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10-Jan-2025

Journal: The Journal of Chemical Education
Manuscript ID: ed-2024-00649t.R2
Title: "Integrating “Molecule of the Week” as a Teaching Tool in an Undergraduate Organic Chemistry Course"
Manuscript Type: Article
Author(s): Chen, Changqing; Manyanga, Fidelis

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Thank you for agreeing to review Manuscript ID ed-2024-00649t.R2, entitled Integrating “Molecule of the Week” as a Teaching Tool in an Undergraduate Organic Chemistry Course, for the Journal of Chemical Education. I greatly appreciate your help and look forward to receiving your comments by 24-Jan-2025.

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Integrating "Molecule of the Week" as a Teaching Tool in an Undergraduate Organic Chemistry Course

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Integrating "Molecule of the Week" as a Teaching Tool in an Undergraduate Organic Chemistry Course

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ABSTRACT

Student motivation, particularly among non-chemistry majors, remains a crucial area of focus in undergraduate education. This study explored the implementation of "Molecule of the Week" (MOTW) reports from the American Chemical Society (ACS) website as an educational tool in the second-semester Organic Chemistry course (CHE213) at Salem State University. By incorporating guided questions and requiring literature search, the MOTW assignment was designed to connect molecules relevant to everyday life with organic chemistry concepts to increase student engagement, motivation, as well as integrating writing and research into the organic chemistry course curriculum. Results from this study indicated that students found the MOTW reports to be effective in highlighting the relevance of organic chemistry to students' daily lives. Additionally, this assignment encouraged interdisciplinary connections by linking organic chemistry with other fields such as biology, biochemistry, environmental science, and allied health sciences. This integration was intended to develop students' motivation, critical thinking and problem-solving skills. Qualitative and quantitative analyses of the results suggest that incorporating MOTW assignment was effective at improving student motivation and deepened their comprehension of complex chemical concepts.

KEYWORDS

General Public, Curriculum, Organic Chemistry, Distance Learning, Communication/Writing, Enrichment/Review Materials

INTRODUCTION

Different teaching tools serve various purposes and play crucial roles in enhancing the learning experience for students.[1-5] Traditional methods of teaching and learning college level chemistry often face challenges in promoting student motivation, student engagement, and critical thinking skills. When learning organic chemistry, students often feel less motivated due to the abstract nature of the subject, challenging concepts, student perception of irrelevance, and disconnection from practical applications. By incorporating a variety of tools and strategies, educators can create interactive and effective learning environments that support student success through personalized learning experiences.

Abundant literature shows that conducting literature reviews fosters independent inquiry, critical analysis, and knowledge synthesis,[6-8] which ultimately helps to increase student performance.[9] It can contribute significantly to the development of students' research skills, scientific literacy, and ability to evaluate and communicate scientific information effectively.[10-12] More specifically, reading, studying

and researching chemistry literature outside the classroom, can be highly motivating and beneficial for students. Additional benefits include: (1) Broadening students' knowledge base in basic and advanced knowledge in life science studies, including chemistry, (2) Challenging students to higher order thinking by fostering curiosity that leads to their scientific growth and inspiration for participating in research, and (3) Real-world relevance and keeping current with new developments. The MOTW articles provided information on molecules suggested by readers. These molecules are closely related to our everyday life. Many molecules are related to the current events. Students learned the real-world applications and relevance of chemistry outside the traditional classroom environment through reading these articles. The MOTW articles provided important updated information which are not usually included in textbooks. The editors strive to keep the readers updated with new developments by publishing MOTW update on some previous MOTW in the archive. Reading these articles helps the students to stay current with cutting-edge research and developments and motivate them to explore organic chemistry further.

In this study, MOTW tool, an educational resource provided by the ACS's website[13] since 2001 was assigned to students. Molecules are suggested by the ACS audience. At the beginning of the MOTW page, an interesting/important application of the molecule is featured to attract readers' attention. This is followed by a 2-D molecular structure and an image of the ball-and-stick model of the molecule. This page also includes a summary of the molecule's discovery or its first reported synthesis date, along with links to related information and chemists who made these contributions is included. Functions and applications of the molecule including recent findings or research work are discussed. Fast facts e.g. (Chemical Abstracts Service (CAS) registration number, name, molecular formula, and some physical properties) as well as hazard information are also included.

