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Technology Report

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Interactive Computer Game That Engages Students in Reviewing Organic Compound Nomenclature

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Supporting Information

ABSTRACT: This report provides information about an interactive computer game named Say My Name that allows high school and undergraduate students to review individually nomenclature of organic compounds in an engaging and fun way by answering up to 600 questions distributed in three difficulty levels. Responses from students and teachers who have played the game have been quite positive. An assessment of students' knowledge gains was also performed; the results reveal that students who used the game as a complementary didactic tool in their studies had higher numbers of correct answers than did students who studied using conventional learning methods. Say My Name can be played in Portuguese, Spanish, and English online (free of charge) via a Web browser.

KEYWORDS: *High School/Introductory Chemistry, Organic Chemistry, Computer-Based Learning, Nomenclature/Units/Symbols*

INTRODUCTION

Nomenclature is a systematic method established by the International Union of Pure and Applied Chemistry (IUPAC) to name or draw organic molecules in an unambiguous way.[1] Organic nomenclature is one of the topics of greatest importance in organic chemistry, being included among the topics which define the content of a "standard" two-semester organic chemistry course.[2] It is essential that the basis of naming molecules is mastered by students. Failure to understand this topic often results in difficulty in understanding future material covered in advanced topics.[3] In addition, the correct use of the nomenclature rules allows scientists to communicate globally with each other.

Despite this importance, the study of chemical nomenclature has been a source of frustration for teachers and a perceived nuisance for their students.[4] On the other hand, several works have been reported as alternative methods[5−9] that would be able to remove some of the tedium found on the task of naming organic molecules and to assist the students in their studies.

Educational games have been established as an increasingly popular way of learning in the classroom,[10] and studies have indicated that games enhance student motivation and learning outcomes significantly[11] and had positive effects on problem solving, achievement, and interest and engagement in task learning.[12−14]

Students are more receptive to learning chemistry concepts when learning activities are combined with the use of games in the classroom, and this combination results in higher motivation[15,16] or better student performance.[17,18]

In addition, the development of computerized educational games can merge the educational qualities of games and attractive technologies, making the traditional chemistry teaching process become much more appealing and effective to students when permeated with interactive technological tools.

This context motivated us to develop and to implement a computer-based game in a board/card format that may assist students in their studies of organic nomenclature.

THE GAME

Say My Name was developed using the Adobe Flash platform and designed to be a dynamic and easy-to-play game that allows students to review nomenclature of organic compounds and to win the game based on a student's knowledge rather than luck.[19]

Players initially select a language on the first screen and choose one of the following options:

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- Play.
- Read the rules.
- Check the leader board (rankings).
- Evaluate the game.
- See the credits.

When the play option is chosen, players are transported to a new screen (Figure 1) to select up to five topics. The number of selected topics determines the questions presented during the game.

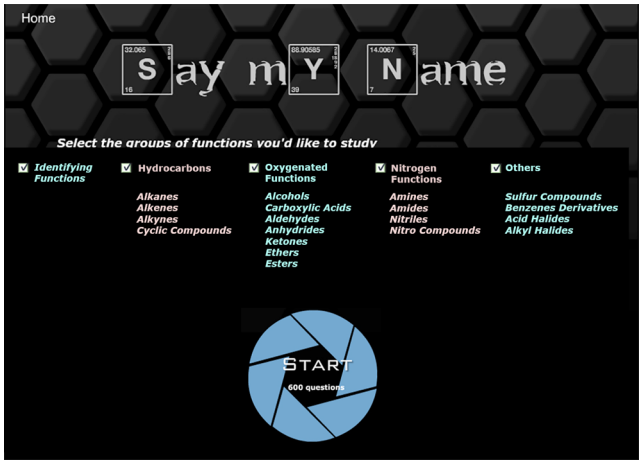

Figure 1. Selecting the functional groups.

Clicking the "Start" button transports players to a virtual board (Figure 2) where a player is represented by a nanokid who walks from the initial gate up to final gate through 30 "houses".

