this sequence, the students did not participate in choosing the topic (Problem) nor in determining how the data would be collected (Planning). This methodological option was adopted because involving students in these two phases would have required us to hold at least one more meeting, which would have been quite challenging to achieve at school. However, the problem was contextualized through guided reading of reports related to risk factors/disease prevention and interaction with the nutritionist, which proved to be adequate due to the indices obtained by the students on the scales and their answers to the questions: "In your opinion, knowing that obesity is a risk factor for diabetes, what can schools do to promote prevention of both obesity and diabetes?" and "What, in your opinion, can be improved in this activity so that other students can understand the risk of obesity and diabetes?":

- *Conduct studies on the topic, promote conversation groupsand hold round tables to discuss this subject, making them participate.*

- *Avoid fatty foods, increase vegetable intake, reduce sugar intakeand raise awareness through lectures about these problems and how to avoid them.*
- *Place warning posters on the subject. Promote conversation circles and contribute to healthier eating.*
- *Talk more about the diseases caused by DM and obesity and about alert movements for the entire community.*
- *Promote classes and discussions on mental health.*

These answers show how the knowledge of the context of Gal's model (2002) was covered and give us the dimension of how much the students became aware of the problem based on the ITS. We remind readers that the groups processed data on eating habits and physical activityand the guided readings concerned the excessive consumption of sweets, sugary drinksand ultra-processed carbohydrates, as well as the importance of physical activity and the consumption of fruits and vegetables.

The second point highlights the relevance of student-student interaction. This interaction was made possible when the development of research data analysis was planned in eight groups composed of three or four students who worked on a statistical variable and carried out readings and statistical treatment of the risk/prevention factors or symptoms of diabetes.

The students interacted constantly with each other, discussing the problems of obesity and diabetes while executing the statistical procedures to extract data from the database to fill in the tables, construct the graphand interpret the results.

The third point highlights the teacher's role as a mediator, developing questions to ensure that this approach involved students and allowed them to share their knowledge in class. In this research, the ITS was developed by the main researcher, who, together with the class teacher, was at the forefront, interacting with students in guided readings, interacting with the nutritionistand providing guidance for extracting data, filling out tables and graphsand interpreting the results.

The fourth point concerns creating an encouraging environment where students can express their ideas. In this work, we made it clear to students that they could clarify their doubts, present ideasand answer the questionnaires and the activity guide based on their knowledge, as there would be no judgments regarding the questions or their answers.

The fifth point recommends considering the knowledge that the student brings to the classroom. In this ITS, students' prior knowledge was raised during the conversation circle, which began with students' knowledge and responses to the activity guide on the topic. Students asked questions during the development of the sequence that allowed customized ITS development.

We also highlight an episode that portrays well how student-student interaction, the creation of an encouraging environmentand the relevance of prior knowledge were considered in the development of the ITS. At some point, Group 6 asked the researcher to briefly explain how to complete the FDT (see Figure 5). However, one of the group members already knew how to carry out the activity and had explained it to the other group members; however, they did not trust their colleague. As soon as the researcher explained, this group member immediately spoke up: "But that's exactly how I explained it to you. I knew this was done like that and you chose not to trust me."

Figure 5: Table completed by Group 6 – Excessive thirst

Categorias	Quantidade de alunos	Porcentagem
0-Não	0	0%
1-Sim	15	57,6%
2-Não sei	11	42,4%
Total	26	100%

Source: Simões (2023)

One student knew how to do the activity and had the autonomy to explain it to her classmates. Therefore, it is clear that the research approach contributes to the teacher granting students autonomy to formulate hypotheses, interpretand reach conclusions, even though some are not yet prepared to use this autonomy (Moura, Valois, & Sedano, 2019).

Regarding prior knowledge, specifically of mathematics, we observed that some of the groups whose sum of category frequency was below 100% (Figure 6) raised questions about the reason for this result and even tried to correct the error, although without success, showing that they were aware that the sum of the percentages should have given 100%. This fact caught our attention because we erroneously believed that the high school third graders mastered the treatment of decimal numbers and rounding criteria. Therefore, mathematics teachers should be aware of the prior knowledge to be mobilized when working with statistical knowledge.