OBJECTIVES OF THIS STUDY

The primary goal of this study was to incorporate MOTW as a teaching tool into an Organic Chemistry II course.[14] This integration aimed to demonstrate the relevance of scientific concepts by connecting them to everyday life experiences, thereby making the subject matter more relatable and engaging for undergraduate students.

A secondary objective was to provide students with opportunities to gain a practical understanding of complex organic chemistry principles through a "hands-on" approach. This approach was intended to deepen their comprehension of organic chemistry. By incorporating writing and literature research into the curriculum, students explored interdisciplinary connections between chemistry and other fields such as environmental science, biology, physics, politics, and allied health sciences. For example, L-Alanine and L-serine (MOTW of 10/29/2018) are important amino acids that are necessary for the biosynthesis of proteins. Penicillin X (MOTW of 7/22/2024) and L-Thyroxine (MOTW of 12/12/2022) are important biomolecules. Vinyl chloride (MOTW of 3/6/2023), the starting material for the production of polyvinyl chloride (PVC) plastics, caused serious environmental problems in the rail disaster in East Palestine, Ohio. For the MOTW teaching tool, guided questions were designed to encourage students to think logically and critically about the organic molecules they studied, develop problem-solving skills, and foster curiosity about chemistry and its applications. This, in turn, was anticipated to foster a deeper appreciation for the world around them.

Additionally, another objective was to assess the impact and effectiveness of the MOTW tool on students' learning experiences. To achieve this, students were encouraged to evaluate the utility of the MOTW tool in enhancing their understanding and engagement with the material.

METHODS

In this study, students were assigned the assignment of searching for and studying various aspects of the MOTW articles and conducting related literature search. The study was conducted in an Organic Chemistry II course, which is a four-credit course and a continuation of Organic Chemistry I. Most students enrolled in this class were biology majors, with a few chemistry majors, and the majority are sophomores, juniors, or seniors.

The MOTW report served as an extra-credit assignment and **was not mandatory. Each weekly report was approximately two pages long, and students typically spent a couple of hours completing it.** The MOTW topic was consistent for the entire class each week, as published on the ACS website. An assignment group called "MOTW" was created on Canvas,[15] our learning management system (LMS), in the beginning of the semester. Each week on Monday, an assignment was posted in

this assignment group for students to submit the report for the MOTW. Each assignment title included the dates of the week, such as "Molecule of the Week 10/23/2023-10/29/2023." The assignment was open from Monday till Sunday each week. Word documents were required for submission. Students had one week to work on the report and submit it before the deadline. Depending on the semester schedules, students had the opportunity to complete between twelve and fifteen weekly MOTW reports. Each report was worth one point toward their final exam grade. Students who submitted their reports before the deadline and included all required information according to the guidelines (see Table 1) received one extra point to be added to their final exam grade. The final exam was 150 points and contributed to 25% of the final course grade. Students could earn a maximum of 2.5% toward their overall course grade for their participation in this assignment, if 15 MOTW reports were submitted in a semester.

Phase 1: MOTW Report Guidelines

In Phase 1, at the beginning of the semester, students were provided with detailed course-specific guidelines for the MOTW (Molecule of the Week) report, as outlined in Table 1. These guidelines were crafted to ensure that the report would keep students motivated and engaged while being manageable and not overly time-consuming.

The objective of the MOTW report was to stimulate student interest and involvement in the class by integrating real-world applications of organic chemistry without overwhelming them with excessive work. The study included feedback from students spanning from the spring 2019 semester to the fall 2023 semester to assess the effectiveness and impact of this assignment. A summary of the course-specific report guidelines for Organic Chemistry II is provided in Table 1.

Table 1: A Summary of Items/Information for MOTW Report:

1. Molecular formula/drawing: you can copy and paste the chemical formula from the ACS website. Reference appropriately.
2. Physical properties: appearance, odor, melting point/boiling point, solubility, etc.
3. How was it discovered/synthesized?
4. Circle and name all functional groups.
5. Chemical properties: synthesis, reactivity, etc.

