Learning Analysis of an Introductory Immunology Laboratory Course

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ABSTRACT

Medical laboratory science (MLS) educators must frequently evaluate their instructional techniques to ensure that learners are being adequately prepared for professional practice. For this purpose, a learning analysis was performed on an introductory immunology laboratory course in a university-based MLS program. The course was examined through the lenses of constructivism and McClusky's Theory of Margin. While the course was found to utilize several constructivist- and margin-centered techniques, the analysis revealed areas that may be improved through further operationalization of constructivist- and margin-based teaching and learning methods.

ABBREVIATIONS: BSL-2 - biosafety level 2, LMS - learning management system, MLS - medical laboratory science, PPE - personal protective equipment.

INDEX TERMS: medical laboratory science, education, constructivism, margin.

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INTRODUCTION

The promotion of learning is a complex, effortful, and ever-evolving process. To facilitate the promotion of learning, a medical laboratory science (MLS) educator must frequently evaluate their techniques to ensure that learning is truly at the forefront of their practice and that their educational techniques are functioning in an effective manner. Learning theories, scientifically validated explanations for learning,[1] are a rich source of instructional techniques.[2] An occasional reflection on an instructional context, through the lens of a contextually relevant learning theory, can be an effective means through which educators can continually improve their promotion of student learning.

However, theory cannot effectively inform solutions to learning barriers without a thorough analysis of the instructional problem.[2] Toward this purpose, an MLS laboratory course was examined, first through the lens of constructivism and then through the lens of McClusky's Theory of Margin. An MLS laboratory course is an interesting, complex instructional context to analyze because MLS student laboratories are both academically and professionally focused, rigorous due to the large volume of concepts to be understood and applied, and populated with diverse learner populations (eg, adult learners, traditional students, second-degree seekers, working professionals). The complexity of the MLS student laboratory warrants theoretical evaluation because it represents one crucial context in the MLS curricular sequence.

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INSTRUCTIONAL CONTEXT

Academic MLS programs prepare students for their future professional roles through a mix of classroom, laboratory, and clinical experiences, each designed to complement the other. Classroom experiences provide a foundation for knowledge growth. Laboratory courses build upon classroom knowledge through opportunities for application and skill development. The knowledge and skills developed in the classroom and laboratory environments coalesce in the clinical experience. Each plays an important role in MLS student growth. In this learning analysis the laboratory curricular niche was explored in more detail; specifically, an introductory immunology laboratory course in a university-based MLS curriculum.

Introductory Immunology Laboratory

Introductory Immunology Laboratory is a 1-credit course taken concurrently with a 3-credit introductory immunology lecture course. While each course is informed by the other, novel content must be introduced in the laboratory course because immunology is a complex discipline that encompasses a considerable volume of information. Therefore, the lecture course focuses on general immunology content and the laboratory course focuses on MLS-specific content required for professional practice.

Preparation for laboratory sessions

Immunology laboratories meet once a week in an on-campus, biosafety level 2 (BSL-2) laboratory. One week prior to a laboratory session, students are provided access to materials that introduce the content, procedure, and expectations for the laboratory via the university's learning management system (LMS). Preparatory materials include 1) a narrated lecture video that describes concepts

relevant to the laboratory test that will be performed; 2) the laboratory procedure, which includes step-by-step instructions for performing the test; 3) a demo video that depicts the test being performed in the student lab with the same equipment and reagents that will be used by the students; and 4) a short prelab quiz designed to help students self-assess their understanding of testing applicability, mechanisms, performance, interpretation, and common sources of error. To ensure adequate preparation for the laboratory session, students are required to review the materials and complete the prelab quiz prior to the beginning of the laboratory session.