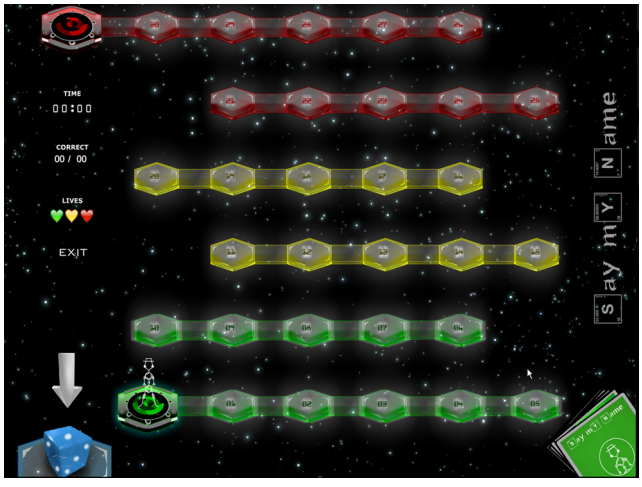

Figure 2. Virtual board.

To start the game, players must click the virtual die that determines how many steps the nanokid will take. The die was programmed to be random, and its values can only be 1, 2, or 3, forcing the player to answer a greater number of questions in each level.

Afterward, a card appears on the screen revealing a multichoice question (Figure 3). A bank of questions was created with 600 questions covering the nomenclature of the main functional groups usually present in textbooks. The questions are grouped into three different difficulty levels,

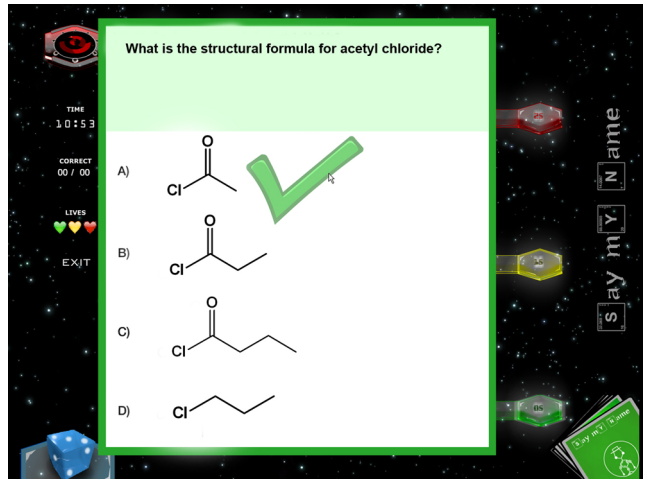

Figure 3. Virtual board after a correct answer.

which are determined by the position of the nanokid on the board: basic (green), intermediate (yellow), and advanced (red).

When a player responds correctly to a question, the card disappears and the nanokid walks the number of houses indicated on the die. After this, the player must click the die again for a new card to appear.

However, if the player chooses a wrong answer, a red X indicating an error will appear. The game shows the correct answer among the multiple-choice alternatives on the card; the player is not penalized (Figure 4). To restart the game, the

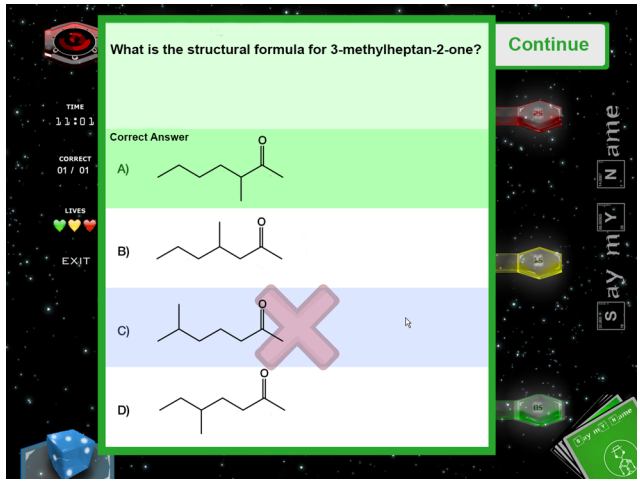

Figure 4. Virtual board after a wrong answer.

player must sequentially click the "Continue" tab and the die. After a fourth error, the player will be penalized and the nanokid will move in the opposite direction, returning the number of houses indicated on the die.

The game finishes when the nanokid reaches the final gate and the game data are registered on the leader board. Players' scores are calculated based on the total time spent to complete the course, the number of topics chosen, and the number of correct and wrong answers.

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RESULTS AND DISCUSSION

Evaluators' Opinions

Say My Name was tested and evaluated by 46 Brazilian chemistry teachers from several high schools and 181 12th-grade students from Governador Adauto Bezerra High School in Fortaleza, Brazil. All opinions regarding Say My Name were obtained through an electronic form containing 11 statements with responses based on a Likert-type scale[20] (Figure 5).