6. Safety information: use Safety Data Sheet (SDS) as a reference, include how to work with it safely, its toxicity, its impact on the environment, etc.
7. Reflect on applications:
8. Any fun facts you want to add from your own experience or your search on the web, from a book or journal, etc.

Phase 2: Student Survey on MOTW Reports

A comprehensive understanding of students' feedback was obtained from both qualitative and quantitative data. This was essential for gaining insights and reflections into student experiences, opinions, and areas for improvement. A survey was distributed to all students who participated in the MOTW assignment in Organic Chemistry II. The survey link was published on Canvas. Both guided (rating scale) and open-ended questions were included in the survey to get a more holistic understanding of students' feedback. Open-ended questions provided students with the opportunity to express their opinions and thoughts, thus allowing us to gain a deeper understanding of students' perspectives and experiences.

The survey was conducted using a Google administration software program, "Google Forms: Online Form Creator."[16] Statistical analysis was performed using Microsoft Excel. The sample consisted of 238 students, from spring 2019 semester to fall 2023 semester, representing a response rate of 95.2 percent. The survey consisted of fourteen rating scale questions (1=not helpful, 10=very helpful) and three open-ended questions. A copy of the student survey was included in the supporting information.

Students were encouraged to evaluate the MOTW assignment on learning organic chemistry as specified in Table 2.

RESULTS AND DISCUSSION

The following are the analyses of the results of the MOTW survey conducted among students in Organic Chemistry II.

Quantitative Student Survey Data Analysis

The student survey results of the evaluation on the perceived helpfulness of the MOTW assignment on learning organic chemistry are summarized in Table 2.

Table 2. Summary of Median, Mean, and Standard Deviation Scores for the Perceived Helpfulness of the Molecule of the Week Assignment in Learning Various Aspects of Organic Chemistry II (N=238), Maximum =10

Rating of the MOTW Assignment on:	Median	Mean	Standard Deviation (±)
a. Learning Molecular Formulas	9.0	8.0	2.3
b. Learning Naming Organic Compounds	9.0	8.2	2.1
c. Learning Physical Properties of Organic Compounds	9.0	8.2	2.0
d. Learning History of Organic Compounds	8.0	7.9	2.2
e. Learning Fun Facts of Organic Compounds	9.0	8.3	2.0
f. Learning Syntheses of Organic Compounds	8.0	7.8	2.1
g. Learning Functional Groups	9.0	8.4	2.0
h. Learning Reactivities of Organic Compounds	8.0	7.8	2.1
i. Learning Safety Precautions in Lab	10.0	8.6	1.8
j. Learning Health Hazards	10.0	8.8	1.7
k. Learning Applications of Organic Compounds	10.0	8.8	1.6
l. Learning Relevance of Organic Chemistry to Your Life	10.0	8.8	1.7
m. Motivation of Learning Organic Chemistry	9.0	8.2	2.1
n. Helping You Succeed in Organic Chemistry	8.0	7.9	2.2

NB: These letters of the alphabet (a to n) were used as the x-axis for Figure 1.