Figure 6: Table completed by Group 1 – Industrialized sweets

Categorias	Quantidade de alunos	Porcentagem
0-Sempre (Todos os dias da semana) 4	4	15,3
1-Frequentemente (de 4 a 6 dias por semana) 3	3	11,5
2-Às vezes (de 2 a 3 dias por semana) 8	8	30,7
3-Raramente (1 dia por semana) 10	10	38,4
4-Nunca (Nenhum dia da semana) 1	1	3,8
Total	26	99,7

Source: Simões (2023)

The sixth point concerns the importance of the content (problem) being meaningful to the student. Initially, we chose the topic of the spread of obesity and diabetes because it is a global emergency (WHO, 2020), but also because we observed that students in schools face the problem of bullying related to obesity. Studies carried out in schools in the region account for this problem, such as the research by Santana (2022), which found that 75% of students are overweight. Furthermore, diabetes is a silent diseaseand citizens must be alert.

With the development of ITS, we found that this topic was closer to students than we imagined: reports about knowing people with diabetes confirmed the need to discuss such issues in the school environment. The students reported knowing people with diabetes, including those in their family circle; for example, a student reported that her uncle had his leg amputated due to complications arising from diabetes.

The seventh point discusses the relationship between science, technologyand society. Within this research, science and technology "worked" together. The construction of ITS was based on scientific data published in documents from WHO (2020), IDF (2021)and WOF (2022) covering obesity and diabetes: the platform made available by IDF and SBD so that people can calculate their risk of developing type-2 diabetes in the next ten years; the

knowledge that this incurable disease can be controlled with a healthy diet and physical activity, starting at school age.

We found that the students' habits were not as harmful to their health, as shown in Table 3. Following the development of the ITS, students expressed their intention to adopt healthier habits, as Table 4 shows.

Table 3: Students' eating and physical activity habits before the intervention

Consumption frequency	Eating habits			Physical activity habits	
	Pastries (*)	Sugary beverages	Carbohydrates (*)	Frequency of execution	Physical exercises
Always	15.38	7.69	19.2	Never	23.08
Often	11.54	7.69	30.8	Rarely	3.85
Sometimes	30.77	50.00	34.6	Sometimes	11.54
Rarely	38.46	30.77	15.4	Often	19.23
Never	3.85	3.85	0.0	Always	42.31
Total	100.00	100.00	100.0	Total	100.00

Note. (*) industrialized.

Source: Simões (2023)

Table 4: Intention to change habits after the intervention

Habits	Keep	Reduce	Total
Food			
Regarding your habits of consuming processed pastry (candies, gum, chocolate, lollipops, etc.), you intend to:	2 (8.0%)	23 (92.0%)	25 (100%)
Regarding habits of consuming sugary drinks (soda, juice from bags or boxes, chocolate drinks), you intend to:	3 (12.0%)	22 (88.0%)	25 (100%)
Regarding habits of consuming industrialized carbohydrates derived from wheat flour (biscuits, instant noodles, etc.), you intend to:	8 (32.0%)	17 (68.0%)	25 (100%)
In physical activities	**Keep**	**Increase**	**Total**
Regarding physical exercise habits (walking, cycling, swimming...), you intend to:	4 (16.0%)	21 (84.0%)	25 (100%)

Source: Simões (2023)

The eighth point deals with the transition from everyday to scientific language, highlighting the importance of developing argumentative capacity using the mother tongue, mathematical expressionsand graphic representations. In the development of ITS, we observed this change from students' everyday language to scientific language, as we can see in the following excerpts:

About diabetes:

Before ITS: *Diabetes is when our body cannot produce enough insulin to meet our needs.*

After ITS: *Diabetes is the lack of insulin produced by the pancreas, which cannot control blood glucose. [They are] type 1, 2, 3. [Symptoms] Excessive thirst, wounds that take a long time to heal, etc. Control can be done with injected insulin.*

About obesity:

Before ITS: *When a person is overweight for their height.*

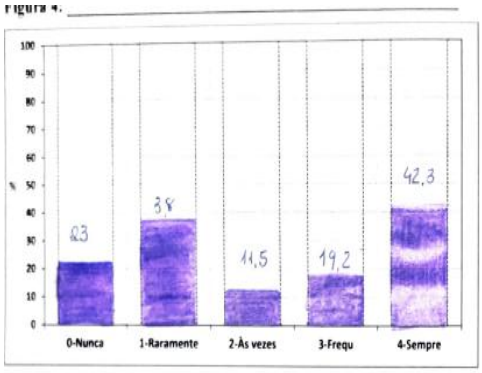
After ITS: *It is the accumulation of fat in the body, almost always caused by the consumption of more energy in food than that used by the body to maintain itself and carry out its daily activities.*

Regarding the development of argumentative capacity using the mother tongue, mathematical expressionsand graphic representations, we can observe how the students constructed tables, transformed the data in the table into graphsand, from these results, could extract appropriate conclusions, as we can see in the answers of Group 4, which worked with the variable "performing physical activities" (see Figure 7).

Group 4 concluded: "At the moment, our class does not have this risk factor, as 42.3% (always) practice physical activity." Regarding the advice they would give to the class, the students said: "People who practice should encourage those who don't practice or only practice sometimes."

We found that with ITS, we could work on the mathematical knowledge that supports statistical knowledge, the statistical knowledge involved in the entire process of statistical research and the processing of raw data in tables, graphsand statistical measuresand the ability to elaborate critical questions and improve one's mother tongue, components of the knowledge elements of Gal's model (2002).

Figure 7: Graph constructed by Group 4 – Physical Activities



4. Com esses dados vocês conseguem responder a pergunta de pesquisa? ( )0-Não (X)1-Sim

5. O que vocês podem concluir analisando os dados da tabela/gráfico?

Pode-se analisar que a porcentagem de pessoas que praticam atividades físicas, é maior do que as pessoas que praticam raramente.

5. What can you conclude by analyzing the data in the table/graph?

"We can analyze that the percentage of people who practice physical activities is higher than those who rarely do it."

6. Como está a turma em relação a este fator de risco no desenvolvimento do DM?

No momento nossa Turma não se encontra com esse fator de risco, pois 42,3% praticam atividade física.

7. Que conselhos vocês dariam para a turma?

As pessoas que praticam incentivem aqueles que não praticam ou praticam só as vezes.

Source: Research collection

Regarding the elements of disposition, specifically beliefs, attitudesand critical stance, students overcame some beliefs about obesity and diabetes. One student, for example, stated:

"I think it thins the blood (...)," and another, "I know obese people who are healthier than many thin people." In the latter case, it was important to clarify that obesity implies a state of permanent inflammation of the organs and has long-term consequences.

As for the critical stance, we can evidence this stance in the responses about the possibility of raising awareness among students and the community about the risks of obesity and diabetes. Twenty-three students answered positively, using the verbs awareness, alert, educateand prevent. Most indicated possible actions for prevention and care:

- *Yes, because with lectures, adding more classes with food education, even adding more healthy foods to the school menu, as much as possible.*
- *Yes, because the school must promote education, healthand quality of life.*
- *In my opinion, you can raise awareness by talking more and creating more public places with physical activities.*
- *Yes, these warnings serve as an alert so that people are aware of the risks, symptomsand how to control them.*
- *Yes, this way, the school can bring in people who understand the subject and teach and carry out campaigns in schools so that students can begin to understand more about obesity.*

In this way, we can verify that the ITS, built considering the components of Gal's statistical literacy (2002), guided by the eight points recommended by IBSTand outlined by the investigative cycle, managed to engage students in the investigative process, awakening them to their roles in school and the community, with a theme that was very close to their reality.

6 Final considerations

The school environment is a relevant space for working on issues of social urgency and using different methodological approaches. It is essential that teachers feel comfortable developing teaching sequences that can enhance student learning.

The alarming prevalence of diabetes and obesity in Brazil and around the world demonstrates that discussing those themes inside and outside the school environment is paramount. The objective is to raise awareness among individuals about preventing and caring for these diseases.

