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Activity

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Picture Chem: Playing a Game To Identify Laboratory Equipment Items and Describe Their Use

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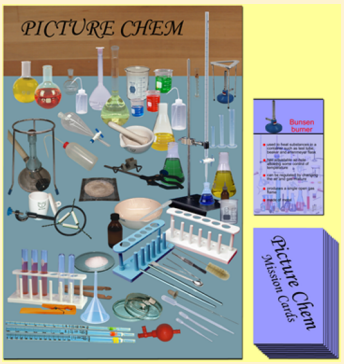
Supporting Information

ABSTRACT: Laboratory activities are an important means of instruction in science; as such, they have been used in chemistry education since the 1880s. Many learning objectives can be achieved through the use of laboratory activities undertaken by chemistry students. In student-centered laboratory activities, students should know how to use an apparatus in designing an experiment. In this Activity, we describe the development and preliminary use of a game to help students learn the names and functions of common chemistry laboratory equipment. The game, Picture Chem, was played with 30 cards and a playing board. An analysis of the strengths, weaknesses, opportunities, and threats was used to improve the game. The effectiveness of the game was tested quantitatively, with results showing that students find Picture Chem to be both enjoyable and beneficial.



KEYWORDS: *High School/Introductory Chemistry, Laboratory Instruction, Hands-On Learning/Manipulatives, Laboratory Equipment/Apparatus, Humor/Puzzles/Games*

The laboratory is an excellent learning environment that provides students with opportunities to engage in processes of investigation and inquiry.[1−3] Recent research literature suggests that school science laboratories are the best environment for introducing students to central conceptual and procedural knowledge and skills in science.[4] On the other hand, in the laboratory, meaningful learning is possible if the students "manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts".[5]

Laboratory activities are a very important part of science education. A laboratory activity *is* most effective when it is carefully designed and structured by teachers. According to Hodson:[6]

> *[T]he principal focus of laboratory activities should not be limited to learning specific scientific methods or particular laboratory techniques; instead, students in the laboratory should use the methods and procedures of science to investigate phenomena, solve problems, and pursue inquiry and interests.*

The National Science Education Standards (NSES) in the United States and contemporary science education literature recommend inquiry as a method for learning and doing natural science in formal classrooms. Inquiry-based learning involves the process of questioning, exploring, and reflecting. In learning environments that use inquiry, "learners can investigate the natural world, propose ideas, and explain and justify assertions based upon evidence".[7] Experimental design is a key step in inquiry-based learning. However, students cannot succeed in this step if they do not identify the equipment needed for different experiments. For that purpose, we have developed and evaluated a game for introductory chemistry students (advanced high school or beginning college) aimed at improving their knowledge of common laboratory apparatus.

■ PREPARING THE GAME MATERIALS

Picture Chem, a game similar to Pictureka, is played with 30 mission cards and one game board. The board and the cards of Picture Chem should be prepared by the teacher or students. Pictures, definitions, and functions of common laboratory apparatus in chemistry should be included on the mission cards (Figure 1). On the other hand, there should be only pictures of the common laboratory apparatus on the board (Figure 2). The board and card templates are given in the Supporting Information and can be printed with a color printer on heavy cardstock and then cut out. The cards may be laminated for added strength and durability.

■ PLAYING THE GAME

The aim of the game is to find a picture, which is defined in the mission card, across the board to collect cards. One player or one team should collect the determined number of cards in order to win the game.

First, teacher or students can extend the length of the game by deciding how many cards they collect. In the ideal case, in a class of 20 students, we advise that 10 cards should be collected. In this case, the length of the game is approximately 40 min.

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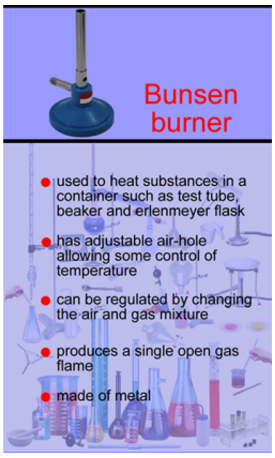

Figure 1. A sample of the mission cards.

Figure 2. Playing board of the Picture Chem game.

This game is played with two players or teams. If the game is played with teams in the class, the teacher should divide class into two teams before starting the game. Then, it is decided who goes first. The starting team could be determined by lots or other convenient and fair methods.

The board of the Picture Chem game is laid out on the table. After mission cards are shuffled, the deck is placed face down near the playing board. A student from each team comes to the table. The starting team member draws a card from the mission card deck. She or he loudly reads the definitions and functions of an apparatus that is stated on the drawn card. After the timer is started, the opponent guesses what this apparatus might be and then finds the picture of this apparatus on the board. If this student's guess is correct, the player keeps that card. Players repeat the same process by changing their position. After two players at the table complete the round, a new student from each team comes to the table. The game continues in this way until one team wins the game.

