Symposium

Improving Completion Rates in Gatekeeper Courses

Facilitator: Steve Beyerlein

Abstract:

Every college has initiatives in an effort to improve first year and second-year gatekeeper course completion rates. Additionally, organizations like NSF keep an eye on graduation rates and they are aware that the number of STEM degrees granted depends upon student performance in these core and required courses. The panel was carefully selected of success stories of significant improvement. The outcome of this session is to produce 15 key effective strategies and practices that can be used to improve any gatekeeper course at any college.

Papers & Panelists:

Notes

A Department's Chair's Perspective in STEM

Author: David Kaplan (York College of Pennsylvania)

Students enter gatekeeper courses with widely varying backgrounds. On the most-prepared extreme, some have taken advanced placement courses in high school which have them exceptionally well prepared to perform well in gateway courses; whereas on the other extreme, some students are lacking in key background skills for the courses they are in. These students are most surely at-risk.

By working closely with each student in a classroom divided into working student-groups, the instructor-facilitator will, after a few weeks, learn each student's background and performance level. At this point, it is essential to meet each student at their level and set a series of challenges to move each student to their highest capable level, which is ideally at least at the passing level for all students.

The "intervention" has become the favored approach for working with at-risk students: identifying which students are in the at-risk category and finding pathways within the institution's framework for working with these students: to shore up their background and get them performing at acceptable levels.

The most severely at-risk students may need to meet outside of the classroom with the instructor-facilitator or with tutors at the institution's learning center. However, this asynchronous approach is not at all ideal, as it will have these students always lagging the performance level of the rest of the class, not even able to achieve lowest-level performance in each class.

A much better approach is to put the best-performing students in challenging classroom performance situations by giving them in-class problems that they can solve and present—mostly, or completely, on their own. This provides classroom time for the instructor-facilitator to work closely with the students who need background-skill shoring to be able to make progress with the new material.

So, the instructor-facilitator is a guide and challenge-giver for the best performing students and a tutor who moves the bar, in gradually higher and higher increments, for the lower-performing students. Certainly, it would be much less demanding for the instructor if they were able to simply set challenges for each student in the class and set them off on their own. This approach works well, for the most part, for the high performers.

But, for at-risk students, they need much more instructor assistance. Leaving them to build knowledge and problem-solve completely on their own will doom them to failure. They need, while they are still muddled, a guided and structured – step-wise – approach. Since there is not enough time in the classroom to work through all such steps, it is essential that the instructor have the students work through as much preparatory material as they can before each class. Ideally, the instructor has built a video lecture set that has each student, by watching and working the examples, entering the class having already built rudimentary-level skills that they can then move well beyond during the class.

After the instructor has worked closely a few times with each at-risk student—modeling the step-wise problem-solving approach—they will gradually be able to leave more and more to these students. The crucial step is for the instructor to set challenges that instill in at-risk students more and more confidence so that at some point not too far into the term, a spark awakens them and they realize that, with their newfound confidence and skill, learning and problem-solving in this field is actually a fun activity.

After this awakening has occurred, lower-performing students will *want t*o take on more and more steps on their own, eschewing guidance. They will, as their skills build, want to play the game like everyone else in the class. Every student for whom this transition happens has become a learning-process adherent; ideally with all having successfully navigated the course.

Notes

University of Louisville Project

Author: Carol Atnip (University of Louisville, ret'd)

"If you do not get out of developmental mathematics, you cannot acquire credits to transfer to a four-year institution, and you often cannot get access to vocational and technical training programs. The bumper sticker for this problem is, 'developmental mathematics is where aspirations go to die.'"

Tony Bryk, President of the Carnegie Foundation for the Advancement of Teaching

When I resigned from the University of Louisville in 2001, our university administrators had committed to partnering with Jefferson Community and Technical College to offer all developmental/remedial courses, including over 100 sections of pre-algebra and elementary algebra. At the time it was believed that new high school graduation standards would eliminate the need for developmental courses within the next few years. All students would be required to pass Algebra I in high school in Kentucky. This idea was reinforced by "No child left behind" philosophy and the adoption of the Common Core State Standards – Mathematics. In my work since leaving UofL I have found many who are skeptics.

The mid-90's was a time of changing thought in mathematics education. Documents such as The NCTM Standards and AMATYC Crossroads were calling for changes in content and pedagogy (andragogy) including more collaborative learning, discovery learning, problem solving, using technology effectively, and incorporating advances in learning theory that are widely accepted as effective learning tools in other disciplines. Concerns for high withdraw and fail rates for developmental math students were also drawing negative attention throughout the higher education community.