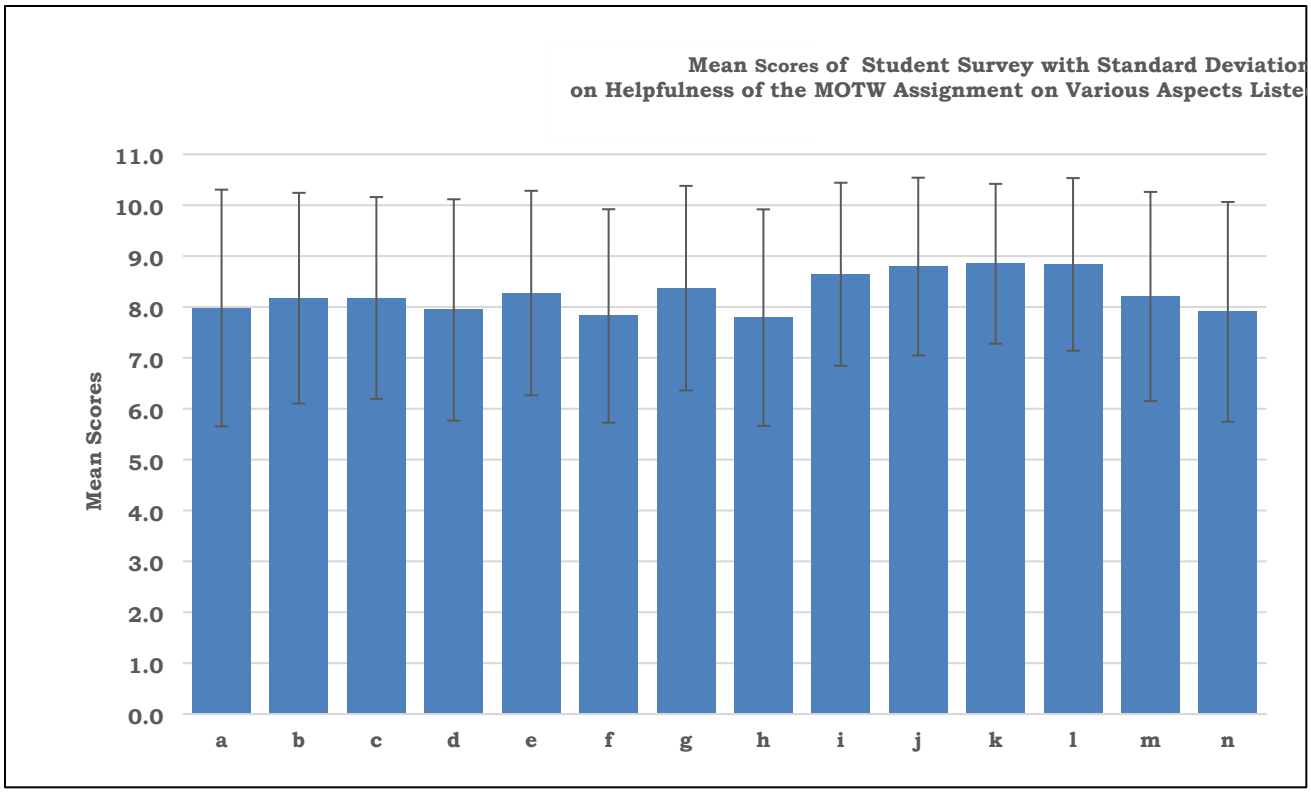

Figure 1. The mean scores for the perceived helpfulness of the MOTW assignment on learning various aspects of Organic Chemistry II (see Table 2 for details of different aspects from a to n. For example, a is Learning Molecular Formulas, b is Learning Naming Organic Compounds, etc.)

History of Organic Compounds, Syntheses of Organic Compounds, Reactivities of Organic Compounds and Helping You Succeed in Organic Chemistry received a median score of 8.0 and a mean score close to 8.0 on the perceived helpfulness of the MOTW assignment. These positive ratings suggest that the students found the assignment as helpful for their learning. The authors argue that typically these high rankings indicate that students found the MOTW assignment to be engaging, relevant, and valuable to their learning experience.

Molecular Formulas, Naming Organic Compounds, Physical Properties of Organic Compounds, Fun Facts of Organic Compounds, Functional Groups and Motivation of Learning Organic Chemistry received a median score of 9.0 and a mean score of 8.0 and higher on the perceived helpfulness of the MOTW assignment. These ratings indicate that students found the MOTW assignment as very beneficial. These authors found evidence that MOTW activity stimulated critical thinking, was intellectually challenging and motivated students.

Safety Precautions in Laboratory, Health Hazards, Applications of Organic Compounds and Relevance of Organic Chemistry to Your Life received a median score of 10.0 and a mean score of 8.5 and higher on the perceived helpfulness of the MOTW assignment. These high ratings suggest that students deemed the assignment as extremely helpful. Through this activity, students expanded their knowledge on Safety Precautions in the Laboratory, especially the use of Personal Protective Equipment (PPE), proper handling of chemicals, and awareness of health hazards, including but not limited to: toxicity, chemical reactivity, carcinogenicity, flammability, allergenicity, and applications that led to awareness and relevance of organic chemistry to daily life. Some students were able to find connections of these topics.

The overall positive feedback from quantitative survey data suggests that students found the MOTW assignment to be highly beneficial across various aspects of organic chemistry, and effectively contributed to undergraduate students' learning experiences in organic chemistry.

