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Innate and Adaptive Immune Response to a Virus: An Integrated Learning Module

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Abstract

Introduction: Medical schools must expand their teaching strategies to address a new generation of medical students and ensure their growth into lifelong, self-directed learners. Integration across basic science disciplines packaged together with clinical medicine produces learning materials that better enable medical students to achieve these goals. **Methods:** We created a narrated audiovisual learning module illustrating the foundational sciences and clinical presentation surrounding immune responses to viral infections. We integrated immunology, microbiology, histology, pathology, and clinical medicine and included a self-assessment quiz and clinical vignette with questions to test students' understanding of the material. We published the module on our school's learning management system and tracked student usage, which was followed by an in-class survey to assess student perceptions of the usefulness of the module. **Results:** Sixty-four (59%) of the first-year medical students used the module. Thirty-seven students completed the in-class survey assessing their perceptions of the module. Over 95% of responders reported that the module helped them learn the new material, identify areas of weakness, understand the big picture for this immune response, and apply the material in a clinical context. **Discussion:** This module illustrates an approach to integrating basic science disciplines in order to facilitate students' understanding of the mechanisms underlying patients' clinical presentations. Survey results indicated that students valued the module as a self-directed learning component that integrated essential clinical concepts. The module was a helpful tool for students to evaluate their comprehension of immunology in a clinical context and can be used as required or optional material.

Keywords

Virus, Lymphocytes, Microbiology, Pathology, Histology, Immunology

Appendices

- A. Narrated Module With Quizzes folder
- B. Comprehension Quiz With Answers.docx
- C. Comprehension Quiz Without Answers.docx
- D. Application Quiz With Answers.docx
- E. Application Quiz Without Answers.docx
- F. Survey Questions.docx
- G. Module Without Narration .pptx

All appendices are peer reviewed as integral parts of the Original Publication.

Educational Objectives

By the end of this activity, learners will be able to:

1. Describe the sequence of the innate and adaptive immune responses to a virus.
2. Summarize the innate and adaptive immune responses to a virus.
3. Apply foundational science concepts to clinical problems associated with immune responses to viral infections.

Introduction

The Liaison Committee on Medical Education (LCME) recognizes the importance of self-directed learning and requires medical schools to provide appropriate curriculum content that includes self-directed learning experiences along with sufficient independent study time to ensure the growth of their students as lifelong, self-directed learners (LCME Standard 6.3: Self-Directed and Life-Long Learning).¹ The Practice-Based Learning and Improvement competency domain from the Accreditation Council for Graduate Medical Education and the American Board of Medical Specialties utilizes the plan-do-study-act cycle of continuous quality improvement to inform medical education approaches.²

This cycle helped give rise to the concept in the medical education literature of a "master adaptive learner" who uses critical thinking and reflection as an integral part of his or her learning.³ The four phases

of the master adaptive learner are planning, learning, assessing, and adjusting. During the planning phase, learners identify a learning gap and locate an opportunity and resources for learning. Recognition of a learning gap leads to cognitive dissonance, which is a feeling of discomfort that is best satisfied by finding a learning activity to address the gap. Learning resources that are unique, innovative, and concise are more likely to be utilized during the learning phase; if the resources include immediate feedback, they are even more valuable. During the assessing phase, learners use the new knowledge gained to address the learning gap, form an opinion about the knowledge's effectiveness, and ultimately decide whether to accept or reject it. During the final adjusting phase, learners incorporate what they have deemed effective into their daily routines. This process is self-directed and driven by the learners' perceived needs.³