At UofL completion rates for both pre-algebra and elementary algebra were between 55 and 60 percent for the years of 1991 to 1995. The developmental mathematics program set about devising a plan to significantly improve the throughput of these students to make successful transitions to credit bearing math courses.

A chance meeting on a plane between Dan Apple and University of Louisville Assistant Provost Tom Crawford led to a major revision of University of Louisville's developmental mathematics program. Tom asked Dan Louisville's basketball score which led to conversation, including educational philosophy, and culminated with a date for a Teaching Institute in fall 1994. One of the attendees at that first UoL introduction to Process Education was Carol Atnip, program coordinator of developmental mathematics. After the initial one day teaching institute at UofL, Carol attended a week long institute in Espanola, New Mexico in spring 1995, which led to developing a strategic plan for making significant change to the development math program in Transitional Studies unit at University of Louisville.

Partnering with Pacific Crest was an ideal way to incorporate the above changes through adopting Process Education philosophy. Pacific Crest offered faculty development on a continuing basis each semester and published classroom materials for students designed by UofL faculty. The project had some limited funding by the Transitional Studies Division, but essentially was a supported collaboration between the developmental math program and Pacific Crest as a pilot of Process Education into developmental math.

The Plan

The plan was developed for a five year time-line. Beginning in the summer term of 1995, two instructors began developing PE materials on a day-to-day basis for implementation of PE with collaborative/discovery learning in a prealgebra class. Writing activities with emphasis on critical thinking and discovery learning was challenging, but the students seemed very engaged and appreciative of our efforts. There were four sections offered using PE in fall term. Spring term had all sections (8 in total) using PE materials. The prealgebra completion rate in fall 1995 was 53.1% and rose to 67.6% in 1996; a substantial increase of 14.5%. Encouraged, we began the second year using the same method to pilot changes for Elementary algebra. In fall 1996 there were 10 sections of Elementary algebra using PE and 17 using lecture. By spring 1997 11 sections used PE and nine used lecture, but all had access to critical thinking questions and learning to learn materials. A summary of the results showed that the completion rates of the PE sections outperformed the lecture sections by 10 percentage points. During years 3,4 and 5 a major effort was evaluating changes through pass rates and assessing materials developed in-house for needed changes on a continuing basis.

Math 075 Prealgebra

Term	Pass Rate (-W)	Comp Rate	Students
95S	53.1 %	42.9 %	181
95F	62.5 %	57.5 %	308
96S	67.6 %	59.3 %	162
96U	86.7 %	76.5 %	17
96F	65.7 %	60.0 %	460