Laboratory sessions

On the day of the laboratory session, the instructor provides a very brief overview to the day's lab test, directs students to the location(s) of materials required to perform the laboratory, shares professional experiences related to the day's lab test, and solicits questions from the class. After all questions have been answered, students gather their supplies and perform the lab test. The instructor circulates throughout the duration of the class period to answer any questions that come up, correct inappropriate and/or unsafe lab practice, and engage the class in larger discussion topics. Students record their results and interpretations, disinfect their workspace, put away/dispose of materials, document their results, and "file" their results to the LMS. Daily result sheets include questions that ask students to explain what their results mean—that is, what analytes in the patient's body account for the test results and what follow-up testing would be appropriate. Students are encouraged to talk to and support each other during the lab activity.

Overall, the laboratory activities are formative, rather than summative, assessments of learning. Because students are performing the lab test for the first time, laboratory reports are graded mostly on participation, with a much smaller grading component designated to accuracy. During grading, the instructor provides students with ample feedback toward future improvement.

Laboratory practical exams and reflections

At the midpoint and end of the semester, students complete a practical exam that draws from lab tests performed during the corresponding half of the semester. Students are informed of the general content to expect on each practical and the grading schema that will be used to evaluate the practicals. Students are allowed to use prelab materials, previously graded lab reports, textbooks, etc to complete the practical. Practical exams are intended to simulate the skills and decision-making necessary for professional practice in healthcare, an environment that demands accuracy in the name of patient safety.

Afterward, students submit a reflection on the practical that includes both metacognition and remediation. Students are asked to reflect on how they felt going into the practical, how they felt after completing the practical, how they prepared for the practical, whether their preparatory efforts worked well, their goals for immunology, what they performed well, and what they need to work on more. Then, students are required to review their practical and remediate all missed questions. Remediations must include their incorrect response and why the response is incorrect as well as the correct response and why that response is correct.

By the time students attempt the practicals, they have approached the content from multiple perspectives and have access to a plethora of reference materials. Additionally, the practical simulates an environment that centers patient health and safety. Therefore, within the context of this one course, practical grading is rigorous and summative. However, within the context of the entire MLS curriculum, practical grading is formative as it helps students refine their immunology knowledge and skills in preparation for their clinical experiences. Practical reflections further enhance the formative aspect of the practicals.

LEARNING ANALYSIS

Two separate learning theories were used to evaluate the strategies and techniques utilized in the introductory immunology laboratory course—constructivism and McClusky's Theory of Margin. Categorically, both are considered epistemologies, or means to study the conditions for knowledge,[3] as opposed to learning theories, which are scientific explanations for how learning occurs.[1] However, a better understanding of the conditions under which learning can occur is, arguably, just as valuable as understanding how the act of learning occurs. In other words, operationalization of epistemological tenets may create environments in which learning flourishes just as effectively as in environments that operationalize theoretical tenets.

Constructivism

The constructivist epistemology posits that learning is created, not acquired, and that social, environmental, and behavioral mechanisms interact in the creation of knowledge.[1,2] Mental models of learned content are constantly being reconstructed and updated, as relevant and varied experiences accumulate over time.[2,4,5] Effective, enduring, transferable learning occurs through practice within meaningful contexts.[2,4] Knowing that the creation and malleability of knowledge are dependent upon accruing experiences within meaningful social and environmental contexts advises instructional direction to better shape these contexts.

Multiple perspectives

Learners construct knowledge from multiple experiences in multiple contexts. Constructivist educators must

accentuate opportunities for students to encounter course content in rearranged, interleaved contexts and to revisit previous content numerous times,[2,4] from multiple perspectives.[1] The introductory immunology laboratory course utilizes several approaches that push learners to engage with content from multiple perspectives.

The laboratory course hosts diverse learner populations including MLS students, non-MLS students, traditional college-age students, adult learners, etc. Therefore, students benefit from opportunities to engage in discussion with students of different identities. Additionally, students explore course content via wide-ranging formats. Reading procedures, viewing lecture and demo videos, participating in question-and-answer sessions, performing lab tests, reviewing instructor feedback, and reflecting on their experiences in the laboratory allows students to work through the same content from differing perspectives at different times.

