JOURNAL OF CHEMICAL EDUCATION

Article

pubs.acs.org/jchemeduc

Promoting Inclusive Chemistry Teaching by Developing an Accessible Thermometer for Students with Visual Disabilities

Felipe A. Vitoriano,[†] Vânia L. G. Teles,[*,‡] Ivanise M. Rizzatti,[‡] and Régia C. Pesssoa de Lima[‡]

[†]Control and Automation Engineering, Federal University of Minas Gerais, Belo Horizonte-MG 31270-901, Brazil

[‡]Roraima State University, Boa Vista-RR 69306-530, Brazil

ABSTRACT: This work discusses the construction and evaluation of a digital thermometer especially designed to be operated by people with visual disabilities. The accessibility thermometer can be used as an educational tool in practical activities in classes for sighted and visually impaired students, with the aim of helping those with special needs gain better access to the scientific world. The thermometer measuring scale ranges from −15 °C up to 115 °C, and the temperature is informed through beeps and vibration pulses similar to Morse code. Two thermometers were used to calibrate the constructed instrument, a LM35 sensor and a 7mercury thermometer; good agreement between the measured temperatures was shown through a linear correlation of 0.9997 with the LM35 sensor. Tests carried out with blind students show that this instrument could be an important tool in helping them to better understand the proper scientific concept of temperature. Besides being low cost, the device is user-friendly and provides quick response and good reproducibility.

KEYWORDS: *High School/Introductory Chemistry, Hands-On Learning/Manipulatives, Laboratory Equipment/Apparatus, Student-Centered Learning*

■ INTRODUCTION

Inclusion of students with disabilities in regular education is of main concern in modern societies, especially because it affects positively their cultural and development levels.[1] The United Nations, through the Convention on the Rights of Persons with Disabilities (CRPD), recognizes the importance of including disabled persons in education.[2] In Brazil, inclusion of students with different disabilities is established in national law no. 9394, "Guidelines and Bases of National Education" (Diretrizes e Bases da Educação Nacional).[3] Preparation of students for a productive life in society, including those with disabilities, is one of the goals of Brazilian law, and skilled teachers, with disposition to deal with the different needs of the students, are a key factor to success.

According to Brazilian Institute of Geography and Statistics (IBGE), there are in Brazil 45 million persons with disabilities, and each year the number of students with different disabilities, enrolled in conventional classes in regular schools, has increased considerably, as an evaluation carried out by INEP (National Institute for Educational Studies and Research "Anísio Teixeira"), for the period between 2007 and 2012, shows.[4,5] Therefore, concerns regarding disabled students have increased, not only related to the appropriate physical environment but especially regarding the understanding of and the respect for their abilities. It is of great importance to recognize that if an individual has limitations it does not mean that he/she is not committed to or is unable to learn. That could be the starting point on reflecting about how to handle differences and meet the basic needs and the inclusion in a social environment.[6] From the perspective of Tiballi, there should be an "inclusive education" not because there are excluded students at school but rather because there are people with different learning skills, and teachers must be prepared to face this diversity.[7]

Democratization of science has an important outcome, that is the study of chemistry that stimulates the students to develop a critical view of reality and be able to use their acquired knowledge in everyday life and to analyze different situations and decide what is relevant for a better quality of life.[8] Since the teaching of chemistry is a representative approach to macroscopic and microscopic phenomena, experimental activities combined with the use of technologies can be excellent tools during experimental classes, promoting opportunities for questions, revealing hypotheses, and guiding the teaching−learning process. Especially for students with visual impairment, such resources give them the opportunity to develop activities in a creative way, related to solutions for daily life problems. Visual observations and representations, usually part of the chemistry teaching, must be translated into a language understandable to blind students, so they can grasp the concepts and demonstrate or discuss ideas in a satisfying way.[9] According to Riendl and Haworth "the chemistry teacher should view the mildly disabled not only as being able to learn chemistry, but also as valuable candidates for entry into the science professions".[10]