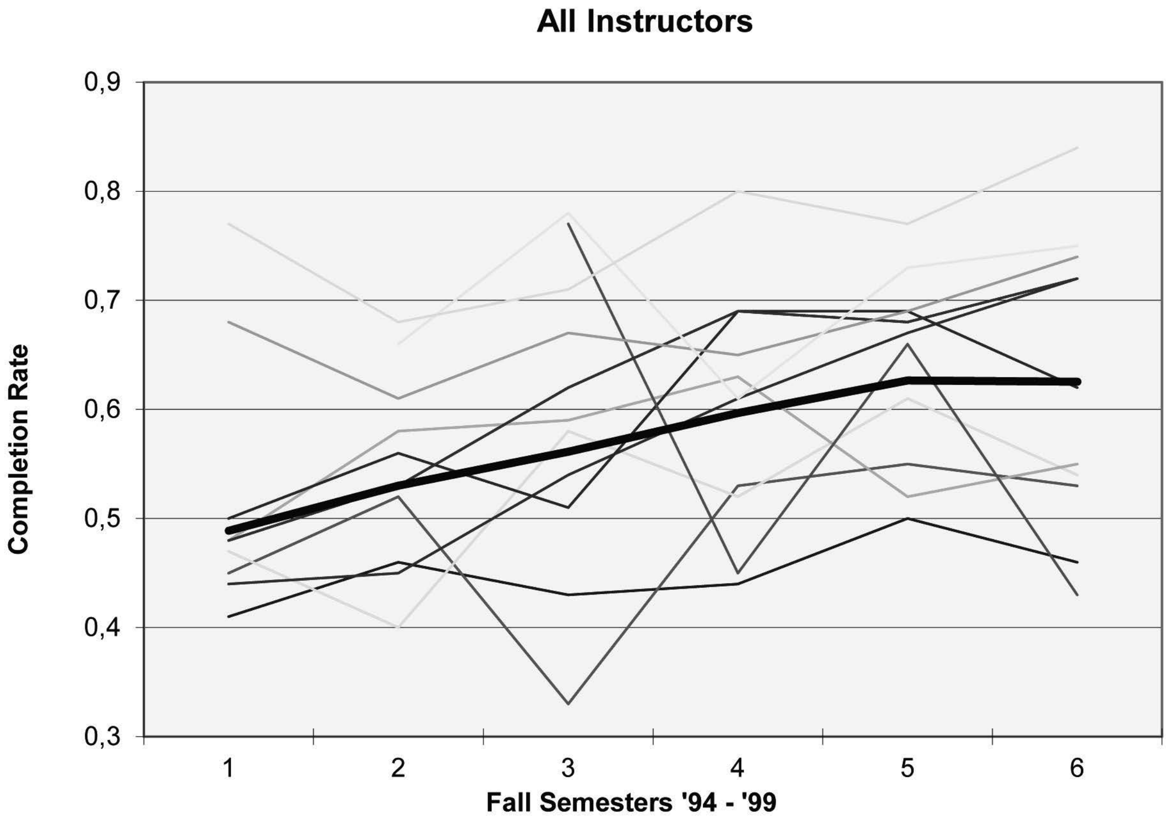
Math 099 Elementary Algebra

Term	Pass Rate (-W)	Comp Rate	Students
95F	60.4 %	51.2 %	787
96S	47.9 %	39.8 %	477
96U	68.3 %	57.7 %	78
96F (Process)	72.0 %	64.3 %	359
96F (Lecture)	64.4 %	55.3 %	441
96F (Total)	67.9 %	59.4 %	800

Also of interest is that the number of Ws given in Process sections was 35 (9.7%), and the number in the non-Process sections was 67 (15.2%).

Team Building and Buy-in

Besides the obvious change in completion rates, highlights include a more engaged faculty, clearer department goals, and participation and connectedness with part-time faculty. Many sections were taught by part-time faculty hence it was important to get them involved in the process of change. They were included on every level, invited to all faculty development activities, and asked to participate in developing, editing, and assessing materials for the good of students and the success of the program. Some faculty embraced the changes more than others. Buy-in was tenuous for some. Following is a graph that shows completion rates linked with faculty buy-in based on performance in faculty development activities by individual instructors.



Developing Materials and Building a Community

One of the major tasks of this project was the development, assessment, and strengthening of classroom activities. Revisions were done on a semester by semester basis. We found that the more an instructor had contributed to the classroom activities, the higher their students would rate the materials. The students needed to have confidence in the materials and so if the instructor approved of an activity, the student would as well.

As issues arose over the course of the project we would develop a tool to address it. For example, instructors often complained that students missed class or did not come prepared. Developmental students need prompts to help them comply/cope with demands. We developed the Persistence log (*Faculty Guidebook*) to help them visualize their success in getting to class, prepared, and participating.

Creating and sharing resources helped keep all sections in agreement as to time management and content. A faculty guidebook/handbook was created which included test banks for each course, work sheets, supplemental material, etc. A common syllabus was developed incorporating standard expectations and a standard final exam was given. In the spirit of openness and truth in advertising, we began posting completion rates and scores on the final exam in department reports.

Conclusion

Developing a strategic plan for dramatically changing the teaching of developmental mathematics was a serious and worthwhile venture. With the help of faculty development opportunities and a massive amount of coaching by Pacific Crest we were able to complete our project as planned. Student performance improved, instructors became better facilitators, instructors became more tuned to students needs and involved with student outcomes and success, attendance improved, and persistence in the classes increased.

Notes

Equipping and Motivating Students to Succeed in Previously Failed Gateway Courses

Author: Janet Vigna (Grand Valley State University)

Abstract:

The GVSU Academic Success Camp engages academically at-risk freshman in an immersive experience in Process Education. Students work in teams to learn a variety of skills and grow their academic performance with the facilitation of faculty mentors. It is a camp objective for students to emerge with a well-developed academic toolbox and intrinsic motivation for success as they repeat failed gateway courses the following fall semester. The camp serves as a model for techniques and strategies that may be used in gateway course curriculum to improve student success, ultimately eliminating the need for at-risk interventions.

The first year college experience includes a variety of challenges, both social and academic. Many incoming students have not yet learned the study and time-management skills required to meet college-level rigor and expectations. They have not learned to problem solve their way through difficulty. Most freshman have never lived on their own before and don't know where to go for academic and emotional support. In addition, students are often financially burdened with full time jobs in addition to their full course loads. Regardless of the reasons, for many students the transition to college becomes a roadblock that puts them at an academic crossroad. Is college for me? Can I make it through successfully? Did I choose the right major? What do I do if I fail? These are the questions that many freshman are exploring as they finish their first year of college and find themselves with a rough start particularly in gateway courses, and a subsequent gpa hole from which to climb.

