Evaluation Report for the Design of a Blended-Learning Organic Chemistry Unit

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Abstract

The development of a blended-learning organic chemistry course demands many skills and competencies. Not only must the designer undertaking such a project take into account learning theories that are relevant to learning organic chemistry, but also instructional design models that will facilitate student success. In this project, I developed a unit for a blended-learning organic chemistry course taking into account many of the learning principles outlined by Cognitive Load theory. The difficult nature of the course demanded that many of the activities contained within were informed by Keller's ARCS Model for motivational instructional design. The systematic development of the instruction largely followed that suggested by the Dick, Carey, and Carey model for systematic design, and the design of the course website leaned upon principles outlined by the *Blackboard Exemplary Course Program Rubric*. After the unit for the course was developed it underwent a formative evaluation to assess several factors. The efficacy of content delivery was determined by way of a summative assessment of the students; the presence of motivational factors was evaluated by a learning specialist; and the usability and navigability of the website was ascertained by surveys and questionnaires filled out by several UC graduate students and an IT expert. The feedback provided served as the foundation for course revisions. Finally the revised course will be presented in an IDT TIE Showcase at University of Cincinnati, on December 3rd, 2019, whereupon I will have to defend the choices made in the course design and development.

Evaluation Plan for Design of a Blended-Learning Unit of Organic Chemistry

Background and Scope

During the 2015/ 2016 academic year, I had the opportunity to teach for the first time an Organic Chemistry course to high schoolers. The course came about after an excellent general chemistry student of mine who had plans to attend a nursing program in college asked me to teach the class. In conversations with older friends already enrolled in nursing programs at Wright State University in Dayton, she had grown very familiar with the reputation college-level organic chemistry had – as a weed-out course. Anecdotal accounts of the difficult nature of organic chemistry are not uncommon, as C.J. Blair, chemistry professor and columnist for the Oberlin Review remarks that nearly every non-science major at Oberlin has an anecdote concerning a “friend” who stressed over a plummeting GPA on account of a failed exam, or botched lab. This was similarly my own experience as a molecular biology undergraduate.

Intrigued by the young student’s disquieted request, I turned my attention to the chemical education literature to see if concerns regarding the difficult nature of organic chemistry were addressed. The literature had much to say: Joel Karty, Assistant Professor of Chemistry at Elon University and author of an excellent organic chemistry text, *Organic Chemistry – Principles and Mechanisms*, stated, “Organic chemistry is a notorious class among undergraduates. Its perceived difficulty seems to resonate across all majors,” (2007, p. 1209). Karty is not alone in this observation as Grove, Hershberger, and Bretz (2008) remarked, “As students watch peers struggle, the myth that organic chemistry is an impossible, unforgiving subject is regrettably passed on to the next generation of students” (p. 157). Still other researchers acknowledged that since there are many college programs that require a passing grade in this course, the inability to pass becomes a game-changer for students as countless end up dropping out of their programs of first choice as a consequence (Anderson & Bodner, 2008).

Course Evolution

Below is a delineation of the evolution of the technology used in the course over three years or iterations. In short, in the first year, we used a textbook only. The second year saw only a textbook and class website. The third year is of principal interest as I am now implementing the course website, textbook, and video instruction.

First iteration. In that first year of teaching, the course followed a flipped or “inverted” classroom format. In typical flipped design, students were required to teach themselves the basics of the content on their own, and bring to class only the most difficult questions (Bermann & Samms, 2012). This format is very conducive to teaching homeschool students, as most academic courses taught to these learners use this format intuitively, as a matter of necessity. Since all the students in the class were exemplary and very motivated, they did quite well at teaching themselves the content - yet time and media constraints did not enable us to get through enough of the textbook.

Second iteration. After completing a summer course at University of Cincinnati on Design for Online Learning Environments (CI 7071), I was made aware of many tools and techniques that could be used for facilitating organic chemistry instruction in a *blended learning environment*. Having used the template I generated from the project I had to complete in CI 7071, I set up something like a learning management system (LMS) using a Weebly website. The website included a weekly announcements page, some text and image-based instruction, a few videos, and a weekly check-off list. With these added supports, I was able to make more progress in the course – covering more materials, but still not enough. Students found themselves overwhelmed still by the very thick college-level textbook. It also seemed the very highly conceptual nature of the topics covered in the course demanded additional instructional resources for these self-learners than what could be provided by the textbook, or even a website. Thus, I considered augmenting the course with additional technological supports.

Third iteration. Organic chemistry students fail for many reasons, among them is the issue of the “tyranny of content,” as the course is often packed with a voluminous amount of instructional material, activities, labs, and assessments (Kennepohl, 2012, p. 671). If such a course is not well-designed – meting out chunked information in a logical, engineered sequence, the content tyranny inevitably leads to cognitive overload (Sweller, Ayres, & Kalyuga, 2011, pp. 67, 68). With the prior year completion of the website, I decided this year to add video instruction, with each video covering exactly one “Section” from the textbook. Great care was taken so that the videos were limited to using *only* images, figures and problems that were in the course textbook, in exactly the same sequence, for the purposes of alignment and to prevent extraneous cognitive load (Sweller et al., 2011, p. 57). The problem of cognitive load is of great importance, as Keller (2009) has identified this as a factor that undermines motivation.

The first month of the academic year was very promising. Within the class, there were three students who did not fulfill the general chemistry prerequisites, as they are taking the organic chemistry class concurrently with general chemistry. After the first three weeks of instruction, all three commented at how beneficial the videos were in helping them to understand material they really had no background for. The recommendation to these students was to watch the instructional videos first, and refer to the textbook for additional support, whenever solving homework problems. This proved to be very beneficial to these three students, as their first test score averages were much higher than the group of students who took the class last year – all of whom had satisfied the general chemistry prerequisites. Hopeful by this data, I decided to use a blended learning environment for the entire year. This project tracks only the Chapter 2 data for this course.

In conclusion, preliminary results suggest adding video instruction to the existing course architecture would enable me to disseminate material in even more controlled, focused chunks limiting intrinsic cognitive load (Sweller et al., 2011, pp. 57 – 61). For the purpose of my Master's Project, I was particularly interested in whether this new suite of technology tools offered to students would improve their performance in the third iteration of the class.

Development and Design

Since I was developing an artifact that covered a very challenging course, it was necessary that careful consideration be given to its design. This design can be thought of as a three-legged stool comprised of: (1) the instructional materials (instructional videos, homework problems, laboratories, and assessments), (2) motivational factors to facilitate feelings of self-efficacy and confidence, and (3) website design. Each respective leg demanded an instructional model that was specific to the leg's purpose.

Instructional Materials

When compiling and publishing the instructional materials, I implemented many of the recommendations made by the Dick, Carey, and Carey (2015) systematic model of instructional design. The model recommends starting design with goal identification (pp. 15 – 28), and goal analysis (pp. 41 – 51), which in turn provides the basis for developing an instructional analysis (pp. 61 – 77, 95 – 105), informing performance objectives (pp. 117 – 127), by which emerge assessment instruments (pp. 137 – 148), followed by an instructional strategy (for intellectual skills only [pp. 173 – 189, 219 - 230]). Following the instructional strategy, instructional materials are selected, modified, and developed (pp. 251 – 264). In the last phase of the design, Dick et al., (2015) suggest the designer implement formative evaluations with the aim of revising and improving the instructional materials (pp. 283 – 301). The instructional materials included videos, chapter homework questions, quizzes, exams, and laboratories.

Instructional videos. One of the strengths of providing instructional videos is that the visual, textual, and auditory elements can be engineered more precisely per unit time, to minimize cognitive load. A big problem for readers of science textbooks is they get overwhelmed by all the visual and textual elements on the pages – to the extent they experience extraneous cognitive load (Sweller et al., 2011, p. 57). With a screencast video, however, the designer can control the amount of content presented per unit time, so intrinsic and extraneous cognitive load is minimized as the focus can be narrowed. Although the textbook company – Norton Publishing – provided some basic PowerPoint slides for instructor use, I redesigned the slides, allowing only 35 words or less per slide whenever possible, and careful to keep the pace of presentation reasonable (Mayer & Moreno, 2003).