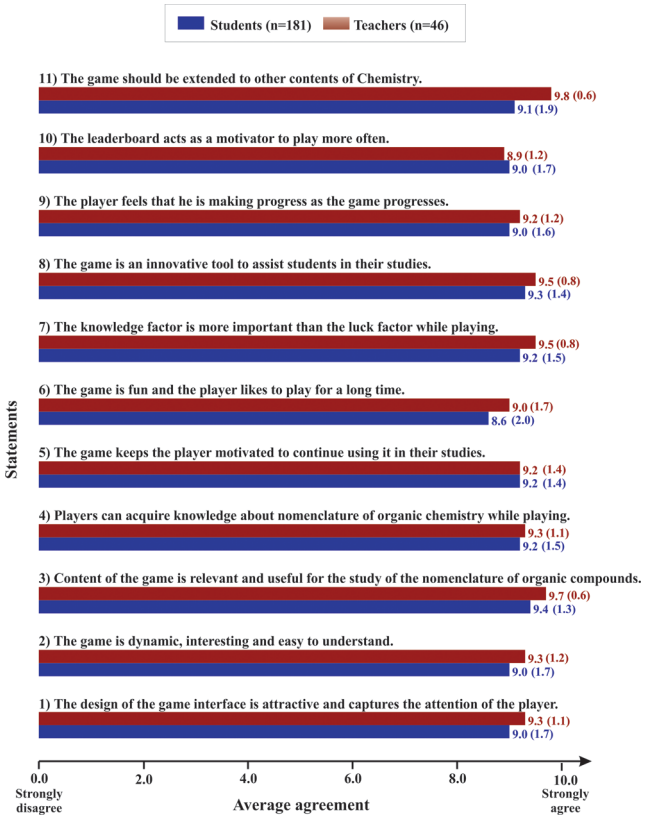

Figure 5. Comparison of the survey results showing the average Likert scores and their standard deviation inside parentheses for evaluators' responses by survey statement.

The level of agreement with the statements presented ranged from 8.6 to 9.8 among evaluators (Figure 5). Therefore, we believe with good confidence that the statements are true because they are closer to "strongly agree" (10) than the neutral point (5) and farther from "strongly disagree" (0). On the basis of the responses, users indicated that the game has a nice interface and is dynamic, interesting, and easy to understand. The questions satisfactorily cover the nomenclature of the main functional groups. Students can also acquire knowledge of organic nomenclature while playing, and to win knowledge is more important than luck. The leader board acts as a motivator to the students to play many times. Therefore, the game can be considered an innovative tool that allows students to play and to review nomenclature of organic compounds, and at the same time it assists them in their studies.

Evaluation of Nomenclature Learning by Use of the Game

The evaluation was an experimental study conducted with a controlled pretest–post-test design to analyze the effect of the instructional role of the developed game on the learning of nomenclature of organic compounds at the high school level (see the Supporting Information).

In this study, the following hypothesis was tested. There is a significant difference between students' learning of nomenclature of organic compounds via utilization of the game as a complementary educational tool and students' learning by traditional lecture in which were used textbook, whiteboard, and slide projection.

Table 1 reports the results, which show that in all groups, there was an improvement in the average number of correct answers (ANCA) in the post-test when compared to the previous pretest. By doing the comparison test (Student's *t*-test) between the differences of the ANCA ($p < 0.05$), we can conclude that there was a greater increase in the ANCA in the experimental groups (EG) than in the control groups (CG).

Therefore, the effectiveness of the game in promoting learning of organic nomenclature is demonstrated by these data.

CONCLUSIONS

A trilingual (Portuguese, Spanish, and English) educational computer game, Say My Name, was designed and is hosted on a Web site.[19] This game is freely available online, and it has been tested and evaluated by teachers and high school students. Results show that the evaluators' opinions were very positive about playing the game and practicing nomenclature skills for organic compounds. The findings of this study demonstrate that the game is an effective tool for testing high school students' knowledge of organic nomenclature.

Table 1. Comparison of Student Performance Relative to Use of the Game

	Students' Average Scores[b] with SD Values, by Group					
	Experimental Group (EG)				Control Group (CG)	
Assessment Instrument[a]	1	2	3	4	1	2
Pretest	6.75 ± 2.27	9.16 ± 3.32	8.04 ± 3.16	8.29 ± 3.86	6.92 ± 2.61	5.97 ± 2.36
n Pretest	36	31	52	46	40	41
Post-test	12.00 ± 4.15	16.83 ± 3.34	13.77 ± 4.32	15.38 ± 3.34	9.58 ± 2.51	9.20 ± 2.60
n Post-test	40	46	60	46	44	39
Average score differences	5.25	7.67	5.73	7.10	2.66	3.23
t-value	6.568	9.726	7.879	9.007	4.522	5.444
df	54	71	105	82	74	68

[a]Possible number of correct answers has a range from 0–25. [b]$p < 0.0001$.

