Educação Química em Punto de Vista
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Chemistry teaching for visually impaired students: experimentation with the use of assistive technology

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Ensino de química para alunos com deficiência visual: experimentação com o uso de tecnologia assistiva

Informações do Artigo

Recebido: 01/02/2022

Aceito: 10/12/2022

Palavras-chave:
Formação de professores de química; Experimentação; Tecnologia Assistiva; Deficiência Visual.

Keywords:
Chemistry teacher training; Experimentation; Assistive technology; Visual impairment.

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A B S T R A C T

Learning results both from the teaching environment provided by the teacher and from the effective participation of students in classes. In chemistry teaching, visually impaired students are excluded from experiments due to lack of adequate material and teacher training to work with these specificities. Containing elements of action research, this investigation focuses on the use of assistive technology as a means for the conceptual meaning of these students in an alcoholic distillation class. Data collection took place through the remaining senses and the intervention of the teacher in training contributed to an independent performance of the students in carrying out the experiment. Our results indicate that assistive technology can be an alternative to inclusive experimental classes stimulated by social interaction aiming at the appropriation of knowledge by the student, that is, a mediation instrument as motivating elements for the learning of chemical knowledge.

INTRODUCTION

Learning results both from the type of activities and the environment provided by the teacher and from the effective participation of the apprentice (MANTOAN, 2003). In the teaching of chemistry, surveys (studies) indicate that experimentation plays a key role in stimulating the active participation of students in the interaction between the involved (teacher and students), as well as in enabling the understanding of the construction processes of science and the role of the scientist in an investigative activity (BENITE et al., 2016, 2021; HODSON, 2005, 2009; SOLOMON, 1980).

However, one of the greatest obstacles in conducting experiments for the visually impaired students is that these activities are based on visual observation (BENITE et al., 2013, 2016, 2017). In addition, other obstacles must be considered, such as: the lack of appropriate resources and specific equipment to work with the specificity, accessibility in laboratories and scarcity of information that accentuates the passivity of the student during class.

To include visually impaired students in chemistry lessons, it is necessary to encourage them to perform activities that stimulate research, observation and experimentation so that these students can have the global ideas required to the process of analysis and synthesis (SÁ, CAMPOS and SILVA, 2007). Thus, we argue that it is necessary to overcome the limitation of blindness to participate in experimental classes (MANTOAN, 2003).

Visually impaired students suffer the consequences of misinformation in experimental classes, usually assuming a passive and dependent posture in the manipulation of glassware and equipment and in the interpretation of observable data because these are disregarded in the planning of classes for the lack of adequate material resources and training of teachers to act with these specificities (BENITE et al., 2017).

However, the technological advances of the last decades have allowed the creation of new means of social relations and, in education, new forms of teaching and learning. From an inclusive perspective, technologies have been the subject of current reflections in their use with dimensions focused on "autonomy and development of individuals as subjects of their processes" (GALVÃO FILHO, 2012).

Throughout this development, relationships mediated by the teacher occur through signs and instruments (VYGOTSKY, 1997). The signs are interpretable elements external to the subject that assist in psychological processes as a representation of reality, referring to elements missing from the present space and time.

The instruments are considered elements instituted between the subject and the world, with the goal of expanding the possibilities of transformation and control of nature (OLIVEIRA, 1998). According to Vygotsky (1997), the instruments have a social function for being made for specific purposes.

In this sense, the assistive technology can contribute as a source of accessibility for the impaired, serving as an instrument of mediation for "assigning senses to the phenomena of their surroundings and to social interaction itself" (GALVÃO FILHO, 2012, p.2).

Whereas these interactions are involved in teaching practice, concerns emerge in teachers at all school levels who receive visually impaired students in their classrooms: What are the resources required to teach them? How will students understand the concepts presented by the teacher? Understanding is the appropriation and internalization of information, i.e., each subject has his/her own mental processes that are influenced by culture, context and other subjects.