Whenever developing instructional materials, Dick, et al., (2015) state an effective strategy is to sequence and cluster content, and generate an opportunity for students to demonstrate their knowledge of that content (pp. 174, 175). While developing the instructional videos, I made certain to sequence and cluster content so that it aligned with the textbook. As importantly, I provided opportunities for students to demonstrate their knowledge of that content by inserting relevant homework problems enabling learners to pause the videos, try to solve the problems on their own and then resume to see the worked out solutions.

Assessments. Norton Publishing provided a very generous test bank as a resource for teachers. For the purposes of the chapter under review by this project (Chapter 2 – Three-Dimensional Geometry, Intermolecular Interactions, and Physical Properties), I had the learners take a summative assessment with nearly all of the multiple-choice questions provided by the test bank. In addition to this, the learners also participated in formative assessment quizzes during class time so as to gauge their learning. The scores from these quizzes are not under consideration in this study, only the summative assessment for Chapter 2 (see Table 1).

Homework assignments. As with the assessments, I can take no credit for authorship of the homework assignments as they came directly from the textbook. The only credit I can take is that I copied them from the various sections of the textbook and consolidated them all in a single document. Students were instructed to print this document out in advance of watching any videos, and have it on hand to answer questions as they watched the videos.

Laboratories. In the two weeks students spent in this chapter, they participated in two laboratories: one was a molecular modeling lab on molecular geometry (VSEPR theory), and the other was a laboratory wherein they made mayonnaise. These labs were administered as the material corresponding to them was covered in the textbook. The importance of the VSEPR lab was that students could actually build real three-dimensional molecules and appreciate bond angles and geometry. The mayonnaise lab provided a powerful illustration as to factors involving solubility of compounds and intermolecular forces.

Motivational Elements

Recognizing that many students come to the organic chemistry classroom with a sense of anxiety (Grove et al., 2008), it seemed very important to enhance feelings of self-efficacy, which in turn would improve motivation. To accomplish this, I implemented many of the recommendations stemming from Keller's ARCS Model for instructional design (1987) whenever and wherever possible.

Attention. Keller reminds us that the nemesis to attention is boredom (2010, p. 47), making it important then, to (1) capture the learner's interest, (2) stimulate an attitude of inquiry, and, (3) sustain the learner's interest over the long term. Knowing this, it seemed appropriate to employ many of Keller's recommendations as provided in *Table 1 – Attention Strategies* (Keller, 1987).

For starters, the course design has a varied format of instruction, such as homework problems, in-class quizzes, a take-home exam, and laboratories. The medium of instruction is similarly varied, as students can watch instructional videos, read material from the textbook, come to class to discuss, read content on the class webpage, and collaborate with friends in the completion of homework problems. Care was taken not only in videos to embed problem-solving activities at regular intervals but also during class discussion, as Keller recommends the provision of worked out examples of every instructionally important concept (1987, p. 4). Whenever possible, content-related anecdotes were also presented so students could relate everyday phenomena to organic chemistry principles. Finally, materials were varied – and this was a function of the very excellent textbook that Karty provided, as it was replete with images, diagrams and tables.

Relevance. It is crucial in a class that is exceedingly difficult, requiring a significant investment of the learner's time, that the learner is convinced the material has a personal relevance to his or her life. If the learner is convinced the material will further their future goals, that it can be applied "on the job," or in "real life," they are more inclined to see the material's relevance and be willing to make the time investment to master it (Keller, 2010, p. 48).

During face-to-face class time and in the instructional videos I reminded students often of the *present* intrinsic value of the content, in addition to *future* learning value. The case for the present value involves how knowledge of organic chemistry can make the students better chefs, more informed consumers, and gain a greater understanding as to how the world works. The future value is apparent; if the students do well in this course, they will be better prepared for success in their college-level class.

For many learners, affiliation and having a sense of belonging to a learning community is very important and provides to them yet another motivation for doing well in the class –

especially if they do not yet appreciate the value of the content itself (2010, p. 49). Understanding this, there were many opportunities for students to satisfy the need for affiliation, as they worked together on problems and labs. These opportunities were under conditions of low risk, as there was an overall environment of trust within the classroom – learners were comfortable to explore options and respectfully debate amongst each other, correct answers to questions.

Lastly, while novel events or stimuli can peak learner's curiosity and get their attention, they do demonstrate interest in content that has some prior connections to past experiences and things they already know (Keller, 2010, p. 50). When putting the videos together for each section, I tried to remind learners of things they were formerly taught in general chemistry, in previous chapters from the class, from prior sections of the chapter, and from everyday experience, so they could connect new concepts to things with which they are already familiar.

Confidence. Knowing the learners in the class were already anxious about the subject of organic chemistry, it was critical to assure them they could be successful if they were willing to work systematically and diligently. Keller (2010, p. 51) remarked that students become particularly anxious if they have no idea as to what the learning requirements are; thus, learning objectives for the chapter were included on the website, and students were reminded of these requirements frequently in the course of both video and classroom instruction.

A key recommendation in *Table 3 – Confidence Strategies* (Keller, 1987) that had significant relevance to this course was to organize materials in a hierarchy; to start with familiar ideas and upon those build more concepts with increasing sophistication. This instructional strategy allows students to conquer challenges incrementally in small chunks, before advancing on to more sophisticated concepts. Whenever possible, I did this at the start of nearly every video. As an example, when discussing how intermolecular interactions impact the boiling points of compounds, I used the more obvious examples from the textbook that demonstrated how the compounds engaging in stronger hydrogen bonding have higher boiling points than those participating in weaker London dispersion forces. Once students could solve the more obvious problems, they could move on to ones more nuanced.

Keller further proposed that as students can gain independence and take more control over their own learning, their confidence will increase (1987, p. 5). The addition of the instructional videos did much to facilitate this, as the students all remarked at how much they appreciated these. They specifically stated they felt like they were in more control over their own learning, as they had the freedom to stop and pause the videos, rewind as needed, and continue them once a concept was understood. In an attempt to further facilitate independence and control, the weekly pages of the class website provided a check-off list, enabling the students to systematically complete each item so they could be prepared for face-to-face instruction.

Satisfaction. *Satisfaction*, like the other elements within the ARCS model, is complicated. Keller suggested that *natural consequences* can play a significant part in generating learner satisfaction (2009, p. 53). In the case of the learners in this class, we would see this play out whenever they enjoy a sense of satisfaction, knowing they have successfully tackled a very challenging concept, or having learned and mastered a skill they could not execute before. I would also expect a group such as this to enjoy the natural consequences of not having to struggle so much when they take this same course in college, especially when they compare their own progress with that of their peers – making social comparisons. The future anticipation of these distant outcomes can certainly do much to motivate students, but more proximal outcomes are just as important.

For facilitating more immediate satisfaction, Keller (1987) recommends several things: for one, avoiding surveillance and the use of threats as a means of getting students to complete assignments. The blended learning format does not really lend itself to surveillance since students are required to learn much of the content on their own. Keller also emphasizes the importance of reinforcing learner's intrinsic pride by reminding them whenever they have tackled a task that is very difficult. Whenever possible, students have been reminded that they are to be commended for tackling as high schoolers a subject that many college sophomores struggle with. Finally, Keller suggested whenever students have mastered a particular task, allow them to lend help to others. In doing this, mutual respect, support and trust is facilitated. Thus far within this group of students, many have had the opportunity to be an "expert" to their peers.

Keller's instructional model has been pretty easy to implement within the context of this course and its materials. What has aided the implementation greatly has been an excellent textbook that is itself clearly informed by motivational design.

Website Design and Navigation

To facilitate ease of navigation, I implemented many of the design recommendations I learned about from the CI 7071 course I took in the summer of 2017, from University of Cincinnati. One of the rubrics we used was the *Blackboard Exemplary Course Program Rubric* (hereafter ECP, 2012). The rubric is divided by 1) Course Design, 2) Interaction and Collaboration, 3) Assessment, and, 4) Learner Support. When designing the website, I was most interested in the guidelines for Interaction and Collaboration, and Learner Support, as applicable to satisfying the objectives of the course.