Received: March 1, 2016
Revised: September 23, 2016

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX

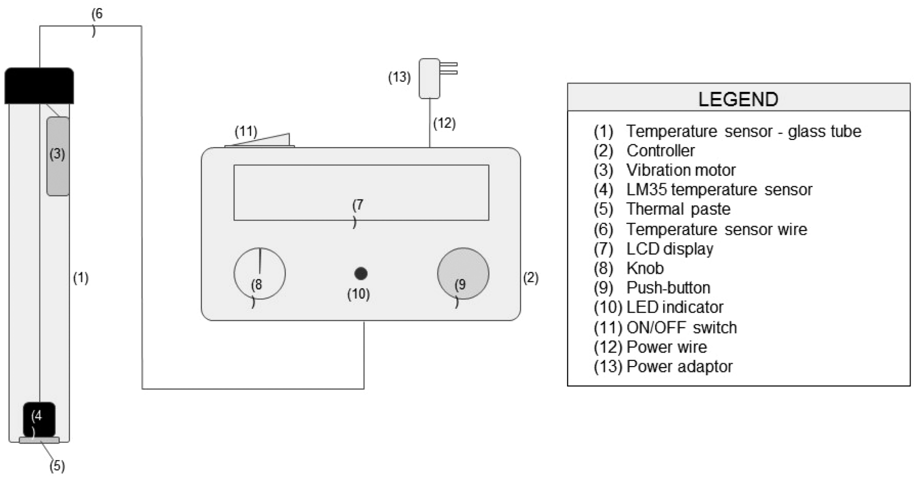

Figure 1. Accessibility thermometer diagram.

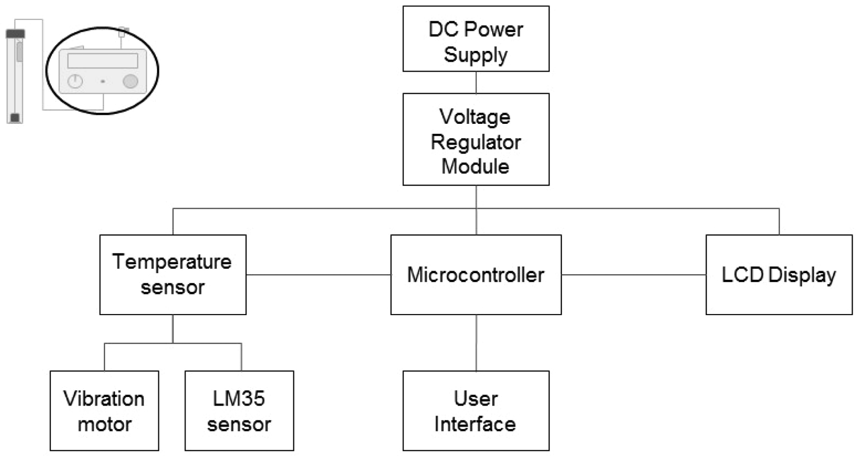

Figure 2. Accessibility thermometer controller—simplified diagram.

Several articles have stressed the importance of making science learning accessible to those with visual impairment, elaborating different means of communication: audio, written, and tactile representations,[9,11,12] and also laboratory adaptations.[13−16] Supalo developed the "Talking LabQuest" equipment for blind/visually impaired students, which also enables temperature measurements, and it is already commercially available.[17,18] Pires, Raposo, and Mól[19] proposed the adaptation and description of a Chemistry textbook, with images, graphics, tables, and chemical representations in braille to be used in a training course for teachers, aiming at the learning of visually impaired students. In recent years Pereira and co-workers, made a significant contribution in the field of inclusive teaching. After making available a web portal to collect important information regarding the teaching of chemistry to blind/visually impaired students,[20] they released free software, NavMol, allowing drawing, interpretation, and editing of molecular structures.[21] Also, a protocol for the sonification of infrared spectra was developed, making it possible for students of chemistry to interpret graphical data.[22] Additionally, Neely[23] highlights that technology and other assistive strategies can make it possible for students with several disabilities, including low vision and total blindness, to perform lab tasks in experimental chemistry classes.

Based on the previous considerations, this paper reports the construction and evaluation of a digital thermometer, an easy-to-handle teaching tool accessible to visually impaired students, aiming to address a current need, the teaching of disabled people, whose number in regular schools increases each year, enabling them access to the scientific world. The device is suitable for temperature measurements in degrees Celsius, emitting sounds and vibration pulses similar to Morse code, with a measuring scale ranging from −15 °C up to 115 °C. This thermometer will give the students the opportunity to participate actively in the acquiring knowledge process, since they will be able to identify the variables and formulate their own hypothesis about the scientific conception of temperature.