The most rewarding aspect of this work was acknowledging that high school students realized the role of school management and their own role in expanding knowledge about disease and prevention actions. The development of a critical stance and the willingness to change the perceived reality were notable.

However, we point out a limitation: we did not carry out a diagnosis before beginning the development of the ITS to identify students' prior knowledge and their difficulties, which would have allowed us to make further progress in improving basic mathematical knowledge, such as rounding and operations with decimals. However, we must remember that the reality of school, with its times and needs, was beyond the researchers' control.

References

Almeida, A. & Sasseron, L. (2013). As ideias balizadoras necessárias ao professor ao planejar e avaliar a aplicação de uma sequência de ensino investigativo. In: *IX Congresso Internacional sobre Investigación En Didáctica de Las Ciencias,* Girona, España.

Almeida, E. L. M. (2016). *Manual Pedagógico: metodologia aplicada à projetos interdisciplinares.* Dissertação. (Ensino em Saúde na Amazônia, Universidade do Estado do Pará. Belém. PA.

Almeida S. S., Lima de A. S., M. M. & Cazorla, I. M. (2021). Percepções de estudantes sobre o impacto do uso de agrotóxicos: a influência do contexto e do ensino de estatística na educação básica. *Revista Paranaense De Educação Matemática*, *10*(21), 112–137.

Cabral, U. (21 de novembro de 2020). *Um em cada quatro adultos do país estava obeso em 2019.* Agência IBGE Notícias, Rio de Janeiro.

Carvalho, A. M. P. de. (2011). Ensino e aprendizagem de Ciências: referenciais teóricos e dados empíricos das sequências de ensino investigativas – (SEI). In M. Longhini (Org.) *O Uso e o diverso na educação* (pp. 253-266). Uberlândia, MG: EDUFU.

Carvalho, A. M. P. de. (2018). Fundamentos Teóricos e Metodológicos do Ensino por Investigação. *Revista Brasileira de Pesquisa em Educação em Ciências e Matemática*, *18*(3), 765-794.

Cazorla, I. & Oliveira, M. (2010). Para saber mais. In I. Cazorla & E. Santana (Org.) *Do Tratamento da Informação ao Letramento Estatístico* (pp. 113-144). Itabuna, BA: Via Litterarum.

Cazorla, I. M., Silva Júnior, A. V. & Santana, E. R. dos S. (2018). Reflexões sobre o ensino de variáveis conceituais na Educação Básica. *Revista De Ensino De Ciências E Matemática*, *9*(2), 354–373.

Cazorla, I. M. & Santana, E. R. dos S. (Orgs.). (2009). *Do Tratamento da Informação ao Letramento Estatístico*. (2a. ed.). Itabuna/Ilhéus, BA: Via Litterarum.

Cazorla, I. M, Utsumi, M. C. & Simões, M., da S. (2023). Nível de conhecimento sobre o diabetes: aliando o ensino de Estatística à tomada de consciência e prevenção dessa doença na Educação Básica. *Ensino e Tecnologia em Revista*, *7*(1), 283-297.

Ciaccia, M. C. C., Vieira, A. M., Oliveira, H. N., Bonfim, A. M. S., Rosenberger, J., Salata, N. A., Duim, E. L. & Rullo, V. E. V. (2018). A Alta Prevalência de Obesidade em Adolescentes de Escolas da Rede Municipal de Santos e Fatores Associados. *Revista Brasileira de Obesidade, Nutrição e Emagrecimento*, *12*(72), 486-494.

Conceição, A. L. O., Corrêa, N. de C., Ferreira, P. R., Rêgo, A. S., Silva, F. B., Carvalho, S. T. R. F. de, Dias, R. da S., Paz, B.K. B, Rocha, V. C. de C. & Dibai-Bassi, D. (2020). Translation, cross-cultural adaptation and validation of the Finnish Diabetes Risk Score (Findrisc) for use in Brazilian Portuguese: questionnaire validity study. *São Paulo Medical Journal, 138*(3), 244-252.

Curcio, R., Lima, M. H. M. & Alexandre, N. M. C. (2011). Instrumentos relacionados ao diabetes mellitus adaptados e validados para a cultura brasileira. *Revista Eletrônica De Enfermagem*, *13*(2), 331–7.