We base our discourse on Camargo (2010), who states the visually impaired students organize their knowledge and relate as any other individual, once they are presented to the objective world, considering their specificities.

There is no denying the amount of information that can be obtained by sight, as ideas of distance, depth and spatial organization. In an experiment, volume, mass and quantities are considered problematic measures for the visually impaired students, since we use our vision as a tool for measurement; the same occurs with color changes, information provided by analog and digital equipment, some factors that characterize occurrences of chemical reactions, among others. These aspects should be considered as assumptions in the development of activities that contribute to the progress of these students.

In an experiment, the observers always follow the handling of equipment and reagents with images taken through sight; the visually impaired students go through isolated experiences (they hear the gas release, touch the test tube and feel the temperature change in endothermic and exothermic processes, among other essays) hampering the integration of these experiences from practical lessons.

We must recognize the special features present in the classroom (BENITE et al., 2011, 2021). The visually impaired students, in particular, are characterized in function of a reduced visual response, which can be mild, moderate, severe or profound (low vision or subnormal vision) or absence of vision (blindness), due to congenital or hereditary causes (MOSQUEIRA, 2010).

Specifically in relation to the teaching of chemistry to the visually impaired students, we are at an impasse:

> The efforts of teachers to address these students become even more difficult when there are very few studies and materials published on the topic. Currently, there are few accessible materials available to students with visual impairments, especially those related to the teaching of Chemistry. Similarly, there is a gap in initial and continued training of Chemistry teachers referring to the approach to education for students with visual impairment (PIRES,

RAPOSO and MÓL, 2007, p.2).

Considering this impasse, which is noticeable in most cases, chemistry teachers tend to ignore the presence of visually impaired students in their classes (SUPALO, 2005; MELO et al., 2010), since the teaching of chemistry is directly influenced by the visual appeal of the interpretation of charts, drawings, and other molecular structures. Chemical information is expressed by symbols, numbers, formulas, equations, and the communication of them is performed using specific language. Thus, the domain of this language is fundamental to the understanding of chemistry.

Therefore, this study deals with the assessment of the use of assistive technology in experimental classes on alcohol distillation with visually impaired students, aiming at the attribution of meaning from the involvement of teachers in initial and continued formation. We understand assistive technology as a possible instrument for the mediation of visually impaired students in experimental chemistry classes, which have the vision as a means of acquiring information (VYGOTSKY, 1986).

This study was developed in a Public Institution for Support1 to students with visual impairment, which has as a proposal the learning in chemistry classes through investigative experiments based on joint analysis of the data collected by the remaining senses and the handling of different materials.

EXPERIMENTATION FOR VISUALLY IMPAIRED STUDENTS

Distillation is a physical process of the separation of mixtures of liquids or solids based on the difference in boiling temperatures of the substances involved. In this process, the distillate has a different composition from the residual liquid, being volatile in its specific temperature reached during the experiment (SARTORI, et al., 2009). In this study, the simple distillation was made with laboratory material and alternative material (Figure 1 and 2) for the separation of alcohol produced in the fermentation of sugar cane molasses (SUPALO et al., 2008).

[1] In Brazil supporting institutions include special schools that function as training centers and support for regular schools, facilitating the inclusion of students with disabilities in regular classes. This Support Institution is a unit of the State Secretary of Education that provides care to people of all ages and localities of the state. Services oriented activities of daily living aim at more independence for the visually impaired in their actions, such as Braille courses, computer science and mathematics, Portuguese support classes and, through this partnership, chemistry support classes.

Figure 1 - Distiller with laboratory material and voice thermometer.
Fonte: LPEQI/UFG.