Qualitative Student Survey Data Analysis

The following are the analyses of the three open-ended questions in the survey.

Open-ended question 1: What was most beneficial about the assignment?

The student feedback indicated a variety of benefits that students derived from the MOTW assignment.

a. **Learning about Organic Chemistry in Everyday Life:** Some students mentioned that the assignment helped them understand how organic chemistry is intertwined with everyday life. They found it beneficial to learn about the real-world applications of organic compounds and how they are used in products we encounter daily. The assignment allowed students to make connections between chemistry concepts learned in class and their real-life applications, fostering a deeper understanding of the subject. One MOTW example was trans-cinnamaldehyde, which was published on 10/28/2019 before Halloween. Students learned that it was used in both foods and pesticides. Ancient Egyptians used it to preserve mummies and give them a pleasing aroma. It was synthesized via aldol condensation, similar to one of experiments students performed in the lab. Students learned mechanism of aldol condensation in lecture. Through working on the MOTW assignment, students could make connections between real-world examples and what they learned in lecture and lab.

Examples of student responses are as follows:

- "For me the most beneficial about this assignment was to observe how these compounds are in our everyday lives, some more than others. Also, it was very interesting looking at the structures and the history behind it as to who discovered this molecule and when it was discovered."
- "I honestly love the fact that we learned more about the application of chemistry in everyday life. I also loved learning about how the molecules were first synthesized. It makes me appreciate science even more and the talents that all these chemists have!"
- "Taking the time to learn about the applications and impact of discoveries and innovations made by organic chemists helps to ground the content of this class with a real-world context."

More detailed student responses can be found in the supporting information (SI).

b. Learning New Molecules: Students valued the opportunity to learn about new molecules each week, expanding their knowledge beyond what is covered in class. This allowed them to discover compounds they were not previously familiar with. In addition, students got an opportunity to stay updated with current and new developments in the field.

Examples of student responses are as follows:

- "I got to learn about many different compounds and chemicals that I most likely wouldn't have known about if I didn't do molecule of the week."
- "It helps expand my knowledge about organic compounds beyond classroom."
- "I enjoyed keeping up to date weekly with the highlighted molecule. I learned a lot of new molecules I had never known."

c. Identification of Functional Groups: The assignment helped students practice identifying functional groups within molecules, which is a fundamental skill in organic chemistry. Functional groups define the chemical properties and reactivity of organic molecules. Knowing the functional group helps predict chemical reactions of the compound.

Examples of student responses in this category are as follows:

- "My favorite part of the Molecule of the Week assignments is the question regarding the identification of functional groups as it provided great practice. I also enjoyed hearing about how the molecules are synthesized/were discovered."
- "This assignment helped me a lot in finding the functional groups in different molecules and also helped me understand better the evolution of chemistry."
- "Naming the functional groups of each compound and seeing how the chemical interacts with other compounds."

d. Relevance to Course Material: Many students appreciated how the assignment related course material to the outside world, making it more engaging and applicable. The connection between theory and practice helped students understand the importance of organic chemistry in addressing real-world challenges, fostering a sense of purpose and engagement in their studies.

Examples of student responses in this category are as follows:

- "I noticed that the molecules ACS reported on often came up during class and lab time - having a "real world" understanding helped me to strengthen my connections to things outside of class."
- "I got to learn about many different organic molecules and connect them to the material we were learning."
- "It made me realize that organic chemistry is surrounding us, and now I'm able to pick up a cleaning product or cosmetic and identify the compounds in it. I think that's really cool."

e. Interest and Motivation: MOTW introduced students to molecules that have practical importance, connecting abstract organic chemistry concepts and reactions to real-world examples and applications. Through effectively relating organic chemistry to practical uses, the MOTW teaching tool helped to increase student motivation and engagement. Students were able to better understand the application of organic chemistry to their everyday lives. Many students mentioned that the assignment sparked their interest in organic chemistry and motivated them to learn more about the subject.