The GVSU Academic Success Camp just completed its second successful year in May. The week-long residential camp works with students who are in academic jeopardy following their freshman year to restore confidence and build academic performance through process learning methodology. The camp was developed as an important retention initiative for students considering an alternative to Grand Valley, largely due to unsatisfactory work in gateway courses in their majors.

During the camp, students engage in immersive experiences that force them to work with and find strength in teammates. They are overwhelmed with a rigorous workload that forces them to prioritize and make choices about time-management. Students engage in exercises that challenge them to look at failure from a positive perspective, and then to turn their personal failures into action plans for future success. The camp stresses feedback assessment from faculty mentors as a mechanism for performance growth and bases its curriculum in the development of an academic toolbox students can use in their future coursework. The development of self and team assessment strategies, writing skills, reading comprehension, metacognition, problem solving, leadership and deep reflection are practiced and improved over the course of the week.

The GVSU Academic Success Camp has been successful at retaining a large proportion of these students for the following academic year, increasing retention rates over those at-risk student groups that don't engage in the camp. Subsequent student success in repeated gateway courses is under initial study. We feel that the camp curriculum helps prepare students to tackle the challenges of gateway courses in a way that K-12 education may not. For many of these students the desperate reality of the academic struggle marks a turning point in their readiness for such a curriculum. They find they are not alone in the struggle and they can go public with their difficulties, seek help, and grow performance in a socially safe environment.

Science educators in particular are aware of the large percentage of students that underachieve in gateway curriculum, including introductory Biology, Chemistry and Mathematics courses. Students come into college ill-equipped to transition from more prescribed high school schedules and homework patterns to a college model where much of their learning takes place outside of the classroom and requires an extensive commitment of time and intrinsic motivation. There is interest among faculty in what might be learned from the Academic Success Camp curriculum that can be applied in gateway courses either before or at the onset of academic difficulty. Can we inspire internal motivation and a habit of self-reflection in students that have never before needed it to succeed? Can we give students authentic practice in effective learning strategies as part of our basic college curriculum, instead of assuming they already have these skills in place and will practice them on their own? Can we develop a handbook for the essential key practices that all gateway courses should include in order to increase student success throughout the arc of college? These are the questions educators must finally answer if we really are authentically committed to the success and retention of every student.

Notes

Creating A Need to Know Through Process Education

Author: Ehren Bucholtz (St. Louis College of Pharmacy)

One of the St. Louis College of Pharmacy's (STLCOP) institutional goals for teaching is for our faculty and students to be involved in active learning. This is based on the hypothesis that students must be engaged with the materials they are learning for true knowledge and understanding to be gained. Therefore, I have made it a priority to choose one particular method of active learning, process oriented guided inquiry learning (POGIL)[1] as a starting point for development of my own teaching methodology. My approach encourages process-oriented skills – such as problem solving, critical thinking, and communication, while students construct knowledge by working with me as a facilitator rather than simply receiving information from me.

I have found however, that I needed to alter the POGIL methodology to fit the needs of our students. A well understood problem in the field of chemical education is the perceived irrelevance of the subject of chemistry to the everyday lives and future careers of students taking those courses.[2] It has been suggested that the perceived lack of relevance is rooted in the way we teach chemistry.[3] Much of the focus is placed on the chemical principles that need to be learned, and not upon its application to the students' future endeavors. As faculty, we focus on the facts and concepts of the subject itself, mostly within the logic of the discipline.

Only after students have learned the fundamental building blocks of atoms and molecules, as well as interactions between those species at a physical and energetic level, do we begin to apply these seemingly esoteric items to matters of interest to the students. Unfortunately, application tends to be an afterthought at the end of a unit and not included on exams, further reinforcing the lack of relevance to students. For students who wish to be future chemists, this approach might be fine, but for non-chemistry majors there is little enticement to learn the core concepts except for a grade.

It is this lack of connection that frustrates students when it comes to learning chemistry.[4,5] Chemistry is, to them, a set of ideas that need to be learned and regurgitated rather than applied. Without the application of those ideas, students do not internalize the concepts and use them in future learning or professional settings. Furthermore, studies indicate that many adult learners will only make measureable gains in knowledge of the subject when it is meaningful and has direct application to their immediate needs and learning goals.[5]

STLCOP's students are not chemistry majors, and generally are not driven to take organic chemistry but for the need as a pre-requisite. Therefore, I have had to create my own version of active learning. Guided inquiry learning is great for developing skills, but it lacks in developing a passion for the subject. Therefore, I have created a novel approach to Process Education that combines the positives of POGIL, with the necessity for learning found in problem based learning. To solve my teaching problem, I created a series of "Who gives a darn? (WGAD)" topics that meet all the teaching needs of the organic chemistry sequence while relating the necessary learning objectives to real life situations.