EFFECTIVENESS STUDIES OF USING THE PICTURE CHEM GAME

A SWOT (strengths, weaknesses, opportunities, and threats) analysis was used to evaluate the usefulness of the game, as well as to identify possible improvements to the game.[8] For this purpose, the Picture Chem game was introduced to 18 chemistry preservice teachers who volunteered to play the game during a laboratory session. A draft SWOT form was given to these participants, who were informed about how to complete the form after they finished playing the game. All participants wrote their thoughts by listing them under each category. Then, the lists were combined into one list by prioritizing and aligning. At the end of the process, internal factors (strengths and weaknesses) and external factors (opportunities and threats) of the game were obtained (Table 1).

Table 1. Results of a SWOT Analysis for the Picture Chem Game

Category	Response Statements[a] from Preservice Teachers Who Played the Game (N = 18)
Strengths	It is fun, motivating, and challenging.
	It provides learning and practice for students.
	Its preparation and its application are easy, fast, and inexpensive.
	It provides visual learning opportunities.
	It can be useful for different age groups and genders.
Weaknesses	Time can be insufficient for learning the name, definition, and the function of apparatuses.
	The resolution of apparatus images is low. Therefore, the apparatus pictured cannot be described.
	The cards can be easily "deformed" or bent through use.
	The number of cards may be insufficient for crowded classes.
Opportunities	It can be redesigned for different apparatuses and safety symbols.
	An electronic version could be prepared. Then it could be played individually by students at home or at school.
Threats	It cannot be used by some teachers who do not use inquiry-based learning in the classroom.
	Apparatus flashcards potentially prepared for computers or smartphones could reduce interest in this game.

[a]Statements translated by the authors from Turkish.

In the second stage of evaluation, the effectiveness of the Picture Chem game to assist in the learning of common laboratory apparatus in chemistry was tested quantitatively using one group pre- and posttest experimental design. The sample of this stage consisted of 20 first-year physics education students who were enrolled in a chemistry lecture and lab in the fall semester. A laboratory equipment test (available in the Supporting Information), including 30 fill-in-the-blank items, was used as pretest before the game's implementation and as posttest after playing the game. The game's implementation was planned in accordance with a teams-games-tournament (TGT) strategy, and took place for four laboratory sessions. In the first two laboratory sessions, students were grouped into two teams and investigated the mission cards in order to learn the definition and function of common laboratory apparatus in chemistry. In the last two laboratory sessions, the tournament was held between the two teams.

The students' pretest and posttest scores were calculated by adding the total number of correct responses; these results were analyzed by paired sample t-tests with a 95% confidence level (Table 2). Analysis of the data showed a statistically significant

Table 2. Results of Paired Sample t-Tests Pre- and Posttest Differences in Mean Scores

Pair	n	Mean	SD	df	t	p[a]
Before	20	13.15	5.97	19	8.424	0.000
After	20	44.80	15.42			

[a]Calculated at the 95% confidence level.

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difference in favor of posttest scores [$t(19) = 8.424$, $p = 0.000$]. It was concluded that the Picture Chem game was effective in assisting students in learning about common chemistry laboratory apparatus.

DISCUSSION

In an evaluation of the game with 20 student participants, the pretest scores ranged from 3 to 30 out of a possible score of 60, with a mean score of 13.15. This result showed that many students, all high school graduates, misidentified or did not identify individual apparatus commonly used in the chemistry laboratory. In juxtaposition, the posttest results yielded a mean score of 44.80, demonstrating an average increase of 31.65 in test scores from pretest to posttest, which suggests that the students benefited from the Picture Chem game. This agrees with the findings of other articles.[9−12]

In the SWOT analysis of Picture Chem game, it is clear that the game has many strengths; the game was described as fun, motivating, challenging, fast, and inexpensive to use. These two preservice teachers' comments (translated by the authors from Turkish) represent some positive reactions:

> *It allows us to easily identify the apparatus. It is fun and engaging for students. It provides class participation. In future I will try to use this game in my class to help students learn.*
>
> *The visual learning is very useful for students to recognize the common chemistry laboratory apparatus. Therefore, this game helps to reinforce the process of acquiring basic lab skills.*

On the other hand, according to the SWOT analysis, there are more opportunities for Picture Chem game to improve. For example, the electronic version of this game could be developed for use on computers and smartphones.

Some limitations should be mentioned. One of them is that the sample is too small to generalize the results. Another limitation is that this research is conducted in a university setting. Therefore, the findings are limited to the context of the current research and we have not generalized these findings to other contexts. Finally, we recommend for future research an examination of Picture Chem with a larger sample size, including different grade levels.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00857.

> Detailed playing instructions for the game; template for printing playing cards and game board (PDF)
>
> Laboratory equipment test (PDF, DOCX)

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Notes

The authors declare no competing financial interest.

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