Examples of student responses in this category are as follows:

- "It made me curious about learning more about organic chemistry. It was inspiring to see the real-world applications and applying my knowledge in new ways."
- "I think that this helped to expand my interest in chemistry. Every week it has me a new molecule to look forward to."
- "The molecule of the week on Remdesivir led me to further research on the drug and I actually presented my findings to doctors at work (at hospital) they were impressed."
- "I would always have fun doing a little research on them and then telling friends about them afterwards. One of them I learned about free radicals which came up later in class, so that was directly useful. Otherwise they were good for general chemistry interest."

f. **Understanding Syntheses and Applications**: Through reading information on MOTW published by ACS and conducting literature search, students were able to learn more about the syntheses and applications of different molecules, gaining insights into their history, uses, and significance. Examples of student responses are as follows:

- "I think learning about the synthesis and applications were most beneficial."
- "I learned a lot about the history of the organic molecules, I found it very intriguing."
- "I enjoyed learning about the applications of organic chemistry and found that practicing naming functional groups also helped me during the exams."
- "To learn and read about many molecules that have significant real-world applications in various industries, medicine, and technology."

Overall, the feedback suggests that the Molecule of the Week assignment was effective in enhancing students' understanding of organic chemistry, stimulating their curiosity, and providing practical applications of course material.

Open-ended question 2: Do you have any suggestions on how to improve on the design of the assignment?

A majority of the students liked the format and requirements of the assignment. The following are some examples of student responses.

- "No, I think the assignment was pretty thorough in its format, so I don't think it needs to be improved or modified. I especially liked that it had a 'fun facts' section because that covered anything and everything else that could have been relevant to the molecule; I often added more in this part of the assignment."
- "No, I enjoyed this assignment every week and was interested in researching a new chemical every time. I think if this assignment was a lot more work and took more time, then not as many students would be interested in doing it."
- "No, I believe the questions are useful and require research in which we learn more about the molecules."
- "No, It was very interesting. I think it was very well designed and it helped in broadening my learning. Even if I did not find some information that I needed from the acs it helped me to search carefully and find the credited site to get information."

Some students provided constructive feedback. The student feedback offers valuable insights into potential areas for improvement in the design of the MOTW assignment.

a. **Student Interest**: Students suggested adding more engaging elements to the assignment, such as discussions in class and more freedom on selection of molecules. This could increase student interest and motivation.

Examples of student responses are as follows:

- "Perhaps add questions from molecule of the week to quizzes/exams, to get more people to do the molecule of the week."
- "Have discussions about each molecule in class."
- "Maybe having a little more freedom with the molecule. Having the students pick which organic molecule they'd like to do for the assignment every week instead of us all doing the same one."

b. **Format:** A few students suggested different formats of the report for clarity and efficiency, such as "a table that you fill in" or "a table, which should have on the left side the requirements and the right side should be empty for students to write their answers."

c. **Submission Deadlines:** A few students expressed a desire for different deadlines, such as "extending the deadline for each MOTW to every two weeks" or changing the deadline to be on a weekday instead of Sunday.

Addressing these suggestions could improve the overall effectiveness and student experience of the MOTW assignment. This may involve discussing some molecules of the week in classes, providing more flexibility in deadlines, giving student more freedom on the selection of molecules and report formats, and incorporating other engaging elements into the assignment design.

Open-ended question 3: Any other comments?

The student feedback provided on the MOTW assignment is generally positive, with many students expressing appreciation for the opportunity to engage with organic chemistry concepts.

a. Positive Feedback: Many students expressed enjoyment and appreciation for the assignment, finding it interesting, helpful, and enjoyable to complete.

Examples of student responses are as follows:

- "I have looked forward to my molecule of the week assignment every week, I am a little sad that I don't have to do them anymore."
- "I am going to continue to check the molecule of the week every week!"
- "It was a simple and fun assignment that was a pleasure to complete for most weeks."

b. Learning Experience: Some students highlighted the educational value of the assignment, noting that it helped them learn about functional groups, safety hazards, physical properties, and other aspects of organic chemistry.

c. Motivation and Relevance: Several students mentioned again that the assignment motivated them to learn and connected the course material to real-world applications, enhancing their understanding and appreciation of organic chemistry.

Examples of student responses are as follows:

- "I think it serves as a great way to integrate practical and applicable organic chemistry, to spark interest and supplement the material."
- "I liked that the molecule of the week connects what we learn in class to 'the real world'."