■ METHODOLOGY

Accessibility Thermometer Construction and Calibration

The accessibility thermometer is composed of a dual (100−240 V) power source, a controller, and a temperature sensor (Figure 1). Each of these components can be constructed with components easily acquired in an electronic supply store.

The controller is made-up of an ATMEGA328 microcontroller chip, a LCD display size 16 × 2, a potentiometer, a RGB LED indicator light, a push button, a switch, and plugs for the sensor cable and power supply. The controller circuit was built on a board using one 16 MHz crystal oscillator, two 22 nF ceramic capacitors, one 330uF/16 V electrolytic capacitor, two 10*k*/0.25 W resistors, one 150*R*/0.25 W resistor, three 1*k*/0.25

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX

W resistors, one BC548 transistor, one 1N4148 diode, one RGB LED, one 100k linear potentiometer, one RJ11 female plug, one 5 V buzzer, one LM7805 voltage regulator, one P4 jack, one PCB board, wires, and connectors. Figure 2 presents a simplified diagram of the accessibility thermometer controller.

The code running in the controller was written in the C algorithm; this programming language performs all processes related to the device operation. Data are processed by the controller device (Figure 3). This component is also used to operate and set the instrument, displaying the acquired information on its screen. So, initial instructions are necessary to prepare the visually impaired student on how to set up the instrument.

Figure 3. Accessibility thermometer controller.

Two operating modes (named "set point" and "numeric indicator") are available when working with the accessibility thermometer device, depending on the preferences and/or the type of measurement. The first mode (set point) allows temperature measurements of a medium within a range chosen by the user. The device emits beeps and a vibration alarm when the temperature measured is within the chosen range and also the numerical value is displayed on the screen. In the second mode (numeric indicator), the instrument measures the actual temperature and the corresponding information is delivered through sounds and vibration pulses similar to Morse code. So, after the equilibrium and temperature measurement, the device sounds and vibrates synchronously and the number of beeps and pulses corresponds to the numerical value temperature.

The temperature sensor (Figure 4) was built using a glass tube with a plastic cap, a LM35 temperature sensor, 1 m length 4-way cable, a RJ11 male plug, and a vibrating DC motor (used in mobile phones). The elements used in the construction of the sensor are arranged in the glass tube as follows: the LM35 temperature sensor, connected to thermally insulated wires, placed on the glass tube bottom upon a layer of thermal paste, to increase the heat transfer between the sensor and the glass wall, and the vibration motor on the upper part of the glass tube, also connected to the wire of the four-way cable. The bottom part of the temperature sensor must be immersed into the medium whose temperature is to be measured.

Figure 4. Temperature sensor.

A user's guide, describing the components of the instrument, sensor, and controller, operating modes, and instructions for use, was also elaborated. Practical examples were included to make it easier to understand its operation.

A LM35 temperature sensor (connected to an Arduino board) and a calibrated mercury thermometer were used to calibrate the accessibility thermometer. The three thermometers were placed into a beaker containing water and fixed one next to the other. The accessibility thermometer was set on "Numeric Display" operation mode. The Arduino was connected to a computer to show on the monitor the temperature measured by the LM35 sensor. The maximum difference between the thermometer measurements had been recorded. As the calibration started, the water temperature was gradually increased while stirring. The temperatures displayed by the three devices (accessibility thermometer, independent LM35, and mercury thermometer) were measured within a range from 0 up to 100 °C. After that, graphics were plotted correlating the values measured by the accessibility thermom-

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX

eter instrument and the reference thermometers. The accessibility thermometer calibration was carried out using the plot with the best coefficient correlation.

Accessibility Thermometer Evaluation by Students with Visual Disabilities

In order to evaluate the accessibility thermometer, tests were executed with four undergraduate students of a chemistry course at the State University of Roraima, wearing blindfolds. After that, tests were performed with three visually impaired students from public high schools in the city of Boa Vista-RR attending the first semester of 2015. One of these three students has low vision, and the two others have developed blindness. Student A is enrolled in the third year of high school, and student B is in the last year of middle school. Both students A and B are from the same school, and they are enrolled in a program for youth and adult education (Educação de Jovens e Adultos, EJA). Student C attends the first year of regular high school at a different institute. All of them spontaneously agreed to participate in these tests.