Interaction. According to the ECP, *Interaction* denotes the communication between the instructor and the learner, and between the learners themselves. For the blended learning course, the learners are expected to collaborate with one another during classroom instruction and laboratories; the class Discussion Board was established on the website to facilitate distance communication, however. Students are instructed in the Course Overview to use this Board to post any homework problems they are struggling with, perhaps so that peers can offer suggestions or strategies for solving. They are also welcome to post questions concerning assignments. A button/ link to the Discussion Board appears on every page of the website. Finally, the ECP recommends that the instructor uses communication tools to provide course updates, reminders and special announcements. For the course, learners are contacted by *email* at least once a week to remind them to look over the update class webpage. There is a general understanding that if we need to contact one another, email is the best way.

Learner support. The ECP guidelines for *Learner Support* recommend that contact information for the instructor is obvious, along with expected response times, and the methods by which student assignments will be collected and returned. These are similarly indicated on the Course Overview page. Supportive software required to use course materials is also supposed to be indicated – this is found on the Course Overview page as well.

Lastly, it was very important that the course demonstrate usability. *Usability* is apparent whenever the learner finds the system (or software) easy to learn; able to hold their interest; and generates satisfaction (Roy & Pattnaik, 2013, p. 535). When designing the website it was important to demonstrate consistency from one page to the next by providing hot buttons or keys to links in the same place providing contact information, the course overview, discussion board, written materials such as homework and laboratories, videos, and finally conferencing software.

Several evaluations were carried out on the areas of design characterized above and are evaluated and summarized below.

Data Analysis and Results

There were three areas of evaluative interest to me in the development of this project: 1) success in instructional delivery, 2) presence of motivational elements, and 3) usability of the website and associated technology. Evaluations were developed for each, informed by their respective literature domains.

Success in Instructional Delivery

To ascertain the degree to which the instructional design was a success, I administered a chapter exam, using about two-thirds of the questions from the Norton Publishing test bank – twenty three questions in all (See Appendix A). The exams from five students from varying backgrounds and abilities were selected for analysis, in Table 1.

Table 1

Mean Student Exam Scores Broken Down by Chapter Sections

Section	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
Question ID#'s on Exam	*1 to 13*	*6 to 11*	*N/A*	*14, 15, 17*	*12, 13, 16, 18*	*15 - 23*	*N/A*	*N/A*
Mean Scores (out of 100)	76.9	70.8	N/A	66.7	41.7	75.9	N/A	N/A

Notes. Sections 2.3, 2.7, and 2.8 did not have any questions directly associated with content. Exam was derived from test bank provided by Norton Publishing, and reflects the performance of five students of varying backgrounds and abilities.

The students (n = 5) total scores on a percent basis were 82.6, 82.6, 56.5, 60.9, 95.6, and 60.9, with a mean percentage score of 73.2%. Last year, the same test for the entire class averaged 70.8%, with a class that all had a background in general chemistry. From these five exams listed above, three of the students are taking General Chemistry concurrently.

The Mean Scores (out of 100) for each respective Section out of the textbook, reflect the percentage of questions that were answered correctly. From these data, Questions #12, 13, 16, and 18, representative of Section 2.5 in the chapter, show a mean of 41.7%, which is concerning. Certainly instruction from that particular Section needs to be revised, along with Section 2.4, demonstrating a mean of 66.7. Note that Sections 2.3, 2.7, and 2.8 do not have any exam questions associated with them, as those sections really served to undergird other sections.

Presence of Motivational Elements

To determine whether motivational elements were present, I enlisted the help of a learning specialist who is quite knowledgeable about the target population, as recommended by Dick et al., (2015, p. 287). As an instructional designer for the University of Dayton, Paul Dagnall is quite familiar with college-age students, and the struggles they face in challenging coursework. Using a Likert-scale survey (Appendix B.1) derived from tables out of Keller's ARCS Model (1987, pp. 4, 5), Mr. Dagnall assessed the course website and accompanying materials, for the presence of motivational elements, of which the results are recorded in Table 2.1. In correspondence with Mr. Dagnall, he indicated that he went through the website, perused the homework questions, laboratories, and watched a few of the videos.

In a second assessment, a questionnaire was developed (Appendix B.2) using ideas derived from Dick et al., (2015, pp. 285-287), with some slight modifications. The questionnaire asked Mr. Dagnall to answer yes-no questions on the presence of motivational strategies, providing space to comment in more detail. Mr. Dagnall's insightful comments are recorded in Table 2.2. Reference to Likert Scale: Wakita, T., Ueshima, N., & Noguchi, H. (2012).

Table 2.1

Learning Specialists Survey of Presence of ARCS Motivational Elements Using Likert Scale (1 [Needs Improvement] to 5 [Very Satisfactorily Met])

1	2	3	4	5		Attention-getting strategies
□	□	□	□	x	1.	Shows visual representations (images, photographs, models) of any important object or set of ideas or relationships (A2.1).
□	□	□	□	x	2.	Provides worked out examples of every instructionally important concept or principle (A2.2).
□	□	□	□	□	3.	Uses content-related anecdotes, case studies, biographies, etc. (A2.3).
□	□	□	x	□	4.	Varies the format of instruction (content presentation, practice problems, reflection, etc.) according to the attention span of the audience (A3.2).
□	□	□	x	□	5.	Varies the medium of instruction (platform delivery, film, video, print, etc.) (A3.3).
□	□	□	x	□	6.	Breaks up print materials by use of white space, visuals, tables, different typefaces, etc. (A3.4).
□	□	□	□	x	7.	Shifts between student-instructor interaction and student-student interaction (by way of labs, collaboration) (A3.6).
□	□	□	□	x	8.	Uses creativity techniques to have learners create unusual analogies and associations to the content (A5.1).
□	□	□	□	x	9.	Embeds problem-solving activities at regular intervals (A5.2).
1	2	3	4	5		Relevance Strategies
□	□	□	□	x	1.	States explicitly how the instruction builds on the learner's existing skills (R1.1).
□	□	□	□	x	2.	Uses analogies familiar to the learner from their past experience (R1.2).
□	□	□	x	□	3.	States explicitly the present intrinsic value of learning the content, as distinct from its value as a link to future goals (R2.1).
□	□	□	□	x	4.	States explicitly how the instruction relates to future activities of the learner (R3.1).
□	□	□	□	x	5.	To enhance achievement-striving behavior, provides opportunities to achieve standards of excellence under conditions of moderate risk (R4.1).
□	□	□	x	□	6.	To satisfy the need for affiliation, establishes trust and provides opportunities for no-risk, cooperative interaction (R4.3).
□	□	□	□	x	7.	Models enthusiasm for the subject taught (R5.3).

Notes. Survey derived from Keller, J.M. (1987). The systematic process of motivational design. *Performance & Instruction*, *26*(9-10), 1-8. Letters next to the written strategy correlate to those in Keller’s Tables 1 to 4. Survey filled out by Paul Dagnall, Instructional Designer at University of Dayton.

Table 2.1

Learning Specialists Survey of Presence of ARCS Motivational Elements Using Likert Scale (1 [Needs Improvement] to 5 [Very Satisfactorily Met])

1	2	3	4	5		Confidence strategies
□	□	□	□	x	1.	Incorporates clearly stated, appealing learning goals into instructional materials (C1.1).
□	□	x	□	□	2.	Provides self-evaluation tools which are based on clearly stated goals (C1.2).
□	□	x	□	□	3.	Explains the criteria for evaluation of performance (C1.3).
□	□	□	□	x	4.	Organizes materials on an increasing level of difficulty; that is, structure the learning material to provide a "conquerable" challenge (C2.1).
□	□	□	x	□	5.	Includes statements about the likelihood of success with given amounts of effort and ability (C3.1).
□	□	x	□	□	6.	Explains to students how to develop a plan of work that will result in goal accomplishment (C3.2).
□	□	□	x	□	7.	Attributes student success to effort rather than luck or ease of task when appropriate (i.e. when you know it's true!) (C4.1).
□	□	□	□	x	8.	Allows students opportunity to become increasingly independent in learning and practicing a skill (C5.1).
□	□	□	□	x	9.	Have students learned new skills under low risk conditions, but practice performance of well-learned tasks under realistic conditions (C5.2).
□	□	□	x	□	10.	Helps students understand that the pursuit of excellence does not mean anything short of perfection is failure; the student learns to feel good about genuine accomplishment (C5.3).
1	2	3	4	5		Satisfaction Strategies
□	□	□	x	□	1.	Verbally reinforces a student's intrinsic pride in accomplishing a difficult task (S1.2).
□	□	x	□	□	2.	Allows a student who masters a task to help others who have not yet done so (S1.3).
□	x	□	□	□	3.	Gives verbal praise for successful progress or accomplishment (S3.1).
□	□	□	□	x	4.	Avoids the use of threats as a means of obtaining task performance (S4.1).
□	□	□	□	x	5.	Avoids surveillance (as opposed to positive attention) (S4.2).
□	□	□	□	x	6.	Avoids external performance evaluations whenever it is possible to help the student evaluate his or her own work (S4.3).