- "I thought this was a really interesting idea, I learned interesting things and it was a good way to tie what we do in class with the various aspects of chemistry."
- "This was a fun assignment, and it was really cool to see and learn about molecules we use in our everyday life! This assignment made me appreciate organic chemistry a bit more."

By performing the MOTW assignment, students learned how the reactions and theories they studied in class are applied in scientific research, industry, and everyday life, which in turn enhances their appreciation of chemistry and motivates them in learning organic chemistry. Overall, the feedback indicates that the Molecule of the Week assignment served as a valuable teaching tool and motivational factor for students.

Comparative Analysis of Student Performance

The final average course grades were compared among students who actively participated in the MOTW assignment (submitted ten or more MOTW reports) and the rest of the class, as shown in Table 3. The authors chose ten reports as the reference point since the number of weekly MOTW reports could be collected in a semester is twelve to fifteen. The authors intended to study the learning outcomes for students who participated in this activity more consistently. The average grades were calculated without including the extra credits students earned for completing the MOTW assignments.

Table 3. Comparison of final course average grades of students who completed ten or more MOTW reports and the rest of the class.

Semester/Cohorts	Average Grade of the Rest of the Class±Standard Deviation (%)	Average Grade of Students Who Submitted Ten or More MOTW Reports ±Standard Deviation (%)	Class Size
Fall 2023	75.71±9.10	88.85±6.83	24
Spring 2023	82.78±11.38	90.11±8.31	37
Fall 2022	78.28±20.43	90.39±10.99	24
Spring 2022	80.99±11.08	86.55±7.91	25
Fall 2021	79.91±14.11	80.63±13.75	24
Spring 2021	81.39±16.56	90.31±6.88	29
Fall 2020	83.39±11.10	85.90±9.99	35
Spring 2020	77.77±12.18	90.19±8.41	39
Fall 2019	78.78±11.41	85.43±13.44	50
Spring 2019	83.15±11.14	90.33±8.48	61

In each semester, the average course grade of students who submitted ten or more MOTW reports was consistently higher than the average course grade of their peers. Specifically, while the average grade of the rest of the class ranged from 75.71% to 83.39%, the average grade of students who submitted ten or more MOTW reports ranged from 80.63% to 90.39%.

More comparative analysis of student performance was conducted with the help of SPSS Statistics software. SPSS was used to determine if there was a statistically significant difference in grade distribution between mean course grades of students who submitted ten or more MOTW reports and mean course grades of the rest of the class. The statistical analysis data of the student performance was summarized in Table 4. Independent samples t-test results showed that in fall 2023, spring 2020 and spring 2019 semesters, the increases between the mean grades of the two groups of students were statistically significant. The correlating p-values were not greater than 0.05, for the significance level of 0.05. In other semesters, the increases in the mean grades were not statistically significant.

Table 4. Statistical data from *t*-test studies on final course average grades of students. [a]

Semester	Student Cohorts	Descriptive Statistics		*t*-Test Results		
		N	Mean ± SD	df	*t*	*p*
Fall 2023	Submitted ten or more MOTW	9	88.85±6.83	22	3.734	0.001
	The rest of the class	15	75.71±9.10			
Spring 2023	Submitted ten or more MOTW	11	90.11±8.31	35	1.920	0.063
	The rest of the class	26	82.78±11.38			
Fall 2022	Submitted ten or more MOTW	7	90.39±10.99	22	1.470	0.156
	The rest of the class	17	78.28±20.43			
Spring 2022	Submitted ten or more MOTW	10	86.55±7.91	23	1.367	0.185
	The rest of the class	15	80.99±11.08			
Fall 2021	Submitted ten or more MOTW	7	80.63±13.75	22	0.113	0.911
	The rest of the class	17	79.91±14.11			
Spring 2021	Submitted ten or more MOTW	9	90.31±6.88	27	1.544	0.134
	The rest of the class	20	81.39±16.56			
Fall 2020	Submitted ten or more MOTW	11	85.90±9.99	33	0.638	0.528
	The rest of the class	24	83.39±11.10			

Spring 2020	Submitted ten or more MOTW	10	90.19±8.41	37	2.974	0.005
	The rest of the class	29	77.77±12.18			
Fall 2019	Submitted ten or more MOTW	10	85.43±13.44	48	1.589	0.119
	The rest of the class	40	78.78±11.41			
Spring 2019	Submitted ten or more MOTW	23	90.33±8.48	59	2.657	0.010
	The rest of the class	38	83.15±11.14			

[a] Statistically significant at the 0.05 level.