The result is a workbook[7] of 66 activities that covers the necessary concepts that are covered in a two semester organic sequence. The premise is that each class day requires the coverage of specific learning objectives, but these objectives can be used as way to solve a particular problem.

Each activity begins with background information and a WGAD question that can be answered through the material that would be traditionally covered in a typical class day in organic chemistry. Students are presented early on with ideas that need to be explored deeper in the classroom activity. Through learning the new material of the activity, students can answer the WGAD presented. Much like a traditional POGIL activity, students are presented with learning objectives, success criteria, models and critical thinking questions. Models are not used to directly answer the WGAD question, but to explore data and invent concepts that can be used to explain the WGAD situation. The difference in these activities is that the students are encouraged to use these new concepts through a new set of questions to an answer about the WGAD question.

For example, a classic organic reaction that students learn is electrophilic addition of bromine to alkenes. For students who want to become synthetic organic chemists, this is an important topic by itself. However, for students taking this sequence for foundational background, a need to know is critical to encourage deep learning that can be applied elsewhere. The "Who gives a darn?" for this topic is – How can citrus flavors that are generally insoluble in water be added to drinks such as Mountain Dew? The solution to the problem is through a bromination reaction and formation of brominated vegetable oil. Students are provided with all the background information and tools to explain how the brominated vegetable oil is formed and why it solved this particular problem. (See Activity 28 from *Foundations of Organic Chemistry*, available on the following pages.)

Sometimes the WGAD question is simple, and can be answered within a few minutes of class, other times; it takes the entire class period to build the knowledge framework to be able to explain the chemistry behind the question such as the one of brominating vegetable oil. By the end of the workbook, the topics are very complex and require multiple learning experiences to generate the knowledge required to answer the question.

As an assessment of the workbook's effectiveness, students have taken the American Chemical Society's End of Year Organic Chemistry Exam FORM2012[8] a 70 question normalized exam covering many topics of organic chemistry. Not everything covered on the exam is in the workbook as the workbook was not intended to teach to the test. Of the 70 questions on the exam, 50 questions were determined to be questions that students should be able to answer from material covered in the workbook. Two groups of students from STLCOP have taken the test. The first group of STLCOP students were in the traditional second year organic curriculum. The second group of students were in a newly revised curriculum where general and organic chemistry is taught concurrently over a series of four semesters, however, the organic component is completed after the third semester of college.

As indicated in Table 1, the two groups of STLCOP students compare favorably to the national normative data for the ACS exam. While the averages are slightly lower than the national average, the groups are not statistically different. Given that the workbook does not cover all aspects of the exam, and that students are not chemistry majors, the results indicate that the materials are effective in helping students learn the major concepts of organic chemistry.

Table 1 STLCOP students ACS End of Year Organic Exam Results compared to National Norms

	National Normalized Data	STLCOP 2014-2015 Traditional Sophomores	STLCOP Fall 2015 New curriculum
Mean	**36.99**	**34.45**	**34.49**
Std. Deviation	**10.62**	**7.70**	**8.38**
Median	**35.2**	**34**	**33**
Number of students	**4230 in 71 colleges**	**201**	**164**

This workbook started out with the hypothesis that every organic chemistry class day can have meaning beyond the classroom. The overarching goal for using Process Education is to help students learn chemistry not as an end in itself, but as a basis for lifelong learning, and especially as a key method to inform their career endeavors. Teaching organic chemistry is not about information transfer, it is about student learning. While not all the students appreciate the process initially—after all, learning is hard and takes mental energy—I am able to support the students as they take ownership of the material and see that the material does help them to see the world through the eyes of a chemist.

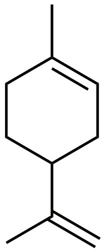
Endnotes

1) "Instructor's guide to process-oriented guided-inquiry learning." Hanson, D. M. 2006, Pacific Crest, Lisle, IL
2) "Making Chemistry Relevant: Strategies for Including All Students in a Learner-Sensitive Classroom Environment" Sharmistha Basu-Dutt editor 2010, John Wiley & Sons, Inc. Hoboken, New Jersey.
3) El-Farargy, N. Evaluation of a chemistry curriculum intervention using the Perry model of intellectual development *Chem. Educ. Res. Pract.*, (2010) 11, *98–106*
4) Carter, C. S.; Brickhouse, N. W. *J. Chem. Educ. (*1989) 66, *223*.
5) Seymour, E. *J. Coll. Sci. Teaching*, (1995), *May*, *392*.
6) Knowles, M.S. *The adult learner: a neglected species*, (1990), 4th ed. London: Gulf Publishing Company.
7) *Foundations of Organic Chemistry* by Ehren C. Bucholtz, 2015, Pacific Crest, Hampton, New Hampshire.
8) http://chemexams.chem.iastate.edu/sites/default/files/national-norms/OR12_Norm_Sheet.htm accessed 5/30/2016

CLASSROOM ACTIVITY 28

Halogenation of Molecules with π Bonds

Who Gives a Darn?