One way to include self-directed learning experiences and foster the development of master adaptive learners during the preclinical years in a medical education program is to provide quality learning resources that are concise, are easily accessible, and address students' needs for understanding foundational basic science concepts by integrating and applying them in a clinically relevant context. Currently, students utilize multiple online resources such as Pathoma and Khan Academy on YouTube because they satisfy most of these criteria. These resources are limited by providing only one perspective on a given topic and not having been evaluated by multiple content experts, making assessment of reliability difficult for a beginning learner. In contrast, we are faculty with content expertise in multiple basic science and clinical disciplines, and we created this interactive module on the immunological response to a virus based on our prior work and incorporation of student feedback.⁴ This narrated learning module outlines the steps in the immune response to a virus and correlates the immune reactions with the histopathologic picture and clinical presentation. It emphasizes the interplay between innate and adaptive immunity in viral infections and illustrates the pathologic changes resulting from the immune response. By including a self-assessment quiz and a clinical vignette with questions, the module provides students with valuable immediate feedback. The goal of the module is to help students develop a mental picture that integrates immunologic, pathologic, and clinical findings into a coherent whole, making application of the concepts to clinical situations easier and allowing students to assess their own progress. This multiperspective and integrated learning resource allows learners to demonstrate comprehension of basic immunologic principles and their clinical application and can be used as a tool to foster the development of lifelong, self-directed learners. It is also a unique, innovative method of addressing cognitive dissonance caused by learning gaps in the understanding of basic immunologic responses to viral infection. The material is presented in an effective manner with immediate feedback. The module aids goal setting, another component of becoming a master adaptive learner, because it utilizes a series of graded steps to illustrate the immunologic response and its clinical application. Once the module has been explored, the comprehension quiz questions and the vignette with application quiz questions encourage entry into the assessing phase of becoming a master adaptive learner. The adjusting phase must await future clinical challenges. The module is an excellent model of the type of resource that medical students should be encouraged to seek out during the planning and learning phases of their independent self-directed study time.

Comparison of our module with other immunology modules in *MedEdPORTAL* shows that the latter adhere closely to accepted immunologic principles and tend not to stray into clinical application or attempt to connect the observed clinical presentation and histologic changes with the underlying immunologic reactions. Additionally, the existing modules are intended for in-class use, primarily as team-based learning.⁵ In contrast, our module can be used as a part of an in-class presentation, but it is equally effective as a component of self-directed learning. Physiology modules addressing difficult topics have been recently published in *MedEdPORTAL*^{6,7}; however, they do not provide integration of disciplines or self-assessment quizzes. Our module is a narrated, stepwise, pictorial representation of the immunologic events in a viral infection with accompanying images depicting the corresponding histologic and clinicopathologic changes. The correlation between not only multiple basic science disciplines but also clinical presentations to address an immunologic mechanism is unique and serves to enhance understanding of a complex topic.

Methods

This module (Appendix A), including the annotated and narrated PowerPoint with both the comprehension and application quizzes, was created using iSpring Suite 8.5 software (iSpring Solutions, Alexandria, VA), and the source materials were two medical student textbooks.^{8,9} Appendices B, C, D, and E are Microsoft Word versions of the comprehension and application quizzes, with and without answers, respectively. These have been included for users to utilize either as self-tests for students or as formative or summative assessment material in a portion of an immunology course. Basic immunology was introduced to first-year medical students at the Paul L. Foster School of Medicine within the first few weeks of medical school during the first unit of a curriculum entitled Introduction to Health and Disease (IHD). The stepwise diagrams from the module were presented sequentially during in-class immunology sessions in the IHD unit that described innate and adaptive immunity and the different cell types involved in these responses. The final diagram, which was the most complex, was presented last to illustrate the complexity and interconnectedness of the immune response. We advised students during the session on adaptive immunity that a supplementary online learning module covering all of the steps along with the practice questions would be made available to them on our learning management system (LMS).