Overall, the comparative analysis of student performance suggested a possible positive correlation between engagement with the MOTW assignment and student academic performance in this course. Regular participation in reading, researching, and writing about MOTW might have enhanced student understanding and mastery of course material, thus contributing to higher course grades.

The limitations of this study include its focus solely on Organic Chemistry II classes, with discussions based on student feedback and academic performance specific to those courses. Limited sample size may reduce the generalizability of results. Stronger proof that the MOTW assignment improves student learning outcomes may be obtained by implementing a control group that does not take part in the activity. Furthermore, longitudinal studies need to be performed in the future to gain more comprehensive insights over time to capture long-term effects or sustainability of the teaching tool's impact.

CONCLUDING REMARKS

The principles of chemistry, through their applications in various organic compounds such as carbohydrates, lipids, proteins, vitamins, nucleic acids, and polymers, are intertwined with other scientific disciplines. This study demonstrated that an adapted curriculum and teaching strategy based on the MOTW approach was effective at connecting scientific concepts to real-life. This method has the potential to motivate students, create additional learning opportunities, promote adaptive learning and promote analytical thinking. An additional benefit includes introducing undergraduates to research experiences.

The authors believe that incorporating MOTW assignments into the organic chemistry course can enhance the learning experience in several ways by : (1) promoting more interest and motivating undergraduate students who were surveyed, (2) expanding students' knowledge beyond standard classroom material, (3) keeping students informed about recent developments in the field, thus potentially inspiring career aspirations, (4) improving problem-solving skills, critical analysis, and fostering creativity, (5) providing more opportunities on academic writing, and (6) improving academic performance in this particular undergraduate organic chemistry course.

This MOTW teaching tool could be adapted by instructors teaching other chemistry courses with modifications to the assignment guidelines to match the course content.

Similar to ACS's MOTW, resources are available for biology educators and students.[17, 18] Molecule of the Month (MotM) published at the Research Collaboratory for Structural Bioinformatics Protein Data Bank (RCSB PDB)[17] could be incorporated similarly in biology or biochemistry education. The education portal PDB - 101[18] offers an ongoing resource for molecular biology educators and students. Biology educators could design assignments similar to MOTW using information from the Molecule of the Month for students to write short essays on biological processes.

FUTURE PERSPECTIVES

To build on the findings of this study, several key areas for further investigation and development include: (1) Collecting and analyzing additional data to strengthen the correlation between engagement with MOTW and academic outcomes. Implementing a control group that does not take part in the activity may help to increase the validity of the results. (2) Broadening and expanding the scope of data collection to include a diverse range of student populations, including those from different disciplines and academic levels. (3) Investigating and assessing the long-term effects of the MOTW assignments on students' retention of knowledge and their continued interest in organic chemistry. This could involve longitudinal studies tracking students' academic progress and career choices over time. Collectively, these efforts may contribute to the broader scientific educational community's

understanding of innovative and effective teaching strategies and support the ongoing development of innovative curricula.

DISCLAIMERS

All data was collected with guidelines, compliance, and approval from the Salem State University Institutional Review Board (IRB).

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI:

The Google Form of the MOTW Student Survey

Numbers of Students by Semester

Detailed Qualitative Student Survey Data

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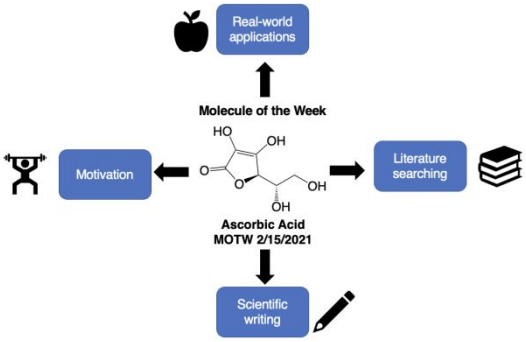

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> Integrating “Molecule of the Week” as a Teaching Tool in an Undergraduate Organic Chemistry Course

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