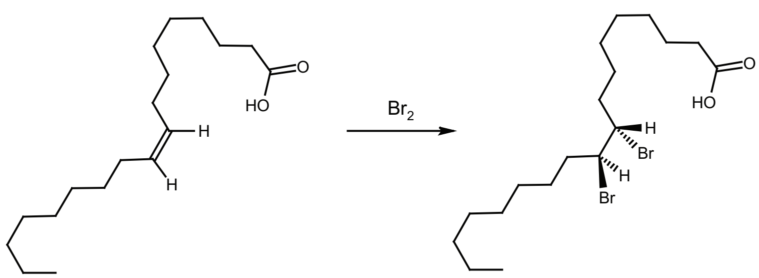


limonene

Limonene, a terpenoid explored in Activity 25, has a citrus flavor and aroma and is the terpenoid found in highest concentration in lime oils. This molecule is often added to citrus-flavored soft drinks such as Sprite, Fanta or Mountain Dew. However, it is not soluble in water due to its non-polar qualities. To improve the solubility of this molecule and other citrus flavorings, soft drink manufacturers have developed a method for solubilizing the citrus additives. By adding another molecule that has both polar and non-polar qualities, an emulsion can be formed that helps to keep the limonene in solution.

This is achieved through addition of a modified vegetable oil.

Vegetable oil has a density of about 0.9 g/ml, which is less than water. By itself, it will not dissolve in water, and will float on top. Since the water and vegetable oil are not miscible, two layers would form and the terpenoid would dissolve in the oil and not the water. The "solution" to this solution problem is to change the vegetable oil to brominated vegetable oil (BVO).



Oleic acid
(a component of vegetable oil)

Brominated
Oleic acid

By chemically reacting bromine to the oil, the vegetable oil's density can be increased to that of water. While the oil doesn't dissolve in water, it has the same density of water and the BVO molecules remain suspended in the water. This results in an aqueous mixture that can dissolve the limonene.

The reaction between vegetable oil and bromine seems unlikely considering that the alkene is a weak nucleophile, and diatomic bromine is a neutral molecule. In today's WGAD, you will explore how alkenes can be brominated.

Learning Objectives

1. Apply temporary dipoles to halogens to generate electrophiles.
2. Compare nucleophilicity of two species to determine products in a reaction.
3. Determine stereospecificity in an addition reaction.
4. Apply Markovnikov's rule to a situation that does not have addition of hydrogen.

Success Criteria

- Predict products including stereochemistry and regiochemistry of electrophilic addition reactions of halogens with molecules containing π electrons
- Use electron pushing arrows to show product formation of addition of halogens to alkenes and alkynes
- Predict products including stereochemistry and regiochemistry of electrophilic addition reactions of halogens with alkenes where other nucleophiles are present

Prerequisite Knowledge

I am ready for this activity because I can...

...describe how temporary induced dipoles in molecules result in partial charges.

☐ **Yes!** ☐ ***No*** ⟶ Review Activity 8: Model 1, CTQ #4

...determine the absolute configuration of stereogenic centers.

☐ **Yes!** ☐ ***No*** ⟶ Review Activity 16: CTQ #11

...explain why secondary alkyl halides can react via S_N1 or S_N2 reactions.

☐ **Yes!** ☐ ***No*** ⟶ Review Activity 20: Model 1, CTQ #2; Activity 23: Model 1, CTQ #1

...draw the mechanism of electrophilic addition of H-X and H_3O^+ to alkenes and alkynes.

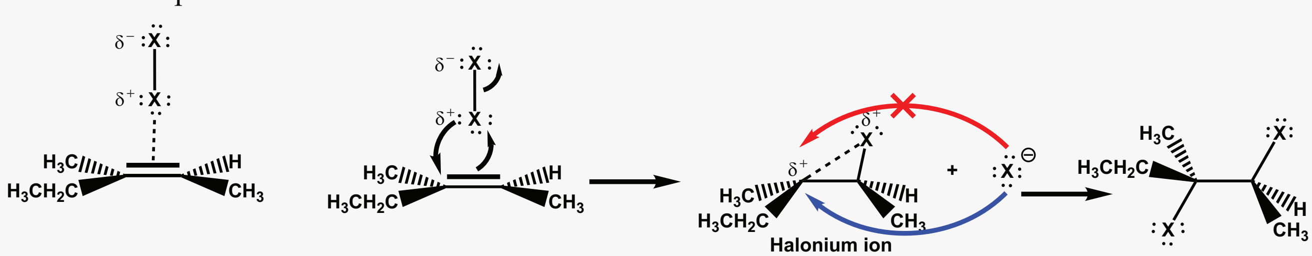
☐ **Yes!** ☐ ***No*** ⟶ Review Activity 27: SYK #2, #5

...can give examples of *syn* and *anti* addition.