First, an introductory and informal presentation was given to make the volunteer students feel comfortable and confident in performing the tasks. Following that, the students were allowed to handle the accessibility thermometer in order to become familiar with the different components of the instrument. “Numeric mode” was used for temperature measurements, which took approximately 10 min to ensure that the thermal equilibrium was achieved. Then, the students performed tests using the accessibility thermometer instrument to measure the temperature of water at cold and room temperatures. All procedures were carried out taking into account the operator safety and the functionality of thermometer operation. After the tests the students were requested to answer a three question quiz to evaluate the accessibility thermometer instrument.

■ RESULTS AND DISCUSSION

Accessibility Thermometer Construction and Calibration

In order to ensure the accuracy of the measurements, the calibration of the temperature sensor must be performed, which can be achieved through absolute or comparative methods.[24] For accessibility thermometer calibration a comparative method was used, correcting the obtained values in comparison with those from the two other well-calibrated thermometers (a standard LM35 sensor and a factory-calibrated mercury thermometer brand INCOTERM). The two reference thermometers and the temperature sensor were directly, entirely immersed in water. The calibration data obtained through linear regression (least-squares method) are shown in Table 1.

The temperature values measured by the constructed instrument, the accessibility thermometer, were very close to those of the reference thermometers, showing good performance of the instrument. Since the results for the plot with the LM35 thermometer were better, the accessibility thermometer calibration was performed using this fit.

Table 1. Accessibility Thermometer Calibration Data Obtained Using the Least Squares Method

Coefficients	Accessibility Thermometer versus Sensor LM35	Accessibility Thermometer versus Mercury Thermometer
slope	1.0541	1.0472
linear	0.284	0.3708
correlation	0.9997	0.9798

Since with usage any measuring instrument is subject to deviations, the accessibility thermometer also requires calibration after some time of use. This can be performed using the calibration curve inserted in the program of the instrument in order to ensure its reliability. A great advantage of inserting this calibration curve in the device’s internal program is the possibility of carrying out the calibration with no need for further measurements using a reference thermometer each time. The calibration can be performed by simply accessing the “calibration mode” of the device settings, and the instrument will be ready to execute the measurement of temperature.

The temperature sensor was evaluated regarding the time for the system to achieve thermal equilibrium when introduced in a new medium, and it was found that about 10 min is required. Considering that, in both instruments, the accessibility thermometer and the reference thermometer, the same sensor LM35 is used, the difference between the two instruments lies in the time required to reach the new equilibrium, since the accessibility thermometer sensor is inside a glass tube, upon thermal paste, and surrounded by air.

Accessibility Thermometer Evaluation by Students with Visual Disabilities

Blind students who are already engaged in inclusion processes, attending regular classes, report about their difficulties in experimental activities mainly because of the lack of instruments adapted to their needs. This highlights the importance of developing materials and instruments making it possible for these students to understand scientific concepts. Experimental activities in science education have an important purpose to motivate students, encouraging their interest to develop scientific attitudes, according to Hodson.[25] Since practical activities should be proposed considering the differences and difficulties of the students, even for regular classes, when implementing educational inclusion, it is even more important to bear in mind the limitations of disabled students, such as those with visual impairment.

Regarding the concept of temperature, the students participating in the evaluation of the accessibility thermometer instruments were not able to demonstrate that they clearly understand this conception, rather they related it with the sense of hot and cold. However, this association is made based on common sense, which could enable the students to make a distinction between bodies at different temperatures and even guide them through the learning process, but it could create epistemological obstacles making it difficult to understand the scientific concept of temperature, as stated by Mortimer and Amaral.[26]

Previously the experiments with visually impaired, undergraduate students of a chemistry course for teachers, wearing blindfolds, conducted tests to evaluate the thermometer. According to their opinion, this was a thrilling experience and the proposal of this instrument was very satisfactory and effective for temperature measurements.