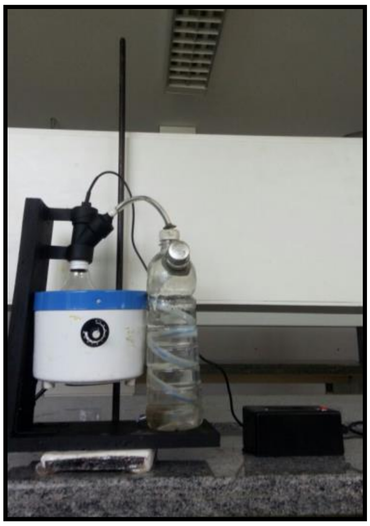

Figure 2 - Distiller with alternative material and voice thermometer.
Fonte: LPEQI/UFG.

The excerpt where the teachers (TCT and TIT) present the distiller with alternative material follows below.

1 – TIT2: *S1, have you ever heard about distillation?*
2 – S1: *Would it be separation, perhaps?*
3 – TCT: *Yes, it is a type of mixture separation.*
5 – TIT1: *Do you have any idea of what composes a distillation device?*
6 – S1: *No.*

7 – TIT1: *We brought a distiller with alternative material. We will put it close to you and then we will do an alcoholic distillation*. (S1 touches the distiller followed by an explanation by TIT1).
8 – TIT1: *This is the condenser, a PET bottle with a hose that enters through the mouth and goes out the bottom, which is perforated and sealed, because between the hose and the wall of the bottle we will put water. Here we have a Y-shaped PVC connection. It connects the bottle to our flask. This is a round-bottomed flask, a light bulb without the insid (a hollowed bulb), and this is where we put our solution, what we want to distill. Do you understand?* (S1 touches each part of the distiller, while TIT1 describes them).
9 – S1: *Yes.*
10 – TIT1: *At the top of the connection, I do not know if you can notice, there is a hole to insert the thermometer.* (S1 touches the connection).
11 – S1: *Right*.
12 – TIT1: *At the end of the condenser hose, there is a beaker to collect the distilled material: ethanol.* (S1 touches the hose at the end of the condenser).

Since one of the ways a visually impaired student obtains information from an object is by touching it, we defend the need for the direct contact of S1 with the experiment equipment. According to Benite and collaborators (2016), laboratories are expensive (areas), equipped with sophisticated instruments, which require technicians to keep them running, and materials must be frequently replaced and renewed. Thus, we support the performance of experiments with alternative materials, in order to provide a discussion on the chemical content from a qualitative analysis, because they do not provide accurate quantitative data.

The equipment consists of an incandescent light bulb replacing the round-bottomed volumetric flask where the mixture or solution is heated, using a heating blanket as source of heat, a PET bottle with an inner spiral hose replacing the condenser and a beaker as a distillate collection container. In the case of a class for visually impaired students, the equipment is adapted by teachers to minimize accidents.

Due to the absence of vision, the teaching process for visually impaired students is done by using Braille for written communication and through the senses (tact, smell, taste and hearing) for gathering information. Being devoid of vision, a useful sense for understanding objects and their spatial position over long distances, S1 relied on tactile observation as an alternative to the understanding of the equipment used in the experiment, which promotes socio-adaptive skills.

Through the sense of touch, S1 explored the surfaces in reach (OCHAITA and ROSA, 1995). According to Grifing and Gerber (GRIFING and GERBER, 1996), the process of tactile development includes the following levels:

1. Consciousness of tactile ability, with the movement of the hands, the visually impaired student perceives textures, temperatures, and consistencies, among other features. In this way, the TIT allowed S1 to understand the contours, sizes and weights, initially with more abrupt movements, and then with more detailed movements of the objects to be exploited;

2. Recognition of the structure and relationship of the parties as a whole – is the ability of a visually impaired student to distinguish the object and discriminate it and then understand the interrelationship. This was one of the goals of the teachers, to allow S1 to understand the structure of the distilling equipment, touching the parts to understand the whole;

3. Understanding graphic representations – is the familiarization with geometric shapes (two- and three-dimensional) of various sizes, allowing the student to relate real objects and their representations, i.e., so S1 could understand the path of ethanol through the distiller; for that, the student should first construct a mental representation of the equipment;

4. Use of symbols – is the signification of the original object by means of symbols; one example is the Braille system in which the visually impaired student must memorize the various settings of the six points of the cells in a progressive movement from left to right, recognizing the symbols with the right hand and discriminating them with the left hand. In this way, the distiller has been prepared so that S1 could understand its extension, building a mental image of the distillers from touch, in sequence.