We provided this module as a supplemental online learning resource during the IHD unit after the students' introductory lectures on innate and adaptive immunity. We published the module in a Shareable Content Object Reference Model–compliant format and uploaded it to our LMS, which allowed us to track the students' use of the module and their performance on quiz questions. We again notified all first-year medical students via the LMS about the optional immunology learning module available as supplemental study material. We informed them that the module could be accessed as many times as desired by learners and that the quiz and question grades were formative and intended only for immediate learner feedback. Students opened the Flash movie using Adobe Acrobat Reader (Adobe Systems, San Jose, CA). Internet browsers were not used because the Flash plug-in had been inactivated in many browsers. We formatted the Flash movies to advance to the next slide once the narration ended; students also could advance to the next slide by clicking the Next button or the slide number on the outline. Additionally, students could skip the narration and go straight to the quiz or clinical vignette. We based the quiz questions on the steps in the PowerPoint with emphasis on the important points in each step. Incorrect answers on the quiz referred users to the appropriate step for refreshment of their knowledge. We designed the clinical vignette with additional questions intended to emphasize important clinicopathologic points and to illustrate the connection to the immunologic principles depicted in the module. Approximately 3-4 months after we made the module available for student use, we administered a 10-question in-class survey (Appendix F) via Poll Everywhere that asked students to give feedback on their reasons for using the module and its effectiveness as a study aid.

At the Paul L. Foster School of Medicine, we are able to open the module using Adobe Acrobat Reader as presented above; however, this software will no longer be available after 2020. We now publish the module as an HTML file saved in a zip folder, which can be opened using software readily available on most computers. Step-by-step instructions for opening the zip folder are as follows: Create a folder on your desktop in which to place the files. Right click on the zip folder icon to open a drop-down menu, select the Extract all option, and go to Browse, where you will select the folder you created on the desktop. Next, choose Extract, and the zip file will open. Select the res folder, and open the index.html file. The module will open and begin playing. Some computers will have a pop-up asking if the user wishes to allow blocked content; when this option is selected, the module will begin playing.

We include a separate annotated PowerPoint presentation without narration (Appendix G), which could be used as an in-class presentation in an immunology curriculum, if desired by users. We recommend using the individual steps in sequence with lectures that illustrate the interconnection between innate and adaptive immunity, followed by presenting the complete module as a component of self-directed learning or review.

Facilitators intending to utilize the module should be familiar with immunologic principles and qualified to teach immunology at this level. Prerequisites for learners to utilize the module are an introductory knowledge of innate and adaptive immune responses to specific stimuli; however, detailed knowledge of immune system function is not necessary. The ideal context for implementation would be during an introductory course in microbiology and/or immunology where responses to viruses are taught. The module cannot be used as a stand-alone course in immunology.

Results

Out of a class of 108 medical students, 64 students (59%) accessed the module at least once. Thirty-one of the students opened the module but did not take the quizzes. The remaining 33 students who accessed the module and took the quizzes had an average score of 75. We did not attempt to determine if these students performed better than those who did not access the module on formative or summative exams. There were 37 students present for the in-class survey. Responses to the first eight questions are presented in the [Table](#).

Table. Survey Questions for Immune Response to Virus

Survey Question	Agree (N)	Strongly Agree (N)	Total (%)
1. The module helped me learn material.	11	21	89
2. The module helped me review material for the unit.	13	13	78
3. The module helped me understand the big picture for this immune response.	15	14	87
4. Immunology content of the module helped me to understand the relevant pathologic process.	18	7	76
5. The module helped me identify areas where my understanding was weak.	18	10	82
6. I liked the presentation style of the module.	15	13	84
7. The module suited my learning style.	16	10	78
8. Overall, I have learned something that I consider useful for me as a future clinician.	18	11	85

These responses demonstrated that the students liked the modular presentation style (28 students, 84%); 32 of the respondents (89%) felt that it aided their learning. Twenty-six students (78%) felt that the module suited their learning style, and 29 (87%) felt that the module helped them understand the big picture for this immune response. The module was also useful to help them identify areas needing review because their understanding of immunologic principles was lacking (28 students, 82%), and it helped them correlate the clinical and histologic findings with the immunologic cause (25 students, 76%). Twenty-nine students (85%) felt that the module helped them learn something that would be useful when they become clinicians.