Notes. Survey derived from Keller, J.M. (1987). The systematic process of motivational design. *Performance & Instruction*, *26*(9-10), 1-8. Letters next to the strategy correlate to Keller's Tables 1 to 4. Survey filled out by Paul Dagnall, Instructional Designer at University of Dayton.

Table 2.2

Comments from the Learning Specialist's Questionnaire on Motivational Design

	Question	Response
1.	Do the materials reflect a natural progression in skills, so as to minimize frustration on the part of the learner? Comments: Videos do a good job as a primary content delivery, and are in alignment with assignments, which align with the stated topics for the week.	Y/ N
2.	What do you perceive to be the chief motivational value of the materials? Comments: The chief motivational value is probably the confidence the videos can install IF the student watches and follows in an active manner rather than passively watching. As mentioned elsewhere, the vocal performance in the video is quite good for attracting attention due to the energy and positivity. Additionally, the visuals have little to no long periods of time with a static screen. There's typically motion.	N/A
3.	Do you think learners will find the materials *relevant* to their needs and interests in both the short term and long term? Comments: Any high schooler studying O-Chem is looking to study science in college. I'm not sure there is enough to communicate relevance to someone without that intrinsic motivator.	Y/ N
4.	Do you think there are adequate cues to *gather* the learner's *attention*? Comments: The video presenter imparts energy and enthusiasm, which is great for attention. Additionally, there are graphics and motion, to also help with attention	Y/ N
5.	Are there adequate steps taken to *maintain* the learner's *attention*?	Y/ N
6.	Could more be done to facilitate learner *confidence*? If so, describe. Comments: Instant feedback quizzes. Interactive video questions. Module solutions in the homework doc are quite good.	Y/ N
7.	Besides satisfying a requirement for granting a degree, are there other elements within the course that might generate learner *satisfaction*? If so, please describe those. Comments: I would say only intrinsic interest in the content, but I may have missed something.	Y/ N
8.	When looking through the course materials and the website, did you get the impression that course success can be realized with hard work? Comments: Yes, but the feedback vehicle is unclear.	Y/ N

Notes. Questions are modified from Dick, Carey, and Carey, 2015, pp. 286, 287. Survey comments come from Paul Dagnall, Instructional Designer at University of Dayton.

Course Website Navigability and Usability

Two assessments were developed to ascertain navigability and usability of the course website, videos, and instructional materials: 1) a Usability Survey for UC graduate students attending the Usability Evaluation class (Appendices C.1, C.2) and, 2) a Real-Time Walkthrough for the IT expert (Appendices D.1, D.2).

Usability survey. The usability survey, like the others used thus far, utilized a five-item Likert Scale (Wakita et al., 2012) with a ranking of one denoting an objective *needs significant improvement*, and a ranking of five denoting the objective was *very satisfactorily met*. The questions developed for this survey were based off of the suggestions for instructional design by ECP (2012). The survey was developed taking into account the time limitations for its administration (about fifteen minutes per participant) and the experience level of the survey participants (graduate students in the Usability Evaluations course). Participants sat down with the survey and were asked to think of themselves as organic chemistry students, and to navigate about the website, looking over materials and videos, and assessing the site for ease of use, ease of finding information, user satisfaction, virtual design, and navigational flow. For items scoring below a three, the participants were asked to provide a suggestion for improvement.

After the participants completed the surveys, the totals for each objective were averaged and recorded in Table 3.1. Suggestions from the participants for improving the individual objectives are recorded verbatim in Table 3.2. Note from Table 3.1 that Objective #10, “I was not overwhelmed by the amount of text on the page,” earned the lowest mean of 3.50, followed by Objective #7, “It was easy to find out how to contact the course instructor” (mean 3.75), and Objective #8, “The font choice and size was just right in my browser” (mean 3.75). Several of the participants took time with me after the survey to comment further on these objectives.

Table 3.1

Mean Rating of Objectives Using Likert Scale (1 [Needs Improvement] to 5 [Very Satisfactorily Met])

Mean		Ease of use
4.75	1.	I was able to access the website easily from the link provided.
4.25	2.	The links to supporting web pages, assignments, and videos were easy to access, and all worked.
4.75	3.	The text verbiage used in navigation was appropriate for high schoolers; there was not too much unfamiliar jargon.
		<u>User Satisfaction</u>
4.75	4.	I believe this course will enable me to learn organic chemistry.
4.75	5.	After navigating through the website, assignments and videos, I have every expectation that I can succeed.
		<u>Ease of Finding Information</u>
4.25	6.	It was very easy locating information and course resources.
3.75	7.	It was easy to find out how to contact the course instructor.
		<u>Virtual Design</u>
3.75	8.	The font choice and size was just right in my browser.
4.25	9.	The color scheme used together with the fonts were easy on the eyes – did not produce eye strain.
3.50	10.	I was not overwhelmed by the amount of text on the page.
		<u>Navigation Flow</u>
4.25	11.	The layout of the website was logical and familiar.
4.00	12.	Course assets, such as videos, homework, quizzes, laboratories and answer keys were places I'd expect to find them.

Notes. Means are calculated from the feedback of four UC graduate students attending the Usability Evaluations class.

Table 3.2

Evaluators Direct Comments on Design Elements of the Course Website

Objective	Rating	Recommendations for improvement
1	4	"The courses link – maybe a little hard to notice."[2]
2	4	"On assignments, why do some open in new tabs, or in same tab on the assignments page?"[1]
2	4	"On the assignments page, the laboratories or videos button does not work."[1]
2	4	"The 'Video' and 'Course Overview' links did not work on laboratories page."[3]
6	3	"Why did the left side bar change b/w pages?"[1]
7	3	"Noticed on Course Overview tab you had email, (making) it harder to find."[1]
7	3	I would provide actual contact info, not just a link to open email."[1]
7	3	"I would make the 'Contact Me' button different from the rest, it gets lost in it all."[1]
8	2	"The black text on 'Discussion Board' etc., is hard to read, try using a different color."[1]
10	4	"A little bit of cognitive overload (lots of text)."[3]
11	3	"Try to include a 'Start here" page, which would include objectives and summary."[1]
11	3	"There could be a divider between 'What to Expect' and 'Intro to Structure' on the Week 5 page."[1]
11	3	"The 'Check-off List of Things to Do' presentation should be more consistent. Why is it not on all the pages? Perhaps make this a separate clickable page."[1]
11	3	"Overall, reduce the users need to scroll down pages, by inserting more clickable pages."[1]
11	3	"Quality Matters protocols would suggest having people connect what learners are actually 'doing' to an objective, so learners understand why they are doing what they are doing."[1]
12	4	"Could not locate answer keys on the pages."[2]
12	4	"Suggest adding a check-off list to each page."[3]
-	-	"Week 6 content page refers to a 'Week 5 Summary,' was this a typo?[2]

Notes. The superscript italicized numbers at the end of each comment correlates to UC graduate students attending the Usability Evaluations course as follows: 1 – Alex, 2 – Christian, and 3 – Robin.
The evaluators were asked to comment on objectives from Table 1, that received ratings lower than 3.
The fourth student participating in the survey did not issue any comments.