We argue that learning chemistry is not only visual. We base this statement on Lowenfeld (1971) to assert that the visually impaired students react with all senses to stimuli received from the environment; however, it is only through the sense of touch that they acquire real knowledge of the objects around them (shape, size, hardness, etc.) and the greatest source of descriptive information is hearing (presence, location or condition of the objects), where the teacher is a first order actor.

Following the mediation process, in the next extract the TIT explains how alcoholic distillation happens.

13 - S1: *What will the alcohol be distilled from?*
14 - TIT1: *It will be distilled from crushed sugar cane mash.*
23 - S1: *What is mash?*
24 - TIT1: *It is the fermented broth of sugar cane; we put in yeast used to make bread*. (TIT1 puts S1’s hand on the lamp used as a counter).
20 - TIT1: *Then we will carry on the alcoholic distillation to introduce the contents of the organic function of alcohol. OK?*
25 - S1: *Yes, but how does it work?*

26 - TIT1: *We put the mash in the flask to distill it. Since it is alternative equipment with no precision, it will not be only alcohol; there will be other compounds with near boiling temperature.*

According to Vygotsky (1978), the relationship of the individual with the world can be direct or mediated. Direct relationships are those in which the individual has direct contact with the object, where the individual is responsible for collecting and interpreting the information acquired by means of the senses.

Mediation is every relationship in which the terms always interact with the intervention of a third element. In this investigation, the third element, the teacher, played the role of mediator between the chemical content of the distillation and S1 using experimentation with alternative material as a means of accessing knowledge.

From a cultural perspective, we advocate that education is understood as a practice in which the teacher is the mediator of the processes constituted by language, i.e. the teacher allows the students to undergo elaborate interactive knowledge on objects in the world, mediating this process (VYGOTSKY, 1997).

Thus, we argue that the training courses of chemistry teachers should (re)organize their curricula, predicting disciplines dealing with studies on “the professionalization of the teaching function, the nature of scientific knowledge, the role of experimentation in teaching, the role of science and science education in society, the fundamentals of curriculum development” (ECHEVERRÍA, BENITE and SOARES, 2010, p.3); however, from an inclusive perspective, since the right to education is guaranteed according to the Universal Declaration of Human Rights (ONU, 1948), independent of the intellectual, physical, social, emotional or linguistic conditions of the individual.

Based on Vygotsky (1997), we assume that the teacher has an essential function of intervention in the zone of proximal development of apprentices, by generating advances that would not happen naturally. According to Oliveira (1998), Vygotsky defines the zone of proximal development as:

> The distance between the actual developmental level, which is usually determined by the independent solution of problems, and the level of potential development, determined through problem solving under adult guidance or in collaboration with more capable companions (p.97).

However, for the teacher to intervene in the zone of proximal development of students with procedures that are regular in school, such as providing demonstrations, assistance, instructions and clues, three types of knowledge are required: content, curriculum and pedagogical content (SHULMAN, 1987). Content knowledge is that in which the professor is a specialist; in the case of this study, chemical knowledge about the distillation process.

Curriculum knowledge is the set of contents and its relationships to attend the objectives of each level of education; it is the relationship between the experiment of alcoholic distillation and the teaching of the organic function alcohol.

The pedagogical knowledge of content is what allows the teacher to identify learning difficulties and conceptual relations that should be made by each student. The pedagogical knowledge of content enables teachers to understand that "science is a symbolic production, and learning science means that the student must assign meaning to the language of scientific culture" (ECHEVERRÍA, BENITE and SOARES, 2010, p.5).

In this class, the experiment with alternative materials common to everyday life and the adapted equipment were didactic-pedagogical resources designed by teachers, aimed at the customized learning of chemistry by S1, considering the specificity in the objectives outlined in the school curriculum.