Damiani, M. F., Rochefort, R. S., Castro, R. F., Dariz, M. R. & Pinheiro, S. S. (2013). Discutindo pesquisas do tipo intervenção pedagógica. *Cadernos de Educação*, 45, 57-67.

Gal, I. (2002). Adults' Statistical Literacy: Meanings, Components, Responsibilities. *International Statistical Review*, *70*(1), 1-25.

International Diabetes Federation - IDF. (2021). *IDF Diabetes Atlas.*

International Diabetes Federation. (2023, setembro 29). 50 days to World Diabetes Day!. IDF.

Lobo, W. de S. & Cazorla, I. M. (2019). Ensino de Estatística e o cuidado com a saúde do adolescente. *Educação Matemática Em Revista*, *1*(20), 120-129.

Milech, A., et al. (2016). Princípios Básicos, Avaliação e Diagnóstico do Diabetes Mellitus. In J. E. P. de Oliveira & S. Vencio (Orgs.) *Diretrizes da Sociedade Brasileira de Diabetes* (pp. 1-122). Rio de Janeiro, RJ: A.C. Farmacêutica.

Moura, A. R. M., Valois, R. S. & Sedano, L. (2019) Análise do enfoque investigativo em atividades experimentais de uma coleção de livros didáticos. *Revista de Educação, Ciências e Matemática, 9*(3), 139-159.

Nascimento, S. P. A., Jerônimo, A. C. & Santos, M. S. S. (2020). Reaproveitando o óleo de cozinha nas aulas de Matemática e de Sociologia: Estudo de caso na perspectiva do ciclo investigativo – PPDAC/Reusing cooking oil in Mathematics and Sociology classes: Case study from the perspective of the investigative cycle – PPDAC. *Brazilian Journal of Development*, *6*(10), 82033–82048.

Pan American Health Organization – Organização Mundial da Saúde. (12 de novembro de 2020). *Diagnóstico e manejo do diabetes tipo 2 (HEARTS-D).* Diabetes - PAHO/WHO | Pan American Health Organization.

Santana, C. V. (2020). *Relações entre variáveis estatísticas na contextualização e apropriação da função afim*. 2020. 164f. Dissertação (Mestrado em Educação Matemática). Universidade Estadual de Santa Cruz. Ilhéus. BA.

Sasseron, L. H. (2018). Ensino de Ciências por Investigação e o desenvolvimento de práticas: uma mirada para a Base Nacional Comum Curricular. *Revista Brasileira de Pesquisa em Educação em Ciências*, *18*(3), 1061–1085.

Sasseron, L. H. (2015). Alfabetização científica, ensino por investigação e argumentação: relações entre ciências da natureza e escola. *Revista Ensaio*, *17*(especial), 49-67.

Shiferaw, W. S., Gatew, A., Afessa, G., Asebu, T., Petrucka, P. M. & Aynalem, Y. A. (2020, outubro). Assessment of knowledge and perceptions towards diabetes mellitus and its associated factors among people in Debre Berhan town, northeast Ethiopia. *PLoS ONE*, 15(10), 1-13.

Simões, M. S. (2023). *Contribuições do Ensino de Estatística na tomada de consciência do risco da Obesidade e do Diabetes.* 2023. 175f. Dissertação (Mestrado em Educação em Ciências e Matemática). Universidade Estadual de Santa Cruz. Ilhéus, BA.

Silva, A. R. V., Zanetti, M. L., Costa e Forti, A., Freitas, R. W. J. F., Hissa, M. N. & Damasceno, M. M. C. (2011). Avaliação de duas intervenções educativas para a prevenção do diabetes mellitus tipo 2 em adolescentes. *Texto Contexto Enfermagem*, *20*(4), 782-787.

Utsumi, M. C., Anjos, E. S. dos & Couto, M. E. S. (2024). Contribuições do letramento estatístico na promoção da Educação para Saúde no Ensino Fundamental. *Ensino Em Re-Vista*, *31*(Contínua), 1–27.

Wild, C. & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*(3), 223-265.

World Obesity Federation - WOF. (2022). *World Obesity Atlas 2022*.