While quantitative data derived from surveys is quite useful, qualitative data probably, ". . . yields the best information about clarity for revising the instruction," (Dick et al., 2015, p. 290). The comments provided by all the UC graduate students were very beneficial, and actionable. One student in particular named "Alex" provided the bulk of the suggestions for improvement - even for items that scored a 3 or 4. Alex's recommendations were informed by his experience with satisfying the requirements of Quality Matters in his own position as an instructional designer. How these suggestions will be implemented in the improved design will be discussed in the Recommendations section of this paper.

Real-Time Walkthrough. An IT expert was provided with a Real-Time Walkthrough Survey which was a modified version of the Norman's Cognitive Walkthrough, and Cognitive Walkthrough for the Web (Mahatody, Sagar, & Kolski, 2010, pp. 747, 748). The purpose of using this modified tool was to determine whether a theoretical "user" correctly interprets the prompts provided on the course website, and is able to follow the progression of the organic chemistry unit based upon those prompts in the form of buttons, links, and icons. Many of the questions on this survey were similarly informed from the ECP (2012) document, with the survey utilizing the same Likert Scale mentioned above.

The IT expert was a gentleman named Blas Morales, who is an analyst and project manager at University of Dayton. Mr. Morales was asked when taking the survey, that for any objectives receiving a "1" or "2," to provide a recommendation for improvement. Mr. Morales' survey results are recorded in Table 4.1, and recommendations for improvement in Table 4.2. Objective #13, "The protocol for asking a general question using the Discussion Board was easy to understand" was ranked the lowest with a score of only 2. Mr. Morales stated that when the page opened up for asking a general question, it appeared as a blog page (which it is), and did not provide clear directions as to how to ask a general question.

Table 4.1

Survey Results from IT Expert's Real-Time Walkthrough Survey, Using Likert Scale (1 [Needs Improvement] to 5 [Very Satisfactorily Met])

1	2	3	4	5		Website/ technology assets objectives
□	□	□	□	X	1.	Website was accessible from the link provided.
□	□	□	□	X	2.	Website's homepage loaded quickly on the browser.
□	□	□	□	X	3.	Website interface was attractive.
□	□	□	□	X	4.	Homepage directs users to all course assets in a logical fashion.
□	□	□	X	□	5.	The amount of text on the homepage was appropriate.
□	□	□	□	X	6.	All graphical elements (images, icons) were properly presented.
□	□	□	□	X	7.	Font size big enough so that anyone with marginal vision could read the text on links, summaries, and check-off lists.
□	□	□	□	X	8.	The web design itself followed typical LMS protocol/ design.
□	□	□	□	X	9.	All links to lesson videos worked.
□	□	□	□	X	10.	All links to written materials worked.
□	□	□	□	X	11.	Contact information to the instructor was easily found.
□	□	□	□	X	12.	The link to the Discussion Board worked as evidenced by feedback by the website itself.
□	X	□	□	□	13.	The protocol for asking a general question using the Discussion Board was easy to understand.
□	□	□	□	X	14.	When the "instructor" replied on your theoretical question on the Discussion Board, I received notifications through my email.

Notes. Questionnaire modified from Norman's Cognitive Walkthrough, and Cognitive Walkthrough for the Web (Mahatody, Sagar, & Kolsi, 2010, pp. 747, 748). The IT Expert was Blas Morales, Analyst and Project Manager for University of Dayton

Table 4.2

IT Experts Direct Comments on Design Elements of the Course Website

Objective	Rating	Comments and recommendations
7	2	Text fonts were excellent, but remove the changing fonts in links on the left side, so they better harmonize with text on the web pages.
10	5	Links work, but should open material in a new page tab.
13	2	Text narrative on the contact page should encourage general questions; it currently looks like a blog page.

Notes. Comments and recommendations are from Blas Morales, Analyst and Project Manager at University of Dayton.

Recommendations

From the feedback gained by the evaluators, there are a few revisions that are necessary which will be made in two key areas: 1) instructional materials/ methods, and 2) website navigation. Since the motivational elements in the course seemed satisfactory, I will not focus on any modifications there, but will certainly keep these in mind when revising the focused areas.

Instructional Materials

On exam questions testing knowledge from S*ection 2.5 - Physical Properties, Functional Groups, and Intermolecular Interactions,* the students performed the worst, demonstrating a mean score of 41.7%. Surprised at this number, I took another look at the exam to determine whether the wording in the questions (#12, 13, 16, and 18) was perhaps obtuse or confusing. The questions were very straightforward, thus, modifications to ameliorate this will need to focus on the instruction itself.

The plan is to revise the Power Point slides corresponding to the Section 2.5 video by inserting more opportunities for solving problems from the textbook, and discussing the role of functional groups in more detail. Once the slides are complete, I plan to put together a brand new video for Section 2.5. I may also add a few comments concerning this Section on the website itself.

Website Navigation

Table 3.2 provides the direct quotes from the UC graduate students who evaluated the navigability of the course. Based upon their comments along with that of the IT expert (Table 4.2), the website will be revised in five key areas: 1) the Contact information, 2) insertion of more pages and format changes, 3) changing the text on the main navigation buttons, 4) provide a clickable Check-off List for each week's page, and 5) include a "Start Here," link to either a new web page or video, in order to "orient" students to the course.

Contact information. The UC graduate students had much to say regarding their perceived "ease" of contacting the course instructor. Alex mentioned that on the Contact Me button, the student should be directed to an actual webpage which includes the instructors email address, as opposed to merely clicking a link prompting the user to send an email. He also mentioned the actual Contact Me button should look different from the navigation buttons. Apparently the Contact Me button was so camouflaged, one user remarked she could not find it at all. I plan to change this by perhaps inserting it at the top of the webpage and having it stand apart from the other navigation buttons.

Page insertion and formatting. Alex recommended the insertion of more pages and clickable links for the purpose of reducing the users' need to scroll down. There was a concern that there was too much text on each of the pages, so perhaps inserting more pages, I can reduce the amount of text per page. The IT expert remarked that whenever learners click on a button, material should open on a new page tab, so this minimizes the need for the learner to click their browsers "back" button if they want to check something on the main page.

Change the text on navigation buttons. The IT expert commented that the actual font on the navigation buttons should better match the font used in the titles and text sections of the web pages. Alex suggested that the font needs to be a different color as well, as the black visually bleeds into the carbon atoms on the images.

Clickable check-off list. As it currently stands, for each "Week" there is a check-off list along the left margin. The IT expert and Alex thought this list was misplaced, and it would make more sense to provide a clickable link for the weekly check-off lists.

Provide a "Start here" page or video. Alex commented when he first loaded the site, he was uncertain as to where to begin. I noticed this with another UC graduate user, when she loaded the site, she was at a complete loss as to what to next. Alex suggested adding a "Start here," link to either a web page or a video that would provide a brief introduction, and perhaps tour of the website. This was an excellent idea, and one that I learned about in CI 7170, but did not implement here in the courses iteration.

The insight gained through the evaluations was helpful. In looking over the surveys and questionnaires, it is apparent the questionnaires provided information that was much more actionable than the surveys did, which supports the statement mentioned earlier by Dick et al., (2014, p. 290) concerning the value of qualitative data. I am optimistic that with these changes, I can put together an excellent blending learning course in organic chemistry for high school students.

Reflections

This was a very challenging project to complete for many reasons. As already established, organic chemistry is very difficult to learn under the best of conditions (Karty, 2007; Grove et al., 2008; Anderson et al., 2008); thus to entertain the notion that a blended learning environment might be conducive to teaching such a challenging course demonstrates boldness or ignorance. I am optimistic however, based upon the results I have already observed that a blended learning environment for organic chemistry is conducive to content mastery, provided the instructional design is purposeful in a few critical areas. For one, motivational design is a must; as already mentioned students enter the course with trepidation and if not expectations for failure, certainly expectations for stress. Knowing this, it was vital to implement motivational elements as characterized by Keller (2009) in the design whenever possible. This was done with intent, from the selection of the textbook, the design and development of the course videos, to the use of narrative and images on the course website.

A further challenge to organic chemistry education is that of cognitive load in the form of intrinsic and extraneous loads. The intrinsic load lies in the difficult nature of the content itself – as learners not only have to learn about numerous models which are highly conceptual and often contradictory to one another (to the end they experience complex element interactivity as characterized by Sweller et al., [2011]), they have to understand the conditions by which they would apply the rules contained within those models. Such intrinsic load can be minimized if the instruction is engineered so that learners are learning only a few elements at a time in the acquisition of model schemas. Cleverly engineered videos can do much to limit the number of elements introduced to a student per unit time.