Based on Vygotsky (1978), we state that the teachers provided S1 with resources that contributed to the increase in the level of knowledge, who would not be able to accomplish this alone, participating in the experiment through touch and hearing (mediation by TIT) more efficiently, optimizing the learning process.

In the following excerpt, TIT instructs S1 to use the adapted test tube to measure the volume of mash to be distilled and to control the boiling temperature of ethanol through a voice thermometer.

> 36 - TIT1: You will measure the volume of the concentrated mash with a 100 mL adapted test tube. As the tip goes down, the volume increases.
> 37 - S1: It is like a float?
> 42 - TIT1: Yes! This is the mash. Place the funnel to transfer, you will measure 20 mL. (S1 transfers the mash and checks the volume by touching the device).
> 45 - S1: Ten, fifteen, twenty mL.
> 50 -TIT1: Transfer the mash to the flask.
> 51- S1: Why did the tip go down the test tube, from that position to this one? (S1 refers to the tip that marks the volume in the test tube).
> 52-TIT1: Because you have placed the mash in it, the float goes up and the tip goes down, showing the volume occupied inside the test tube.
> 57-S1: Got it! When the float goes down, the tip goes up.
> 58-TIT1: This means the volume is zero. When I transfer the liquid, the float goes up and the tip goes down, showing the volume inside the test tube.
> 59-S1: Got it. So it measures backwards.

62-TIT 1: Yes! Let's put the flask in the distiller? (S1 feels the equipment and connects the flask to the distiller).

Learning is a social process and interaction goes beyond communication between teacher and student, it is constructed from the environment in which it occurs, including strategies, information, problems (VYGOTSKY, 1978), organized from the pedagogical knowledge of content apprehended by the teacher during training.

Currently, classrooms are increasingly being diversified, making professors search for features that meet the specific educational requirements of students, aimed at knowledge construction and skill development for an active and autonomous participation in class, in this case, the participation of S1 in the experiment.

From an inclusive perspective, technologies have been the subject of current reflections about their use with dimensions focused on "autonomy and development of individuals as subjects of their own processes" (GALVÃO FILHO, 2012).

Throughout this development, relationships mediated by the teacher occur through signs and instruments (VYGOTSKY, 1997). The signs are interpretable elements external to the subject that assist in psychological processes as a representation of reality, referring to missing elements of space and time. On the other hand, the instruments are considered elements interposed between the subject and the world, with the goal of expanding the possibilities of transformation and control of nature (OLIVEIRA, 1998).

According to Vygotsky (1997), the instruments have a social purpose for being made for specific purposes. In this sense, assistive technology can contribute as a resource of accessibility for people with disabilities, serving as an instrument of mediation for the "assignment of senses to the phenomena of the surroundings and to social interaction itself" (GALVÃO FILHO, 2012, p.5).

We understand assistive technology as a possible tool of mediation for the visually impaired students in experimental chemistry lessons, which features vision as a means of acquiring information (VYGOTSKY, 1997). We also understand assistive technology as the studies involving the development of products, resources, methodologies, strategies, practices and services aimed at the active participation of people with disabilities to improve their autonomy, independence and quality of life (BRASIL, 2005).

The test tube (Figure 3) used to measure the volume of mash to be distilled was constructed with a float system, and the volume, from 0 to 1oo mL, is marked in high relief, measured by S1 in the opposite direction to that of conventional test tubes: from top to bottom (BENITE et al., 2013).

Figure 3 - Test tube adapted to visually impaired students in experimental classes.
Fonte: LPEQI/UFG.

In this sense, we consider the test tube an instrument of mediation for teachers, allowing the students to be the subjects in the process of learning from the potentiation of their interaction with the experiment, as understood by S1 while measuring the volume in the adapted test tube of the lines 42 to 59, boosting the development and autonomy (GALVÃO FILHO, 2012).