Question 9 was a free-text question asking for students' perceptions of the strengths of the module. Representative comments included the following:

- "It was incredibly helpful—informational & it went at a good pace—easy to navigate through."
- "It was helpful to get an overall understanding of all the steps."
- "I liked that it was very visual and was narrated. Never having had immunology during undergraduate, it helped me sort through material I thought was overwhelming at first."
- "It was a great way to visualize the immune response in a bigger picture."

Question 10 was a free-text question asking for students' perceptions of the weaknesses of the module. The responses indicated that most of the students wanted to be able to increase the module's speed. Representative comments included the following:

- "The module was too slow, allowing speed up option would be better. It took too long to watch the videos due to slow speed. Please add speed up button."
- "There should be more like this."
- "Wasn't useful for a first pass of material, much better review."
- "I wish it had more case questions to practice with. I think that would be most useful."

The free-text responses emphasized the students' desire for materials that could be used multiple times if needed and for more self-assessment quizzes.

Discussion

This learning module on innate and adaptive immune responses to a virus was developed in response to positive feedback from students who utilized our earlier modules on the immune response to an allergen/helminth,¹⁰ the immune response to bacteria,¹¹ and the immune response in allergic contact dermatitis.¹² Students viewed this module as a useful resource for learning immunology and its clinical application and found it relevant to their future careers. The free-text comments showed that the module was well received by the students and indicated that this type of learning material fit well with their learning style. It was clear that students also wanted us to prepare more modules, preferably sooner rather than later. The module was not required in our curriculum, but even so, two-thirds of the class used it, suggesting that students valued the module.

A limitation to implementing the module in class is that while the module is a complete summary of the immune response to a virus, in-class presenters may wish to utilize the individual steps in multiple immunology presentations rather than during one lecture. The materials were designed to allow this flexible presentation; however, the instructor will need to plan carefully in order to incorporate the individual steps in different lectures. The individual steps can be used to anchor the basic immunology instruction within the context of immune response to a virus. If the final step is the only portion of the module used in class, its complexity and detail may overwhelm the students. The module was intended as supplemental material and cannot be used as the sole instructional material for an immunology course; however, it is excellent when used to reinforce basic concepts. The classroom, instructor(s), and students must all have access to Microsoft PowerPoint and Microsoft Word programs. The quizzes are easy to use, and the answers have feedback for incorrect responses, making the module an ideal resource for self-directed or distance learning application. A limitation of the module is having only five clinical questions; developing more application questions, especially clinical application questions, would be one way to improve the module. Issues in preparing this type of integrated, narrated module were the time required from all faculty participants and the need for a similar understanding of the concept, objectives, and usage of the module.

As this module was not a required component of the curriculum, its content was assessed in the most general way as part of the overall immunology and pathology curriculum. We cannot conclude that any improvement in student exam performance was solely due to the availability of the module since it was not possible to design questions based on material covered only in the module and not presented elsewhere. For this reason, the evaluation strategy was based on the premise that addressing learners' perceptions regarding curricular improvements would lead to increased satisfaction with the curriculum overall and to improved understanding of immunology. The preclinical curriculum moved at a rapid pace, which precluded changing the mode of instruction during the year and required making any necessary or desired changes in the year that followed. The module was never intended to be used for summative purposes and is primarily expected to expedite individual, self-directed learning. Students' feedback suggests that they perceived the module to be a useful learning tool.

The integrated modules we have created thus far have been very well received by the students at our school. Beyond our school, there has been a remarkable amount of interest in our previously published module dealing with the immune response to bacterial infection.¹¹ Other institutions have recently requested permission to use that unique resource in their curriculum.

We believe that our integrated modules are valuable learning resources for medical students because they are both easy to use and reliable, having been developed and reviewed by multiple individuals in

several different disciplines. Future modules could encompass different topics in other areas where integration of basic science with the observed clinical and pathologic findings would aid learners' understanding of the big picture.

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Informed Consent

All identifiable persons in this resource have granted their permission.

Ethical Approval

The Texas Tech University Health Sciences Center Paul L. Foster School of Medicine Institutional Review Board approved this study.

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