One area that could be improved upon is the somewhat limited opportunity for social interaction amongst students in the lab. While students are encouraged to engage with each other during laboratory sessions, no technique exists that explicitly requires peer interaction. Adding prelab "time-outs" and/or postlab "debriefs" between small student groups may help them better prepare for and reflect on content through social interaction.

Real contexts

MLS programs prepare learners for professional practice. For this reason, course activities and assessments should actively involve learners in manipulation of materials[1] and application of knowledge in real-world contexts.[2] Activities should replicate the wisdom of the culture within which learners will operationalize skills and should incorporate insights and experiences from individuals who work within that cultural context.[2] As the immunology lab course prepares MLS learners for their future professional roles, applicability to real-world contexts is vital.

Immunology lab students simulate work typical to a clinical immunology laboratory. They don and doff appropriate personal protective equipment (PPE) in the BSL-2 laboratory. They perform lab tests using the same reagents and equipment encountered in a clinical laboratory. They interpret tests results, correlate lab findings with disease states, and investigate and resolve testing issues that may cause false results, just as they will in professional practice. Their mid- and endpoint practicals are rigorously graded, a nod to the importance of accuracy in healthcare. The instructor further centers course activities in a real-world context by sharing relevant experiences and stories from the clinical immunology laboratory.

Coaching

In any learning context, it can be difficult for students to recognize and connect salient points. The job of a constructivist educator, then, must be to expose students to content and help them notice important details[5] while coaching them toward expectations for learning outcomes.[2] The instructor of the immunology lab course employs various coaching strategies.

The instructor engages students in prelab discussion just prior to the laboratory activity, then circulates throughout the lab, verbally reinforcing good work and sharing corrective feedback. When especially salient or timely topics emerge, the instructor calls the attention of the class and engages them in a discussion to explore the topic. Probably the most effective means of coaching is the instructor's emphasis on formative feedback throughout the semester, helping students build toward the more rigorous expectations common to the professional arena.

Reflection

Experiences live on in the mind. While much can be gleaned from merely participating in an experience, constructivist learning is enhanced when learners revisit an experience in reflection, compare the experience with previous experiences, make connections between related concepts,[2,4] explicitly explain the sense they are making,[5] and update their mental models with new information.[4] Fortunately, the immunology lab course uses reflection as one strategy to help students make sense of their coursework.

Immunology lab students are required to reflect on and remediate their practicals. Students reflect on their experiences in the lab and on the practical, self-assess areas for improvement and set goals for the future. Students then remediate the questions missed on the practical and provide written statements on the sense they are making of each question.

Mcclusky's Theory of Margin

A thorough learning analysis is best advised by more than 1 theoretical perspective. The second theory utilized in this analysis frames most individual, human resources as finite: time, money, energy to fuel the body through task after grueling task. No theory sums up limitations on individual achievement of learning as effectively and concisely as McClusky's Theory of Margin. The theory states that the *load* of life drains energy that could be devoted to learning and that the *power* of life buffers the effects of the *load*, creating an adequate *margin* for learning to take place.[6] *Load* derives from both internal (eg, goals, self-concept) and external (eg, tasks, socioeconomic status) sources.[6,7] *Power* derives from several sources: physical (eg, health), social (eg, relatedness), mental (eg, cognitive ability), economic (eg, financial resources), and available skills.[6]

Certainly, a margin-oriented educator cannot offset all factors that contribute to a student's load, just as they cannot create all of a student's power. However, rationalization of the learning context from the perspective of margin can help educators better understand why a learner may or may not adequately engage in a learning event at a specific time[6] and can better advise learners

in their efforts to overcome barriers and create adequate margin for learning.[7]

Early access to materials

Uncertainty is unpleasant and induces anxiety. Conversely, knowing what to expect reduces anxiety and extraneous load.[7,8] From an instructional standpoint, allowing students to familiarize themselves with upcoming concepts, skills, and expectations by allowing early access to course materials reduces their load.[9,10] Because adequate familiarity and preparation are essential to navigate the BSL-2 laboratory competently and safely, the introductory immunology lab course provides the opportunity for students to gain familiarity prior to lab activities.