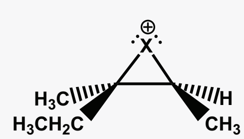
☐ **Yes!** ☐ ***No*** ⟶ Review Activity 27: CTQ #5

Model 1: **Halogens React with π Bonds via Electrophilic Addition**

The diatomic halogens, Br_2 and Cl_2, interact with alkenes to form halonium ions. This is possible because the high electron density of a π bond causes a temporary induced dipole in the halogen. A concerted reaction occurs between the alkene and the halogen to form the halonium ion. Finally, nucleophilic attack results in the product.



Note: Most textbooks draw the halonium in the following way, but the reaction products are the same



Critical Thinking Questions

1. Propose a way that an alkene can cause induction of a dipole in a non-polar molecule like Br_2.

2. The halonium ion is not symmetrical in the model, and results in a carbon with a δ^+.

    a. Why is the partial charge on the indicated carbon of the original double bond, and not on the other?

    b. Laboratory evidence indicates formation of the dihalide occurs via an S_N2 mechanism. Provide steric and electrostatic arguments to explain why the bottom electron pushing arrow in Model 1 is correct and the top arrow is incorrect.

3. Which of the following best represents the formation of the final product?

    a. Anti addition resulting in a geminal dihalide

    b. Syn addition resulting in a geminal dihalide

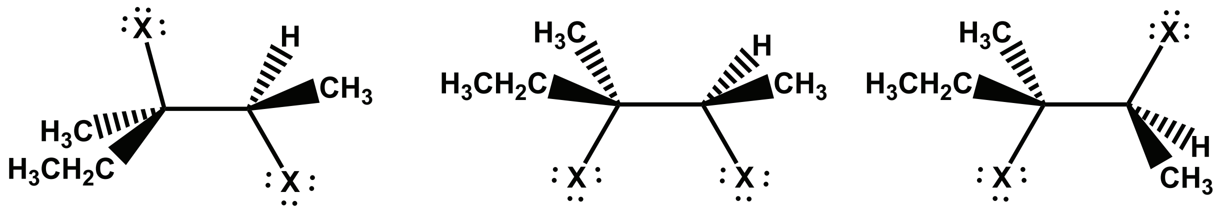
    c. Anti addition resulting in a vicinal dihalide

    d. Syn addition resulting in a vicinal dihalide

4. The halogen can also interact with the alkene by approaching from the bottom side.

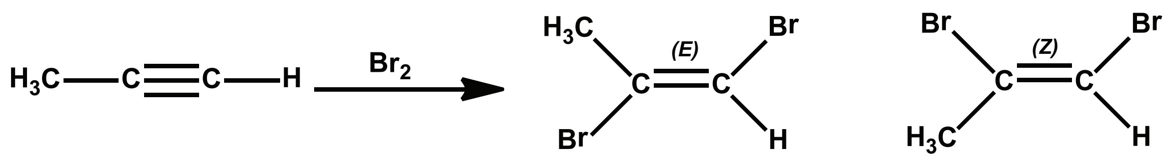
    a. Draw the halonium ion that is formed from this approach of the halogen

b. Explain which of the following best represents the product that forms from that halonium ion.



c. What is the relationship of the products formed in Model 1 and Question 4b?

5. When one equivalent of bromine reacts with 1-propyne, a dibromoalkene product is formed. Do you expect the product to be the E or Z stereoisomer? Explain.