As part of the evaluation, each visually impaired student was allowed to touch and handle all components of the Accessibility Thermometer, shown in Figure 5, to become familiar with the instrument. The first observation made by student B, at the very moment he touched the thermometer, was “it is made-up of glass”. As discussed by Neto,[16] acquiring of information by blind individuals is achieved through combined sensations, such

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX

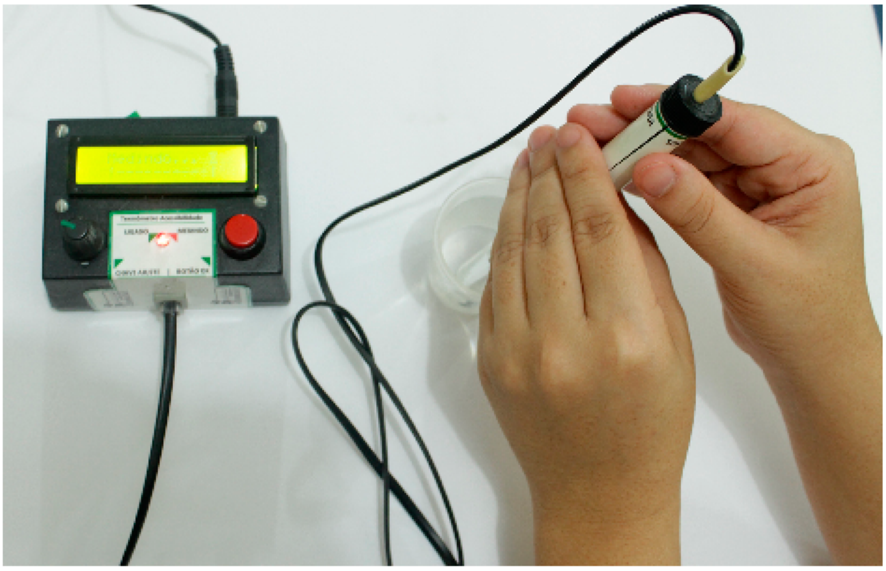

Figure 5. Student with visual disabilities operating the accessibility thermometer.

as tactile, kinetic, and auditory, linked to criteria formed throughout previous experiences. Also, according to the author, besides training the other senses, that allow them to acquire new knowledge, visually impaired individuals also associate information they obtain from listening to sighted people to build up new criteria and to get their own understanding of the world.

Once they acquired familiarity with the instrument, the students executed the tests of temperature measurement. Two of them, students B and C, were well focused and they had no difficulties in handling all the components of the accessibility thermometer. It was also easy for them to associate the beeps and vibration pulses to the values of temperature with no need of repeating the measurements. However, student C was not well focused, and it was necessary for him to repeat the tests several times to get the right measured temperature. He reported his difficulties in counting the beeps and vibration pulses. This difficulty may be associated with hearing deficit or because he was anxious and excited in participating in new and different activities. He complained that in his regular classes he has only a small participation and does not receive much attention from his teachers, not even participating in experimental classes. About his experience using the accessibility thermometer he said “It is very interesting, I just need more practice”. According to Nunes and Lomônaco,[27] due to the little knowledge about the learning skills of visually impaired students, teachers usually have low expectations toward them, so they underestimate the value of alternative pedagogical proposals, adopting strategies that are benefial only for sighted students. In doing so, many teachers display a complete refusal, in the face of the current reality of including disabled students, to address their limitations and explore their potential.

The response of the students to the use of the accessibility thermometer was very positive. In their opinion, the instrument is innovative and promising and its use in practical chemistry classes is important to make it easier to understand the subject proposed by the teacher. Based on the response of the students and their enthusiastic reaction when handling the accessibility thermometer, it is clear that the use of this instrument proved to be effective in its purpose. Considering that the design behind the development of this instrument is not only to meet the needs of visually impaired students but also that it aims at their inclusion in regular classes, promoting respect for diversity and the full participation of all those involved, the accessibility thermometer is a helpful tool for teachers committed to educational impartiality and quality.

The accessibility thermometer is suitable and useful in all experimental classes where temperature parameter measurement and control are required, such as chemistry, biology, and physics, in basic education, high school, and graduation courses and is especially beneficial in training courses for science teachers. Considering the scarcity of research related to chemistry teaching, especially regarding the development of new instruments and adaptation of experiments aiming at the inclusion of those with special needs, promoting their participation throughout the teaching−learning process, the accessibility thermometer can be an effective, inventive, and low cost tool (approximately US$ 40 in 2016).