Extraneous cognitive load seems much more sensitive and responsive to excellent instructional design than intrinsic load. Extraneous load is that imposed upon the learner due to the learning materials themselves, which could result from the inclusion of animations, pictures, stories, and anecdotes that are not necessary. One of the things I have learned with this project is that video technology really enables the designer to focus instruction so that learners are not overwhelmed by too much text or too much dialogue. Several of my students have remarked that the videos are much more helpful than the textbook, as they often feel overwhelmed by the voluminous amount of text, images, diagrams and tables coming at them seemingly at the same time with the turn of every page. A video screencast enables these elements to be introduced as needed, in logical sequence.

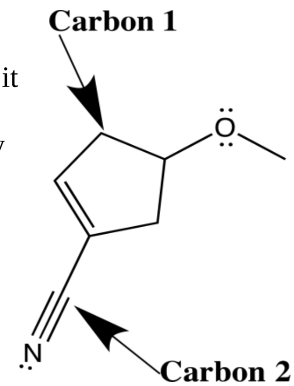
Finally, I found it quite challenging to synthesize in a whole, what seemed to be a hodge-podge of theories, thoughts, ideas, and materials (videos, homework assignments, laboratories, assessments, discussion activities, and assessments). In the development of this project I had to resource information and draw on skills derived from many courses in the IDT program. From the Learning Sciences course (CI 8072) I was made aware of theories that could really explain why organic chemistry is so very difficult to learn (cognitive load theory), and instructional models that might facilitate its learning (Keller's ARCS). From IDT 8010 I was able to develop a systematic model for design using a modification of the Dick et al., (2015) model. CI 7071 and an independent study with Dr. Janet Zydney provided the basis for developing an online course, and IDT 7070 provided much of the basis for drawing feedback from users. Overall, this project is a decent culmination of many skills and competencies developed while in the IDT program.

Revision Notes

Only one student committed to revising my paper, and the student did not leave any revision notes that were obvious at all in the Google doc, thus I was not able to make any revisions on this document based upon such notes. When I looked through the paper that she relinked, I was not able to determine any change requests she would have submitted.

Appendix A – Student Exam for Chapter 2

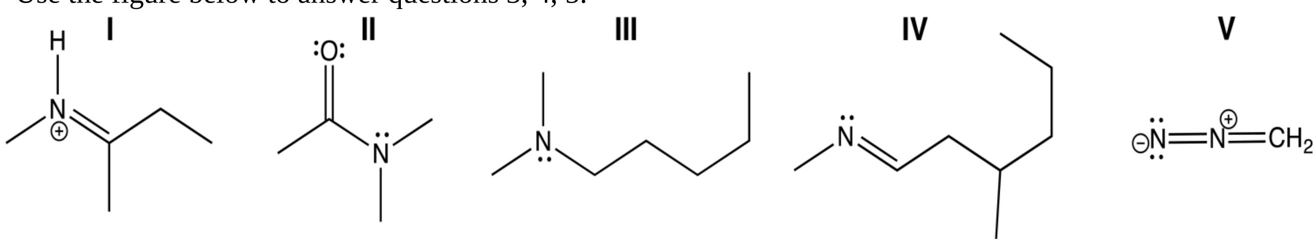
MULTIPLE CHOICE – 4 POINTS EACH



1. When applying VSEPR theory to determine the geometry about a central atom, it is important to count the number of electron groups. Separately consider the two atoms highlighted with an arrow in the molecule shown at right. How many electron groups must be considered for each of these central atoms?
   a. C_1 has two groups; C_2 has two
   b. C_1 has three groups; C_2 has four
   c. **C_1 has four groups; C_2 has two**
   d. C_1 has four groups; C_2 has three
   e. C_1 has four groups; C_2 has four

2. Which of the following statements is true about carbon tetrachloride, CCl_4?
   a. It is polar protic with tetrahedral geometry.
   b. The carbon has trigonal planar geometry.
   c. None of the C—Cl bonds has a dipole.
   d. It is miscible in water with 109.5° bond angles.
   e. **It is nonpolar aprotic with tetrahedral geometry at C.**

Use the figure below to answer questions 3, 4, 5:



3. Which of the above molecules contains a nitrogen atom that has bent molecular geometry?
   a. I b. II c. III **d. IV** e. V

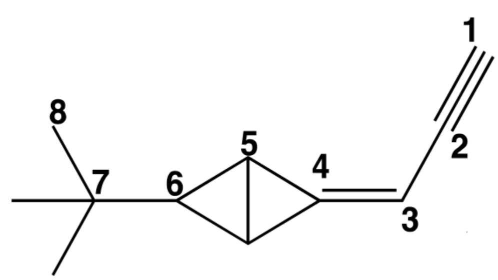
4. Which of the above molecules contain(s) a nitrogen atom that has trigonal pyramidal molecular geometry?

   a. I only b. II only c. III only d. I and II **e. II and III**

5. Which of the above molecules contains a nitrogen atom with linear geometry?

   a. I b. II c. III d. IV **e. V**

Use the figure below right to answer questions 6, 7, 8:



6. The carbon atoms in the molecule above are labeled 1–8. Which C—C—C bond angle in the molecule would be approximately 120°?
   a. C_1-C_2-C_3
   b. **C_2-C_3-C_4**
   c. C_4-C_5-C_6
   d. C_5-C_6-C_7
   e. C_6-C_7-C_8

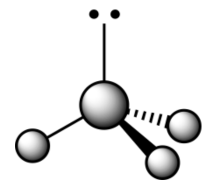
7. Which C—C—C bond angle in the molecule would be approximately 180°?

a. **C_1-C_2-C_3**
b. C_2-C_3-C_4
c. C_4-C_5-C_6
d. C_5-C_6-C_7
e. C_6-C_7-C_8

8. Which C—C—C bond angle in the molecule would be approximately 109.5°?

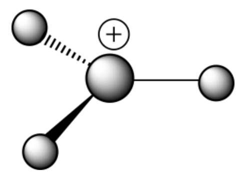
a. C_1-C_2-C_3
b. C_2-C_3-C_4
c. C_4-C_5-C_6
d. C_5-C_6-C_7
e. **C_6-C_7-C_8**

9. What are the approximate H—C—H bond angles expected for the carbanion whose structure is given in the ball-and-stick representation at right?



a. 180°
b. 150°
c. 109.5°
d. **107°**
e. 90°

10. Which of the following choices correctly describes the structure of the ball-and-stick representation with the formula H_3C^+?



a. A carbocation with a tetrahedral carbon
b. **A carbocation with trigonal planar geometry**
c. A carbocation with unknown geometry
d. A carbanion with a tetrahedral carbon
e. A carbanion with trigonal planar geometry

11. Which of the following cycloalkanes contains a C—C—C bond angle of approximately 90°?

a. A seven-membered cycloalkane
b. A six-membered cycloalkane
c. A five-membered cycloalkane
d. **A four-membered cycloalkane**
e. A three-membered cycloalkane

12. What is the VSEPR geometry for the carbon atom of a carbonyl?

a. Linear
b. Tetrahedral
c. Trigonal pyramidal
d. Trigonal planar
e. Bent

13. What is the VSEPR geometry for any carbon atom in a phenyl ring?

a. Linear
b. Tetrahedral
c. Trigonal pyramidal
d. Trigonal planar
e. Bent

14. Which of the following molecules possesses at least one polar covalent bond but does not have an overall net molecular dipole?

a. CH_4
b. $CHCl_3$
c. CCl_4
d. CH_2Cl_2
e. CH_3CH_3

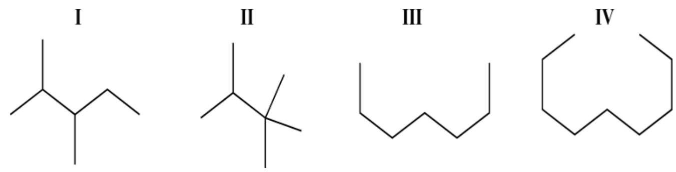
15. Which of the following intermolecular forces is responsible for the boiling-point trends in alkanes?