The voice thermometer (TOMBAUGH, 1981) served as an instrument for the control of the variable of the phenomenon – temperature. Built in the Assistive Technology Center of the Laboratório de Pesquisas em Educação Química e Inclusão (LPEQI), the voice thermometer allows visually impaired students to monitor temperature variations that occur in experiments, such as the identification of the boiling point of ethanol by S1. The following excerpt highlights the use of vocal thermometer.

68 - TIT1: *Do you know what boiling point means*?
69 - S1: *Is it the temperature at which the liquid evaporates*?
76 - TIT1: *Yes! In the case of ethanol, the boiling point is approximately 78ºC in the city of Goiânia*.
78 - S1: *And how will we know this temperature?* (S1 touches the thermometer).
80 - TIT1: *This is our vocal thermometer in Celsius degrees. If you push this button, it will tell you the temperature in Portuguese and English.* (S1 pushes the button).
81 - Thermometer: *26 Celsius degrees* (Room temperature at that time).
82 - TIT1: *During the heating process, you will verify the temperature. When the ethanol starts to condense, I will tell you.*

86 - S1: *So, the ethanol will boil in the flask and evaporate. The vapor will pass through the hose and fall into the beaker*.
87 - TIT2: *When will the ethanol start evaporating*?
88 - S1: *When it is at approximately 78ºC*.
89 - TIT2: *What temperature is this?*
90 - A1: *Boiling temperature*.
91- TIT2: *Push the button so we know the temperature.*
92 - Thermometer: *62 degrees.*
111- TIT2: *It is already condensing*. (S1 verifies the temperature)
112 - Thermometer: *79 degrees.*
118 - ST: *Do you sense the smell of alcohol?*
119 - S1: *I do*.

The need for vision in material handling and interpretation of phenomena during and experiment and the lack of stimuli of a large part of the teachers in teaching content for visually impaired students generate a passive posture in these students when facing the educational reality. Opposed to that situation, we agree with Suart, Marcondes and Lamas (2010) whose experiments in the teaching of chemistry contribute(d) to the development of cognitive skills that allow students to identify variables, elaborate hypothesis and choose indispensable information for the solution of the investigative problem, converging to the development of logical reasoning of the apprentices, aimed at the learning of content.

Thus, when stimulated by teachers, the limitations of visually impaired students may become a motivational element in the search of alternatives in the performance of these activities (VYGOTSKY, 1997). In this investigation, we argue that S1 was able to be an active subject in the appropriation of knowledge, experimenting “conditions and situations in which the student may, through his/her own interests and the specific knowledge he/she already carries, exercises his/her capacity of thinking, comparing, formulating and testing hypothesis, relating contents and concepts” (GALVÃO FILHO, 2012, p.11).

In the vocal thermometer, the choice of hardware and software for its construction was based on the needs of the group researched (SUPALO et al., 2009): the temperature is communicated by the device through sound (Figure 4). The equipment has dimensions of 12cmx8cmx5cm, with command buttons (on-off, measure, reset and instructions, presented in Braille) and two cables, a power supply and another containing a temperature sensor (BENITE et al., 2016; BENITE et al., 2017).

Figure 4 - Voice thermometer for experimental classes.
Fonte: LPEQI/UFG.

As instruments of mediation for visually impaired students, the test tube (through touch) and the thermometer (through hearing) allowed S1 to take an active role in the experiment, measuring the volume of the mash and, with the mediation of TIT, the student transferred the liquid to the flask by connecting the equipment to perform the distillation, controlling its temperature.

Such performance refutes the passive and dependent postures in these activities, opposing the “significant limitations in their ability to interact with the environment” (GALVÃO FILHO, 2012, p.117). The instruments have allowed S1 to assign meaning to the phenomenological aspects of the experiment with the intervention of TIT, overcoming the barriers of the disability and the obstacles arising from science itself, which uses vision as the most important means of collecting data from the experiments, promoting the development of students.