■ FINAL CONSIDERATIONS

Inclusion of students with disabilities in the regular education system is a requirement of the Brazilian Ministry of Education through the guideline National Curriculum Parameters. However, very little has been done within the scientific education area to achieve that claim of the population, and there are only few practical actions enabling disabled students to have a meaningful participation in experimental classes. As an example, one can mention the lack of laboratory instruments and adapted experiments for those with special needs.

The availability of a thermometer as an educational tool applicable to classes in which blind, deaf, and sighted students can participate all together, since the instrument provides information through beep sounds, vibration pulses, and on a screen, can offer additional learning opportunities to all those involved in the process. Besides the accessibility thermometer’s applicability regarding experiences involving temperature measurements, it was designed considering that individuals have different needs and skills.

According to the evaluation of the students, the thermometer is an innovative and promising instrument to be used in experimental classes of chemistry, because, through tactile and

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX

auditory senses, they were able to be active in the processes of discovering the scientific concept of temperature.

The accessibility thermometer is a low-cost and easy-to-use piece of equipment, with fast response and good repeatability and reproducibility, and it will be very useful in helping the students to acquire scientific concepts, such as temperature. Of course, some adjustments are still necessary, but certainly, it will give the disabled students more independence and the opportunity to be more involved in and committed to their own education.

AUTHOR INFORMATION

Corresponding Author

*E-mail: vaniateles@uerr.edu.br.

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

The authors are thankful the student participation and contributions. The authors are also thankful to PIBID/CAPES for financial support.

REFERENCES

(1) Hanková, M.; Vávrová, S. Emotional and Social Needs of Integrated Disabled Students in Secondary School Environment. *Procedia Soc. Behav. Sci.* **2016**, *217*, 229−238.

(2) Convention on the Rights of Persons with Disabilities and Optional Protocol. http://www.un.org/disabilities/documents/convention/convoptprot-e.pdf (accessed Sep 2016).

(3) Brasil. Ministério da Educação. Proposta de diretrizes para a formação inicial de professores da educação básica em cursos de nível superior. Brasília: Ministério da Educação, 2000.

(4) IBGE. Censo Demográfico 2010: Características gerais da população, religião e pessoas com deficiência 2010. http://www.ibge.gov.br/home/estatistica/populacao/censo2010/caracteristicas_religiao_deficiencia/caracteristicas_religiao_deficiencia_tab_pdf.shtm (accessed Jul 2015).

(5) BRASIL. Ministério da Educação e Cultura. Secretaria de Educação Especial. Dados da Educação Especial no Brasil. MEC/INEP, Brasília, 2006. http://download.inep.gov.br/educacao_basica/censo_escolar/resumos_tecnicos/resumo_tecnico_censo_educacao_basica_2012.pdf (accessed Jul 2015).

(6) Silva, F. C. Inclusão, educação e aprendizagem. EDURJ: Rio de Janeiro, 2001.

(7) Tiballi, E. F. A. Estratégias de inclusão frente à diversidade social e cultural na escola. In Lisita, V. M. S. S.; Sousa, L. F. E. C. P. (Orgs.). Políticas educacionais, práticas escolares e alternativas de inclusão escolar. DP&A: Rio de Janeiro, 2003, pp 195−208.

(8) Cachapuz, A.; Gil-Perez, D.; Carvalho, A. M. P.; Praia, J.; Vilches, A. (Orgs.). A necessária renovação do ensino de ciências. Cortez: São Paulo, 2005.

(9) Miecznikowski, J. R.; Guberman-Pfeffer, M. J.; Butrick, E. E.; Colangelo, J. A.; Donaruma, C. E. Adapting Advanced Inorganic Chemistry Lecture and Laboratory Instruction for a Legally Blind Student. *J. Chem. Educ.* **2015**, *92*, 1344−1352.

(10) Riendl, P. A.; Haworth, D. T. Chemistry and Special Education. *J. Chem. Educ.* **1995**, *72* (11), 983−986.

(11) Tombaugh, D. Chemistry and the Visually Impaired. *J. Chem. Educ.* **1981**, *58* (3), 222−226.

(12) Harshman, J.; Bretz, S. L.; Yezierski, E. Seeing Chemistry through the Eyes of the Blind: A Case Study Examining Multiple Gas Law Representations. *J. Chem. Educ.* **2013**, *90* (6), 710−716.