a. Hydrogen bond
b. Ion–dipole
c. Ion–ion
d. Dipole–induced dipole
e. **Induced dipole–induced dipole**

16. Which functional group will engage in dipole–dipole interactions, but will *not* serve as a hydrogen-bond acceptor?

a. Nitrile
b. Ketone
c. **Alkyl bromide**
d. Carboxylic acid
e. Amine

17. Rank the following molecules based on *increasing* boiling point.



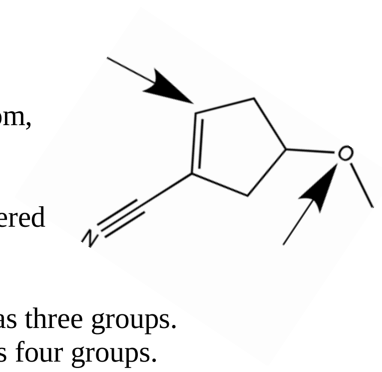
a. I < II < III < IV **b. II < I < III < IV** c. IV < III < I < II
d. II < III < IV < I e. IV < III < II < I

18. Which of the following functional groups contains *both* a hydrogen-bond donor and a hydrogen-bond acceptor?

a. Alkyl fluoride b. Epoxide **c. Carboxylic acid** d. Nitrile e. Ketone

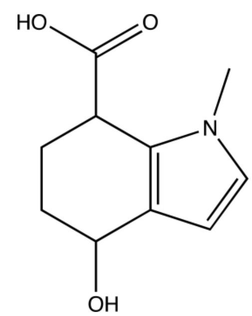
19. Identify the strongest intermolecular force.
a. Hydrogen bond b. Ion-dipole **c. Ion-ion**
d. Dipole-induced dipole e. Induced dipole-induced dipole

20. When applying VSEPR theory to determine the geometry about a central atom, it is important to count the total number of bonded and nonbonded electron groups. Separately consider the two atoms highlighted with an arrow in the molecule shown at right. How many bonded electron groups must be considered for each of these central atoms?



a. C has two groups; O has two groups.
b. C has three groups; O has four groups.
c. C has three groups; O has two groups.
d. C has three groups; O has three groups.
e. C has four groups; O has four groups.

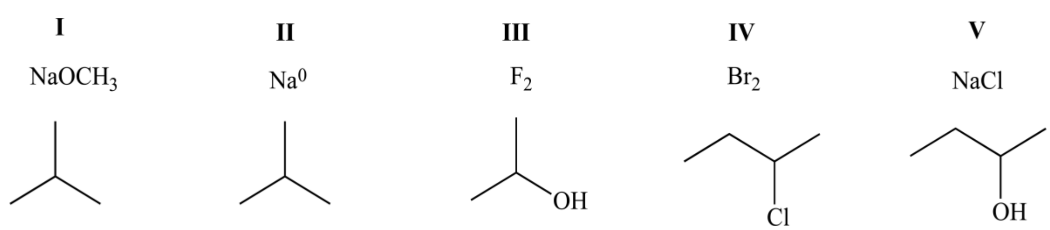
21. How many hydrogen-bond donors and acceptors are present in the following molecule?



a. One donor and four acceptors
b. Two donors and four acceptors
c. Two donors and three acceptors
d. One donor and three acceptors
e. Two donors and two acceptors

22. What is the strongest intermolecular attractive force between an alcohol and a ketone?
a. Hydrogen bond
b. Ion–dipole
c. Ion–ion
d. Dipole–induced dipole
e. Induced dipole–induced dipole

23. When mixed, which of the following pairs of compounds will exhibit *both* ion–dipole and ion–ion intermolecular attractive forces?



a. I b. II c. III d. IV **e. V**

Appendix B.1

Learning Specialist's ARCS Model Strategies Survey Part I, page 1
For each statement, rate the degree to which the strategy was met by √ the box, from 1 to 5:
1 = needs significant improvement
2 = needs some improvement
3 = neutral
4 = satisfactorily met
5 = very satisfactorily met

1	2	3	4	5		***Attention-getting Strategies***
□	□	□	□	□	1.	Shows visual representations (images, photographs, models) of any important object or set of ideas or relationships (A2.1).
□	□	□	□	□	2.	Provides worked out examples of every instructionally important concept or principle (A2.2).
□	□	□	□	□	3.	Uses content-related anecdotes, case studies, biographies, etc. (A2.3).
□	□	□	□	□	4.	Varies the format of instruction (content presentation, practice problems, reflection, etc.) according to the attention span of the audience (A3.2).
□	□	□	□	□	5.	Varies the medium of instruction (platform delivery, film, video, print, etc.) (A3.3).
□	□	□	□	□	6.	Breaks up print materials by use of white space, visuals, tables, different typefaces, etc. (A3.4).
□	□	□	□	□	7.	Shifts between student-instructor interaction and student-student interaction (by way of labs, collaboration) (A3.6).
□	□	□	□	□	8.	Uses creativity techniques to have learners create unusual analogies and associations to the content (A5.1).
□	□	□	□	□	9.	Embeds problem-solving activities at regular intervals (A5.2).
1	2	3	4	5		***Relevance Strategies***
□	□	□	□	□	1.	States explicitly how the instruction builds on the learner's existing skills (R1.1).
□	□	□	□	□	2.	Uses analogies familiar to the learner from their past experience (R1.2).
□	□	□	□	□	3.	States explicitly the present intrinsic value of learning the content, as distinct from its value as a link to future goals (R2.1).
□	□	□	□	□	4.	States explicitly how the instruction relates to future activities of the learner (R3.1).
□	□	□	□	□	5.	To enhance achievement-striving behavior, provides opportunities to achieve standards of excellence under conditions of moderate risk (R4.1).
□	□	□	□	□	6.	To satisfy the need for affiliation, establishes trust and provides opportunities for no-risk, cooperative interaction (R4.3).
□	□	□	□	□	7.	Models enthusiasm for the subject taught (R5.3).

Survey derived from Keller, J.M. (1987). The systematic process of motivational design. *Performance & Instruction, 26*(9-10), 1-8. Letters next to the written strategy correlate to those in Keller's Tables 1 to 4.

Learning Specialist's ARCS Model Strategies Survey Part I, page 2

For each statement, rate the degree to which the strategy was met by √ the box, from 1 to 5:
1 = needs significant improvement
2 = needs some improvement
3 = neutral
4 = satisfactorily met
5 = very satisfactorily met

1	2	3	4	5		***Confidence Strategies***
□	□	□	□	□	1.	Incorporates clearly stated, appealing learning goals into instructional materials (C1.1).
□	□	□	□	□	2.	Provides self-evaluation tools which are based on clearly stated goals (C1.2).
□	□	□	□	□	3.	Explains the criteria for evaluation of performance (C1.3).
□	□	□	□	□	4.	Organizes materials on an increasing level of difficulty; that is, structure the learning material to provide a "conquerable" challenge (C2.1).
□	□	□	□	□	5.	Includes statements about the likelihood of success with given amounts of effort and ability (C3.1).
□	□	□	□	□	6.	Explains to students how to develop a plan of work that will result in goal accomplishment (C3.2).
□	□	□	□	□	7.	Attributes student success to effort rather than luck or ease of task when appropriate (i.e. when you know it's true!) (C4.1).
□	□	□	□	□	8.	Allows students opportunity to become increasingly independent in learning and practicing a skill (C5.1).
□	□	□	□	□	9.	Have students learned new skills under low risk conditions, but practice performance of well-learned tasks under realistic conditions (C5.2).
□	□	□	□	□	10.	Helps students understand that the pursuit of excellence does not mean anything short of perfection is failure; the student learns to feel good about genuine accomplishment (C5.3).

1	2	3	4	5		***Satisfaction Strategies***
□	□	□	□	□	1.	Verbally reinforces a student's intrinsic pride in accomplishing a difficult task (S1.2).
□	□	□	□	□	2.	Allows a student who masters a task to help others who have not yet done so (S1.3).
□	□	□	□	□	3.	Gives verbal praise for successful progress or accomplishment (S3.1).
□	□	□	□	□	4.	Avoids the use of threats as a means of obtaining task performance (S4.1).
□	□	□	□	□	5.	Avoids surveillance (as opposed to positive attention) (S4.2).
□	□	□	□	□	6.	Avoids external performance evaluations whenever it is possible to help the student evaluate his or her own work (S4.3).