Learners are required to complete a prelab module before participating in the lab. The prelab module introduces students to relevant testing mechanisms, gives them access to the lab procedure, visually demonstrates the lab that will be performed, and quizzes students on important concepts and common sources of error. Students are urged to bring their remaining questions and/or areas of confusion to lab for further clarification.

Germane load

Learning in and of itself is effortful, time-consuming, and difficult, thereby contributing to load. However, if learning is the desired outcome, the difficulties that enhance that outcome are desirable, even though they contribute to load.[4,8] Load germane to learning includes effortful cognitive processing, varied practice, and corrective feedback.[4,8] Certainly, much of the load imposed by the immunology lab course is germane to the MLS learning environment.

Prelab quizzes, result interpretation, disease correlation, and troubleshooting are effortful, especially for those inexperienced in the ways of laboratory testing. While this effort contributes to load, it also contributes to meaningful learning that will be applied later in the MLS curriculum and in professional practice. Immunology students are required to practice applying their knowledge and skills in various formats (eg, reading, quizzing, performing and interpreting tests, reflecting on their experiences). Within the context of each varied practice strategy, the instructor provides timely, corrective feedback.

Fidelity

Because many students pursue higher education to achieve the requirements necessary for professional practice, irrelevant content and assessments diminish their margin for learning by creating extraneous load. Extraneous load is created by educators when they prepare students for course assessments rather than practice.[8] This type of extraneous load can be eliminated by simulating practical experiences situated within real-world contexts, increasing the fidelity between academic and professional experiences.[8] Because the introductory immunology lab course prepares learners for future practice, the instructor simulates a medical laboratory whenever possible.

Students are expected to conduct themselves according to the safety standards of BSL-2 laboratories by selecting and wearing situationally appropriate PPE. Upon completion of laboratory activities, students "file" their results to the university's LMS, just as they would file their results to a healthcare institution's laboratory information system. While practical exams are graded rigorously to reflect the need for absolute accuracy in healthcare, students are allowed to use their resources (eg, procedures, feedback on previous labs) to complete the practical, just as MLS practitioners are allowed to use resources in professional practice.

Self-assessment of margin

Each learner must recognize their margin for learning within the context of their current responsibilities. To achieve this, educators can wield margin theory to help students self-assess their load versus power to estimate their available margin for learning.[6] Once assessed, students may be able to identify areas where they can reduce their load and/or increase their power.

The immunology lab course is lacking in robust opportunities for students to self-assess their margin for learning. Questions related to load, power, and margin could be easily incorporated into the reflection and remediation assignments; although, earlier self-assessment in these areas would likely provide more benefit than mid- and end-of-semester self-assessments. That is, adding a preliminary reflection during the first week of the semester may help students identify areas where they can decrease their load and/or increase their power to support an adequate margin for learning over the entire semester.

IN SUMMARY

Because learning theories are a basis for instructional strategies that can be parlayed into instructional action[2] analysis of a learning context from the perspective of learning theory supports instructional improvement. In this learning analysis, the instructional techniques utilized in an introductory immunology lab course were examined through the lenses of constructivism and McClusky's Theory of Margin; epistemologies that may help educators establish conditions in which learning can occur. While several constructivist- and margin-centered techniques are already being operationalized in this instructional context, the analysis revealed areas for improvement; for example, the need for more social interaction amongst learners and the need to help students self-assess their margin for learning and adjust accordingly.

The efficacy of constructivist- and margin-centered instruction may be further improved by sharing the rationale for instructional techniques directly with students. Sharing underpinning justifications with students may

help them better understand the purpose for each course activity, which may improve their motivation to learn. Afterall, both educators and students compose the learning community and can work together to create environments conducive to learning.

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