(13) Gonçalves, F. P.; Regiani, A. M.; Auras, S. R.; Silveira, T. S.; Coelho, J. C.; Hobmeir, A. K. T. A educação inclusiva na formação de professores e no ensino de química: a deficiência visual em debate. *Quim Nova Esc.* **2013**, *35* (4), 264−271.

(14) Supalo, C.; Mallouck, T. E.; Rankel, L.; Amorosi, C.; Graybill, C. Low-cost Laboratory Adaptations for Precollege Students who are Blind or Visually Impaired. *J. Chem. Educ.* **2008**, *85*, 243−248.

(15) Flair, M. N.; Setzer, W. N. A Laboratory Technique for the Visually Impaired. *J. Chem. Educ.* **1990**, *67* (9), 795−796.

(16) Neto, J. D. *A experimentação para alunos com deficiência visual: proposta de adaptação de experimentos de um livro didático*; Dissertação, Universidade de Brasília, Brasília, DF, 2012. http://www.ppgec.unb.br/images/sampledata/dissertacoes/2012/versaocompleta/joaquim_dantas_neto.pdf (accessed Jul 2015).

(17) Supalo, C.; Isaacson, M. D.; Lombardi, M. V. Making Hands-On Science Learning Accessible for Students Who Are Blind or Have Low Vision. *J. Chem. Educ.* **2014**, *91*, 195−199.

(18) Supalo, C. The Next Generation Laboratory Interface for Students with Blindness or Low Vision in the Science Laboratory. *J. Sci. Educ. Students Disabilities* **2012**, *16* (1), 34−39.

(19) Pires, R. F. M.; Raposo, P. N.; Mól, G. S. Adaptação de um livro didático de Química para alunos com deficiência visual. In Anais do VI Encontro Nacional de Pesquisa em Educação em Ciências, Florianópolis. 2007. http://www.nutes.ufrj.br/abrapec/vienpec/CR2/p657.pdf (accessed Jul 2015).

(20) Pereira, F.; Aires de Sousa, J. A.; Bonifacio, V. D. B.; Mata, P.; Lobo, A. M. MOLinsight: A Web Portal for the Processing of Molecular Structures by Blind Students. *J. Chem. Educ.* **2011**, *88* (3), 361−362.

(21) Fartaria, R. P. S.; Pereira, F.; Bonifácio, V. D. B.; Mata, P.; Aires-de-Sousa, J.; Lobo, A. M. NavMol 2.0 − A Molecular Structure Navigator/Editor for Blind and Visually Impaired Users. *Eur. J. Org. Chem.* **2013**, *2013* (8), 1415−1419.

(22) Pereira, F.; Ponte-e-Sousa, J. C.; Fartaria, R. P. S.; Bonifácio, V. D. B.; Mata, P.; Aires-de-Sousa, J.; Lobo, A. M. Sonified Infrared Spectra and Their Interpretation by Blind and Visually Impaired Students. *J. Chem. Educ.* **2013**, *90* (8), 1028−1031.

(23) Neely, M. B. Using Technology and Other Assistive Strategies to Aid Students with Disabilities in Performing Chemistry Lab Tasks. *J. Chem. Educ.* **2007**, *84* (10), 1697−1701.

(24) Romio, C.; Lorscheiter, T. A.; Silva, I. N. L. Calibration of a Type k Thermocouple for Use in a Data Acquisition System with the Arduino. *Periódico Tchê Química* **2012**, *9* (17), 60−66.

(25) Hodson, D. Hacia un Enfoque Más Crítico del Trabajo de Laboratório. *Enseñanza de las ciências* **1994**, *12* (3), 299−313.

(26) Mortimer, E. F.; Amaral, L. O. F. Calor e temperatura no ensino de termoquímica. *Quim. Nova Esc.* **1998**, *7*. http://qnesc.sbq.org.br/online/qnesc07/aluno.pdf (accessed Jul 2015).

(27) Nunes, S.; Lomônaco, J. F. O aluno cego: preconceitos e potencialidades. *Rev. Semestral Associação Brasileira Psicologia Escolar Educacional* **2010**, *14* (1), 55−64. http://www.scielo.br/pdf/pee/v14n1/v14n1a06 (accessed Jul 2015).

DOI: 10.1021/acs.jchemed.6b00162
J. Chem. Educ. XXXX, XXX, XXX−XXX