Survey derived from Keller, J.M. (1987). The systematic process of motivational design. *Performance & Instruction, 26*(9-10), 1-8. Letters next to the strategy correlate to Keller's Tables 1 to 4.

Appendix B.2

Learning Specialist's Questionnaire – Motivational Design – Part II

Question		Response
1.	Do the materials reflect a natural progression in skills, so as to minimize frustration on the part of the learner? Comments:____________________	Y/ N
2.	What do you perceive to be the chief motivational value of the materials? Comments:____________________	N/A
3.	Do you think learners will find the materials *relevant* to their needs and interests in both the short term and long term? Comments:____________________	Y/ N
4.	Do you think there are adequate cues to *gather* the learner's *attention*? Comments:____________________	Y/ N
5.	Are there adequate steps taken to *maintain* the learner's *attention*? Comments:____________________	Y/ N
6.	Could more be done to facilitate learner *confidence*? If so, describe. Comments:____________________	Y/ N
7.	Besides satisfying a requirement for granting a degree, are there other elements within the course that might generate learner *satisfaction*? If so, please describe those. Comments:____________________	Y/ N
8.	When looking through the course materials and the website, did you get the impression that course success can be realized with hard work? Comments:____________________	Y/ N

Questions are modified from Dick, Carey, and Carey, 2015, pp. 286, 287.

Appendix C.1

Usability Survey to UC Graduate Students – Part I

For each question, rate the degree to which the objective was met, from 1 to 5:
1 = needs significant improvement
2 = needs some improvement
3 = neutral
4 = satisfactorily met
5 = very satisfactorily met

For objectives scoring a 1 or 2, please provide a suggestion for improvement on Part II

1	2	3	4	5		
						Ease of Use:
◻	◻	◻	◻	◻	1.	I was able to access the website easily from the link provided.
◻	◻	◻	◻	◻	2.	The links to supporting web pages, assignments, and videos were easy to access, and all worked.
◻	◻	◻	◻	◻	3.	The text verbiage used in navigation was appropriate for high schoolers; there was not too much unfamiliar jargon.
						User Satisfaction
◻	◻	◻	◻	◻	4.	I believe this course will enable me to learn organic chemistry.
◻	◻	◻	◻	◻	5.	After navigating through the website, assignments and videos, I have every expectation that I can succeed.
						Ease of Finding Information
◻	◻	◻	◻	◻	6.	It was very easy locating information and course resources.
◻	◻	◻	◻	◻	7.	It was easy to find out how to contact the course instructor.
						Virtual Design
◻	◻	◻	◻	◻	8.	The font choice and size was just right in my browser.
◻	◻	◻	◻	◻	9.	The color scheme used together with the fonts were easy on the eyes – did not produce eye strain.
◻	◻	◻	◻	◻	10.	I was not overwhelmed by the amount of text on the page.
						Navigation Flow
◻	◻	◻	◻	◻	11.	The layout of the website was logical and familiar.
◻	◻	◻	◻	◻	12.	Course assets, such as videos, homework, quizzes, laboratories and answer keys were places I'd expect to find them.

Appendix C.2

Usability Survey to UC Graduate Students – Part II

In the spaces provided below, please provide suggestions for improvement for those objectives in Part I that were rated at a 1 or 2.

Objective No:	Your Rating	Recommendations for Improvement
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____
_______	_______	____

Appendix D.1

IT Expert's Real-Time Walkthrough Survey – Part I

For each question, rate the degree to which the objective was met, from 1 to 5:
1 = needs significant improvement
2 = needs some improvement
3 = neutral
4 = satisfactorily met
5 = very satisfactorily met

For objectives scoring a 1 or 2, please provide a suggestion for improvement on Part II

1	2	3	4	5		Website/ Technology Assets Objectives:
◻	◻	◻	◻	◻	1.	Website was accessible from the link provided.
◻	◻	◻	◻	◻	2.	Website's homepage loaded quickly on the browser.
◻	◻	◻	◻	◻	3.	Website interface was attractive.
◻	◻	◻	◻	◻	4.	Homepage directs users to all course assets in a logical fashion.
◻	◻	◻	◻	◻	5.	The amount of text on the homepage was appropriate.
◻	◻	◻	◻	◻	6.	All graphical elements (images, icons) were properly presented.
◻	◻	◻	◻	◻	7.	Font size big enough so that anyone with marginal vision could read the text on links, summaries, and check-off lists.
◻	◻	◻	◻	◻	8.	The web design itself followed typical LMS protocol/ design.
◻	◻	◻	◻	◻	9.	All links to lesson videos worked.
◻	◻	◻	◻	◻	10.	All links to written materials worked.
◻	◻	◻	◻	◻	11.	Contact information to the instructor was easily found.
◻	◻	◻	◻	◻	12.	The link to the Discussion Board worked as evidenced by feedback by the website itself.
◻	◻	◻	◻	◻	13.	The protocol for asking a general question using the Discussion Board was easy to understand.
◻	◻	◻	◻	◻	14.	When the "instructor" replied on your theoretical question on the Discussion Board, I received notifications through my email.

Questionnaire modified from Norman's Cognitive Walkthrough, and Cognitive Walkthrough for the Web (Mahatody, Sagar, & Kolsi, 2010, pp. 747, 748)

Appendix D.2

IT Expert's Real-Time Walkthrough Survey Comments – Part II

In the spaces provided below, please provide suggestions for improvement for those objectives in Part I that were rated at a 1 or 2.

Objective No:	Your Rating	Recommendations for Improvement
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________
______	______	________________________________

References

Anderson, T. L., & Bodner, G. M. (2008). What can we do about 'Parker'? A case study of a good student who didn't 'get'organic chemistry. *Chemistry Education Research and Practice*, *9*(2), 93-101.

Bergmann, J. & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. Eugene, OR: International Society for Technology in Education.

Blackboard Exemplary Course Program Rubric. (2012). Retrieved from https://community.blackboard.com/community/ecp

Blair, C.J. (2015, November 13). Organic chemistry's reputation built on unnecessary anxiety. *The Oberlin Review*. Retrieved from http://oberlinreview.org/9148/opinions/organic-chemistrys-reputation-built-on-unnecessary-anxiety/

Dick, W., Carey, L., & Carey, J.O. (2015). *The systematic design of instruction.* Pearson Higher Education.

Grove, N.P., Hershberger, J.W., & Bretz, S. L. (2008). Impact of a spiral organic curriculum on student attrition and learning. *Chem. Educ. Res. Pract.*, 9, 157-162.

Karty, J.M., Gooch, G., & Bowman, B.G. (2007). Teaching a modified Hendrickson, Cram, and Hammond curriculum in organic chemistry: curriculum redesign to turn around student performance. *J. Chem. Educ., 84* (7), 1209-1216.

Karty, J. (2014). *Organic Chemistry: Principles and Mechanisms*. WW Norton & Company.

Keller, J.M. (1987). The systematic process of motivational design. *Performance & Instruction, 26*(9-10), 1 – 8. doi: 10.1002/pfi.4160260902

Keller, J. M. (2009). *Motivational design for learning and performance: The ARCS model approach*. Springer Science & Business Media.

Kennepohl, D. K. (2012). Teaching science at a distance. In M. G. Moore & W. G. Anderson (Eds.), *Handbook of distance education*, (pp. 670-683). Mahwah, NJ: Lawrence Erlbaum Associates.

Roy, S., & Pattnaik, P. K. (2014). Some popular usability evaluation techniques for websites. In *Proceedings of the International Conference on Frontiers of Intelligent Computing: Theory and Applications (FICTA) 2013* (pp. 535-543). Springer, Cham.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. New York, NY: Springer.

Wakita, T., Ueshima, N., & Noguchi, H. (2012). Psychological distance between categories in the Likert scale: Comparing different numbers of options. *Educational and Psychological Measurement*, *72*(4), 533-546.