Both tools, test tube and thermometer, were developed in the LPEQI, as means of approximation between university, school and society through actions and considerations concerning teacher training for the inclusion in the field of experimentation in the teaching of chemistry.

The vocal thermometer served as an instrument of mediation, a mediating element used by teachers between S1 and the chemical phenomenon, created with the specific purpose of measuring and controlling temperature for visually impaired students, i.e. external stimulus driven by social interaction. In this way, assistive technology served as an instrument of mediation, that is, catalyzing and stimulating educational strategies of teachers in training and of learning for S1, enabling new ways of interaction with chemical knowledge from the tools adapted to the specificity.

CONCLUSION

Currently, there is an increasing demand for professionals able to meet new requirements, aimed at decreasing school evasion and failure. Therefore, it is fundamental that degree courses provide training and research spaces aimed at the development of privileged interventions and pedagogical processes, focusing on the promotion of development of the subjects involved through the appropriation of the necessary knowledge for their constitution and action.

The intervention of the teacher in the classroom in an inclusive perspective reinstates the question: What strategies can be considered for promoting learning, according to the specificities found? Visually impaired students present limitations in their ability to interact in experiments, as this practice uses sight as a means of acquiring information on the phenomenon to be treated theoretically. In this investigation, the use of assistive technology allowed TIT to reach the educational objectives of the experiments, allowing S1 to handle and control the events in an investigative way, contributing to the development of skills that are necessary for creative research, attributing meanings to data observed by touch and by hearing through the interaction mediated by the teacher in training.

However, the difficulties faced in carrying out this study triggers the alert regarding the need to (re)think educational public policies aimed at inclusion that in the last government suffered so much attacks and setbacks and the incentive to launch public notices to promote research aimed at the training of teachers who work within the scope of school inclusion and the development of assistive technology aimed at access and permanence of students with disabilities or special educational needs in Science/Chemistry classes and other areas, both in basic and higher education, with equity and quality teaching.

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RESUMO

A aprendizagem resulta tanto do ambiente de ensino proporcionado pelo professor como da participação efetiva dos alunos nas aulas. No ensino de química, alunos com deficiência visual são excluidos dos experimentos por falta de material adequado e formação de professores para trabalhar com essas especificidades. Contendo elementos da pesquisa-ação, esta investigação tem como foco o uso de tecnologia assistiva como meio para a significação conceitual desses alunos em uma aula de destilação alcoólica. A coleta de dados ocorreu por meio dos sentidos remanecentes e a intervenção do professor em formação contribuiu para uma atuação independente dos alunos na realização do experimento. Nossos resultados indicam que a tecnologia assistiva pode ser uma alternativa às aulas experimentais inclusivas, estimulada pela interação social, visando a apropriação do conhecimento pelo aluno, ou seja, instrumento de mediação como elementos motivadores ao aprendizado do conhecimento químico.

Palavras-chave: Formação de professores de química; Experimentação; Tecnologia Assistiva; Deficiência Visual.

RESUMEN

El aprendizaje resulta tanto del ambiente de enseñanza proporcionado por el docente como de la participación efectiva de los estudiantes en las clases. En la enseñanza de la química, los estudiantes con deficiencias visuales son excluidos de los experimentos por falta de material adecuado y de formación docente para trabajar con estas especificidades. Con elementos de investigación-acción, esta investigación se enfoca en el uso de tecnología de asistencia como medio para el significado conceptual de estos estudiantes en una clase de destilación alcohólica. La recolección de datos se realizó a través de los restantes sentidos y la intervención del docente en formación contribuyó a una actuación independiente de los estudiantes en la realización del experimento. Nuestros resultados indican que la tecnología asistiva puede ser una alternativa a las clases experimentales inclusivas, estimuladas por la interacción social, visando la apropiación del conocimiento por parte del alumno, o sea, un instrumento de mediación como elementos motivadores para el aprendizaje de los saberes químicos.

Palabras clave: Formación de profesores de química; Experimentación; Tecnología de asistencia; Discapacidad visual.