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■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.7b00793.

Game rules, handouts, survey, pretest, post-test (PDF, DOCX)

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Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) Skonieczny, S. The IUPAC Rules for Naming Organic Molecules. *J. Chem. Educ.* **2006**, *83* (11), 1633−1637.

(2) Report of the Organic Subcommittee of the Curriculum Committee. *J. Chem. Educ.* **1972**, *49* (11), 761−763. DOI: 10.1021/ed049p761

(3) Orvis, J.; Sturges, D.; Rhodes, S.; White, K.; Maurer, T. W.; Landge, S. M. A Mailman Analogy: Retaining Student Learning Gains in Alkane Nomenclature. *J. Chem. Educ.* **2016**, *93* (5), 879−885.

(4) Mullin, J.; Courtney, P. Using Inexpensive "Find & Circle" Word Search Software in the Study of Chemical Nomenclature. *J. Chem. Educ.* **1996**, *73* (6), A130−A131.

(5) Flynn, A. B.; Caron, J.; Laroche, J.; Daviau-Duguay, M.; Marcoux, C.; Richard, G. Nomenclature101.com: A Free, Student-Driven Organic Chemistry Nomenclature Learning Tool. *J. Chem. Educ.* **2014**, *91* (11), 1855−1859.

(6) Moreira, R. F. A Game for the Early and Rapid Assimilation of Organic Nomenclature. *J. Chem. Educ.* **2013**, *90* (8), 1035−1037.

(7) Calvo Pascual, M. A. Using Product Content Labels to Engage Students in Learning Chemical Nomenclature. *J. Chem. Educ.* **2014**, *91* (5), 757−759.

(8) Crute, T. D. Classroom Nomenclature Games − BINGO. *J. Chem. Educ.* **2000**, *77* (4), 481−482.

(9) Palacios, J. Octachem Model: Organic Chemistry Nomenclature Companion. *J. Chem. Educ.* **2006**, *83* (6), 890−892.

(10) Franco Mariscal, A. J.; Oliva Martínez, J. M.; Bernal Marquez, S. An Educational Card Game for Learning Families of Chemical Elements. *J. Chem. Educ.* **2012**, *89* (8), 1044−1046.

(11) Cordova, D. I.; Lepper, M. R. Intrisic Motivation and the Process of Learning: Beneficial Effects of Contextualization, Personalization, and Choice. *J. Educ. Psychol.* **1996**, *88* (4), 715−730.

(12) Kim, B.; Park, H.; Baek, Y. Not Just Fun, But Serious Strategy: Using Meta cognitive Strategies in Game-based Learning. *Comput. Educ* **2009**, *52* (4), 800−810.

(13) Oyen, A.; Bebko, J. The Effects of Computer Games and Lesson Context on Children's Mnemonics Strategies. *J. Exp. Child Psychol.* **1996**, *62* (2), 173−189.

(14) Robertson, J.; Howells, C. Computer Game Design: Opportunities for Successful Learning. *Comput. Educ.* **2008**, *50* (2), 559−578.

(15) Westera, W.; Nadolski, R. J.; Hummel, H. G. K.; Wopereis, I. G. J. H. Serious Games for Higher Education: A Framework for Reducing Design Complexity. *J. Comp. Assist. Learn.* **2008**, *24* (5), 420−432.

(16) Stringfield, T. W.; Kramer, E. F. Benefits of a Game-Based Review Module in Chemistry Courses for Nonmajors. *J. Chem. Educ.* **2014**, *91* (1), 56−58.

(17) Revell, K. D. A Comparison of the Usage of Tablet PC, Lecture Capture, and Online Homework in an Introductory Chemistry Course. *J. Chem. Educ.* **2014**, *91* (1), 48−51.

(18) Liberatore, M. W. Improved Student Achievement Using Personalized Online Homework. *Chem. Eng. Educ.* **2011**, *45* (3), 184−190.

(19) *Say My Name*; Universidade Fedaral do Ceara, 2018. http://ldse.ufc.br/smn/ (accessed February 2018).

(20) Likert, R. A Technique for the Measurement of Attitudes. *Arch. Psychol.* **1932**, *22* (140), 55.

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J. Chem. Educ. 2018, 95, 899−902