6. Starting with either 1-butene or 1-butyne:

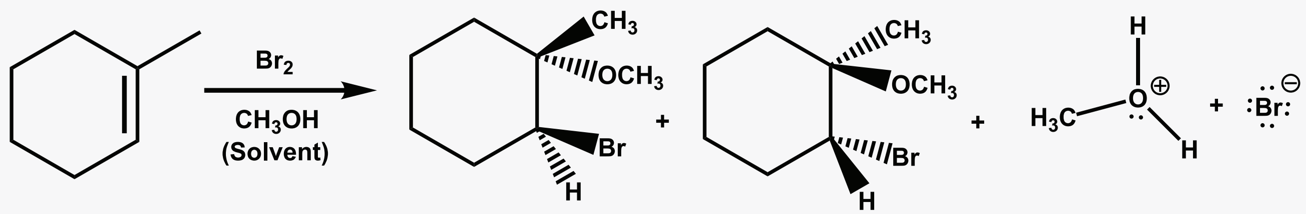
a. Propose a synthesis to form 1,2-dibromobutane

b. Propose a synthesis to form 2,2-dibromobutane

c. Propose a synthesis to form 1,1,2,2-tetrabromobutane

Model 2: **Halogenation Reaction with Other Nucleophiles Present**

In the halogenation reaction in Model 1, only one nucleophile is present (X^-). However, if another nucleophile is present, it can react with the halonium in an S_N2 mechanism, followed by deprotonation.



The product that forms when the solvent is an alcohol the result is an α-bromo ether. If the solvent is water, the reaction forms a halohydrin.

7. Draw the ***unsymmetrical*** bromonium ion that results in the product shown below from Model 2.

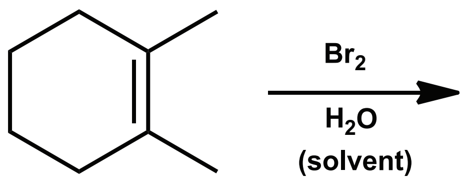
8. It would be expected that tertiary alkyl halides react via S_N1 mechanisms.

   a. Are the new groups incorporated via *syn* or *anti* addition?

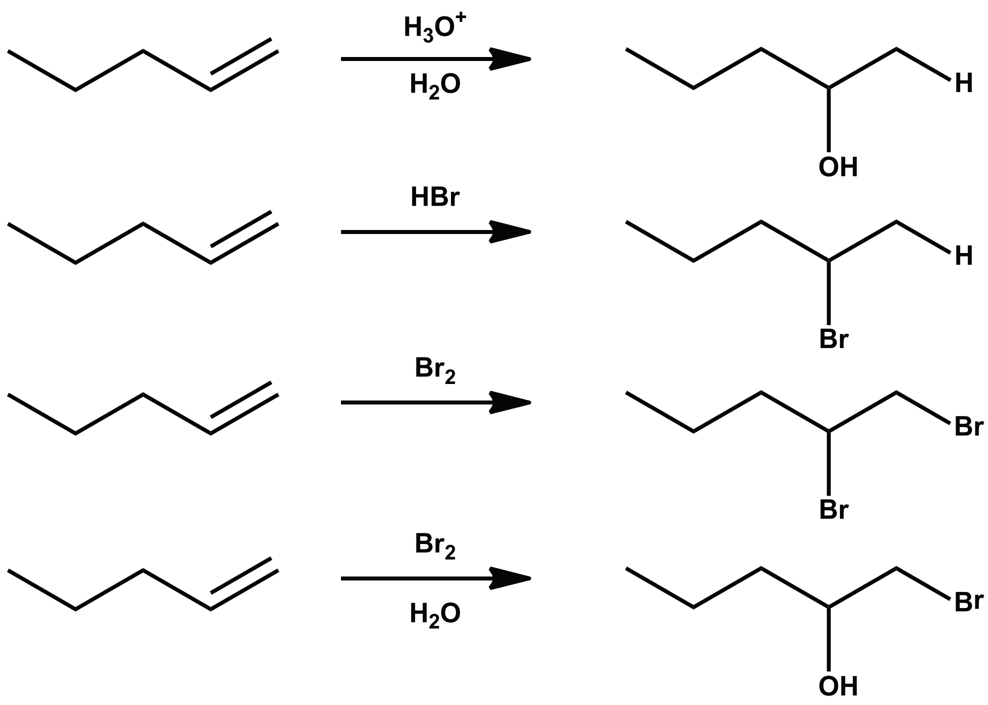
   b. What evidence is provided in the products to indicate that the products must form via an S_N2 and not an S_N1 mechanism?

c. Bromide is a better nucleophile than methanol in S_N2 reactions. Why is nucleophilic attack on the bromonium by methanol much more likely than bromide?

9. Propose the enantiomeric products that form from the following reaction:



10. Previously Markovnikov's rule was stated: "in an electrophilic addition reaction, the hydrogen adds to the carbon of the alkene that has the most hydrogens." However, in halohydrin-like reactions, hydrogen has not been added to the double bond. How can Markovnikov's rule be modified to explain the results of the following reactions from the perspective of the nucleophile?



Who Gives a Darn? I Do!

1. Propose a mechanism for the addition of bromine to oleic acid- one of the key fatty acids found in vegetable oils: