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The Hormone Project: Application of Art to Engage Critical Thinking for Undergraduate Medical Education

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Abstract

Active learning is a technique used to help transfer passive knowledge into true learning of material, which can be very beneficial when learning challenging topics. The endocrine system is a complex series of topics that can be challenging to tackle in the short amount of time allotted to it in the medical school curriculum or an undergraduate anatomy and physiology course. Pedagogical strategies that use art as a tool have been shown to motivate and induce students to self-learn such complex physiology topics. The hormone project was designed to help students manage the vast amount of information and acquire knowledge in a meaningful and creative way. Students were asked to create a visual project to depict an endocrine disorder that incorporated art into their learning of the endocrine system. Based on post-session survey results, students found the activity to be beneficial to their learning and they enjoyed engaging in the activity. Providing students with opportunities to engage with material in a creative, artistic manner can be both engaging and enjoyable. This activity provided students with a chance to develop their own memory hooks to facilitate easier recall of the complex topics in the endocrine system. A pilot study of this activity shows great promise to be a staple in curricula that embrace active learning.
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Key words: active learning, physiology, medical education, art in medicine

Introduction

One of the great challenges in teaching physiology is finding a way to make the endocrine system interesting and straightforward to understand, while engaging students in the learning process. This challenge is one that exists at nearly all levels of education for learners, from high school students first learning about the endocrine system to medical students who are applying more advanced facets of the endocrine system to include disease processes and treatments. Through observations and direct experience with students, as well as curriculum evaluation and review, we have found that students significantly reduce the time they spend undertaking activities such as textbook reading and attending (or watching a recording of) passive lectures. The students of today prefer resources that approach the delivery of through modalities that involve images and animations. A recent study looking into YouTube as a study tool found that students use it as an exam preparation tool, to learn new subjects, and to help them recall prior knowledge (Burhanli and Bangir-Alpan 2021). Another study evaluating the use of videos as lecture tools in a nursing program's anatomy and physiology courses found that the students preferred videos to traditional didactics and found them to be a valuable teaching tool (El-Sayed and El-Sayed 2013).

Other innovative approaches to teaching physiology include integration of art and creativity into the teaching practice. It has been shown that integrating art into topics such as biology has aided in improving student enjoyment of the material and in developing their critical thinking skills (Housen 2002; Naghshineh et al. 2008; Perry et al. 2011). Studies such as the PhysioArt project directed students to incorporate physiological concepts into already established works of art (Flôr et al. 2020). From this work, students confirmed that integrating art into the study of physiology with PhysioArt was an effective method to learn and that their project increased their interest in physiology (Flôr et al. 2020). This concept of applying art to physiology (as well as other sciences) was the underlying goal of the pilot project for the "Hormone Project" described here.

This perspective represents the first of its kind to use a team-based artistic approach to teach the endocrine system to medical students. It provides a type of mind-mapping

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procedure where students need to brainstorm, research, compare, contrast, consolidate, and organize a variety of disciplines and clinical considerations, related to a pathology that is significant to the students as a central theme. There is growing evidence of the benefits of mind mapping for learning and retention (Adodo 2013; Erdem 2017; Heideman et al. 2017; Kalyanasundaram et al. 2017). The Hormone Project activity first relies on teamwork to determine the most appropriate content. It then allows for the learners' creativity to take over in designing an image that is helpful to them instead of relying on commercially available resources that may be considered too difficult or contain obscure references, which in themselves would need to be studied so that they are understandable to the student. This work compliments the array of team-based learning, problem based learning, and interactive case studies currently available in the literature for the endocrine system.

Methods

Project Implementation and Facilitation:

The Hormone Project was initially designed for first-year medical students, in the early phases of study with the endocrine system, as part of an organ systems-based curriculum that assists students with integrating the various basic and clinical science concepts. The Hormone Project activity was implemented during the Gastrointestinal, Human Nutrition, Endocrine, and Reproductive (GIHNER) organ systems course which is the fourth official course in the sequence of the basic science curriculum. GIHNER is preceded by the Professional Immersion, Fundamentals, and Hematology courses and it is strategically placed to build on knowledge acquired from these prior blocks. The Hormone Project was placed at the beginning of the second week of the endocrine system portion of the GIHNER course. Students had approximately half of the endocrine system content in physiology, pathology, pharmacology, biochemistry, and anatomy prior to this activity. This placement was important to allow for the students to be familiar with the concepts and to support integration of the material.

During the in-class portion of the activity, faculty facilitators helped to guide the students to stay on topic and to facilitate small group dynamics. The facilitators were not required to have prior knowledge of the curricular content in order to facilitate the activity and were provided with a facilitator's guide (Table 1) for the activity. A facilitator meeting was also held one week prior to implementation to review facilitator roles and session logistics.

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Objectives:

1. Identify hormones of the endocrine system and their regulation.
2. Identify the effects of hyper- and hypo-secretion of hormones.
3. Associate clinical findings and pathophysiology for endocrine abnormalities.
4. Determine appropriate standards of diagnosis and treatment for endocrine abnormalities.
5. Create a novel study aid for endocrine diseases.

Directions:

This project is a dive into the endocrine system that consists of two parts.

Part 1:

Student groups will complete a comprehensive table covering selected hormones of the endocrine system. Each group will have a unique table to complete. At the end of the first hour, each group will submit 1 table for their group submission. Please ensure that the group number and all group members names are on the document.

Topics for part 2 will be given by the facilitator once the table from part 1 is submitted.

Released as part 1 is turned in: Comprehensive hormone table and disorder for each group.

Part 2:

Using the hormone table (see Part 1), students will use their collective creative powers to create a "Sketch-E" (short for Sketch-Endocrine) study aid for the endocrine disease/disorder the group has been assigned. The project should be an original depiction of the topic and include:

1. clinical presentation and epidemiology
2. lab tests
3. hormones involved
4. feedback involved (in (4a) a healthy individual and (4b) where the disease can affect)
5. common causes
6. treatments
7. pathophysiology behind the disease and widespread effects.

Everyone is expected to participate in the activity in some way. The "Sketch-E" final product must contain a key for the image indicating how the different components are addressed.

Facilitators, please help students to ensure that the work is original and not just a copy or close resemblance of an existing resource/study aid.

Projects may be drawn on the whiteboard for a photograph or some other electronic product (PowerPoint, Word, Notability, etc.). It is highly recommended that they use something that they can revisit to edit, as they may not complete this in the 1 hour they have in session to complete and may need to return to it later.

Each group is responsible for generating one final product.

At the end of the day, students must submit either a screen shot or picture of their progress. This will be emailed to the facilitator and course directors. This will likely be a draft after one hour, and the students will need to complete their image by Friday. If they complete this in class, awesome!

At the completion of the projects, they will be shared with the other groups.

For the Friday submission, students must take a picture of the final product and submit the picture and key to the assignment by the deadline.

Topics will include: • Addison's Disease • Growth Hormone Deficiency in Children • Prolactinoma • Type I Diabetes Mellitus	• Hyperaldosteronism • Syndrome of inappropriate antidiuretic hormone secretion (SIADH) • Hyperparathyroidism

Table 1: *Facilitator Guide: Group Project: The Hormone Project*

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Students completed the activity in their previously established problem-based learning groups of 7-8 students per group. The 100-minute activity was divided into two parts. At the start of the activity, students were given part one of their directions (corresponds to Table 1, Part 1) and then completed a Microsoft Excel workbook, which contained categories for completion for 5-6 unique but related hormones. Each group specifically completed the hormones' regulation, effects of hyper/hypo secretion, pathophysiology of the hyper/hypo secretions, treatments, and any related genetic components. At the conclusion of the first 50 minutes, one group member turned in the completed table for the group and a 10-minute break was taken.

For part two of the activity, each group was given the second set of the directions (corresponding to Table 1, Part 2) and was assigned a specific endocrine disease/disorder. For each disorder, students were asked to design a picture representation of the clinical presentation and epidemiology, lab tests, hormones and feedback involved (in a healthy individual and where the disease causes changes), common causes and treatments, and pathophysiology behind the disease and widespread effects. Students spent the remainder of the in-class activity time working on a draft of the image which was submitted to the block directors at the end of the 100 minutes (to encourage work to be completed in the session). Each group was then given 3 additional days to finalize the project, and one member from each group was asked to submit the completed image and the key to their learning management system.

Assessment

The table including hormones and information from part one was graded for accuracy of medical knowledge and completeness. For part two, a predesigned rubric (Table 2) for the project was used. Students received a combined grade for both parts, which accounted for 4% of their total grade for the GIHNER course.

	3 points	**2 points**	**1 point**	**0 points**
Originality, creativity, cohesiveness of project	Project is not a duplication of existing work, demonstrates creativity, and is a thorough representation of the assigned disease	One aspect is missing	2 aspects are missing	Not original or creative and not a relevant representation of the disease
Key for the image	All aspects of the project are explained/identified in the key	Missing 1 aspect	Missing 2 aspects	Key not present or complete (missing more than 2 aspects) OR key does not explain the image
Clinical presentation and epidemiology	Accurate, thorough, and contains no errors or omissions	One aspect is missing or inaccurate	2 aspects are missing or inaccurate	More than 2 aspects are missing or inaccurate
Lab tests	Diagnostic tests present and accurate	Missing 1 important diagnostic test	Missing 2 important diagnostic tests	Missing more than 2 tests or contains errors
Treatments	Pharmacological and nonpharmacological (if applicable) treatments present and explained (MOA).	Missing 1 common treatment or explanation.	Missing 2 common treatments or explanations	Missing more than 2 treatments or explanations OR contains errors
	4.5 points	**3 points**	**1.5 points**	**0 points**
Hormones and Feedback (normal)	Key hormones and feedback present	Missing an aspect of feedback	Missing more than one aspect of feedback or 1 key hormone	Missing more than 1 key aspect of feedback, more than 1 hormone, or contains errors
Hormones and Feedback (abnormal)	Diseased state differences in hormone production or feedback indicated and accurate	Missing 1 aspect of diseased state/ feedback changes	Missing 2 aspects of diseased state/ feedback changes	Missing this section or contains more than 2 errors
	6 points	**4 points**	**2 points**	**0 points**
Causes/ Pathophysiology	Present with no errors or omissions	Missing 1 aspect	Missing 2 aspects	Missing more than 2 aspects or contains errors

Table 2: *Group Project: The Hormone Project Rubric for Part 2*

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In addition to the products turned in by the students, the facilitators also completed a rubric to assess professionalism and participation during the 100-minute activity. Topics from this rubric related to each individual student's level of participation, ability to work in a team, and how well they stayed on track during the in-class portion.

Project Evaluation:

To identify how the students perceived the activity, an anonymous survey was given using the Microsoft Forms platform. The questions were adapted from Wiggins et. al.'s ASPECT: A Survey to Assess Student Perspective of Engagement in an Active-Learning Classroom survey, with modifications to be specific to the Hormone Project and use of facilitators (Wiggins et al. 2017). The full list of questions is provided as in Table 3 with the results. The students completed the survey during their Reflection, Integration, and Assessment Week, after completing their final exam, which was approximately 4 weeks after completing the activity.

This study was determined as exempt by the Nova Southeastern University IRB (#2022-138)

Results

39 of the 52 potential students (75%) completed the voluntary survey. Students rated the Hormone Project activity as very high on the value of the group work (survey items 1-9), on their personal effort (survey items 10-12), on the instructor/facilitator contributions relating to active learning (survey items 13-16), and the overall project itself (survey items 17-19) as can be seen in Table 3. The Cronbach's alpha for the survey was 0.92, indicating high reliability for the survey responses.

Survey Item	Mean Value +/- Standard Deviation
1. Explaining the material to my group improved my understanding of it.	**5.29 +/- 0.80**
2. Having the material explained to me by my group members improved my understanding of the material.	**5.26 +/- 0.79**
3. Group discussion during the Hormone Project contributed to my understanding of the course material.	**5.29 +/- 0.80**
4. I had fun during the Hormone Project group activity.	**5.34 +/- 0.71**
5. Overall, the other members of my group made valuable contributions during the Hormone Project activity.	**5.44 +/- 0.64**
6. I would prefer to take a class that includes this hormone Project activity over one that does not include this activity.	**4.74 +/- 1.37**
7. I am confident in my understanding of the material presented during the Hormone Project activity.	**5.21 +/- 0.78**
8. The Hormone Project activity increased my understanding of the course material.	**5.18 +/- 0.93**
9. The Hormone Project activity stimulated my interest in the course material.	**5.05 +/- 1.06**
10. I made a valuable contribution to my group during the Hormone Project.	**5.50 +/- 0.60**
11. I was focused during the Hormone Project activity.	**5.47 +/- 0.64**
12. I worked hard during the Hormone Project activity.	**5.18 +/- 0.69**
13. The facilitator's and/or block directors' enthusiasm made me more interested in the Hormone Project activity.	**5.18 +/- 0.90**
14. The facilitator and/or block directors put a good deal of effort into my learning for the Hormone Project.	**5.08 +/- 1.05**
15. The facilitator seemed prepared for the Hormone Project activity.	**5.11 +/- 0.89**
16. The block directors or facilitators were available to answer questions during the group activity.	**5.32 +/- 0.84**
17. The visual product made for the Hormone Project was beneficial to my learning.	**5.32 +/- 0.90**
18. The table for part one of the Hormone Project was beneficial to my learning.	**4.84 +/- 1.20**
19. The timing of the Hormone Project was appropriate in the course (in week 2 of Endocrine focus).	**5.15 +/- 1.10**
Cronbach's alpha = 0.92	

Table 3. *Survey results related to Active Learning for the Hormone Project.*

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To highlight a subset of data, the majority of the students found that the Hormone Project increased their understanding of the course material (43.6% strongly agree, 42.0% somewhat agreed, and 10.3% agreed) and was beneficial to their learning (53.8% strongly agreed, 30.8% somewhat agreed, and 12.8% agreed) as can be seen in Figures 1a and 1b.

When asked what aspect they enjoyed most about the Hormone Project in the free response portion of the survey, the key themes in the comments were an overwhelming statement that the art project and use of creativity was enjoyed (61% of the total responses), collaboration and teamwork (19% of the total responses), along with the interactivity (7%) and just overall it was a good project/use of time (13%) as can be seen in Figure 2.

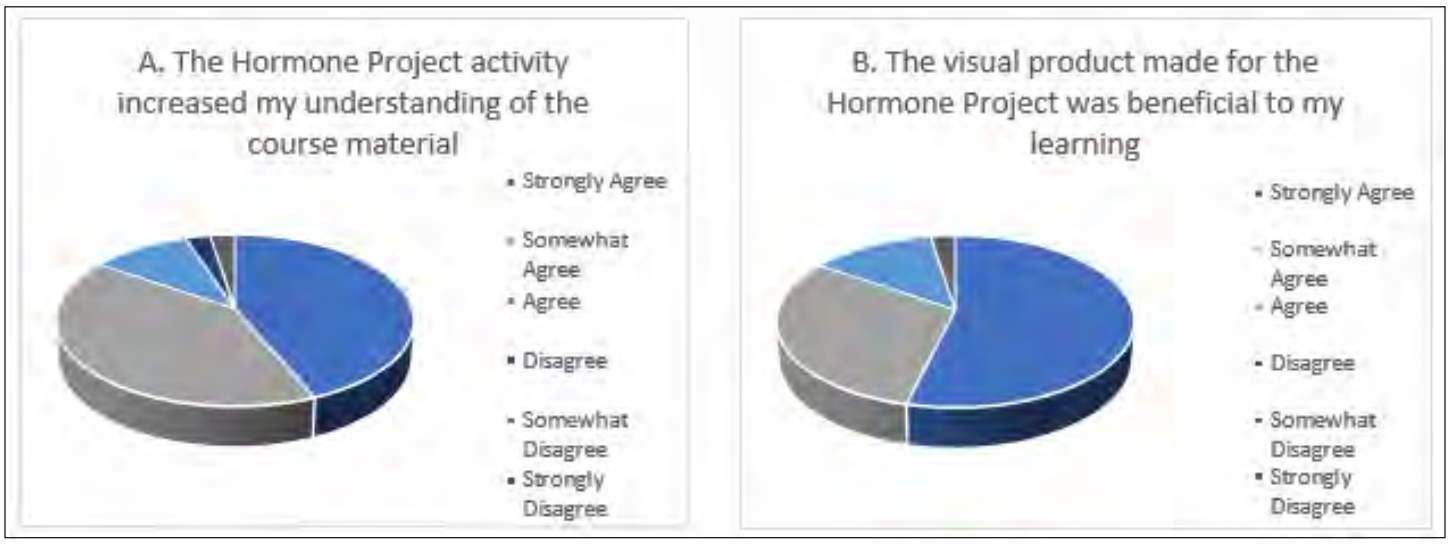

Figure 1. *Highlighted student poll results. Figure 1A shows that students had some level of agreement that the Hormone Project increased their understanding of the course material (95.9% were at "agree" or higher). Figure 1B shows that students had some level of agreement that the Hormone Project was beneficial to their learning (97.4% were at "agree" or higher).*

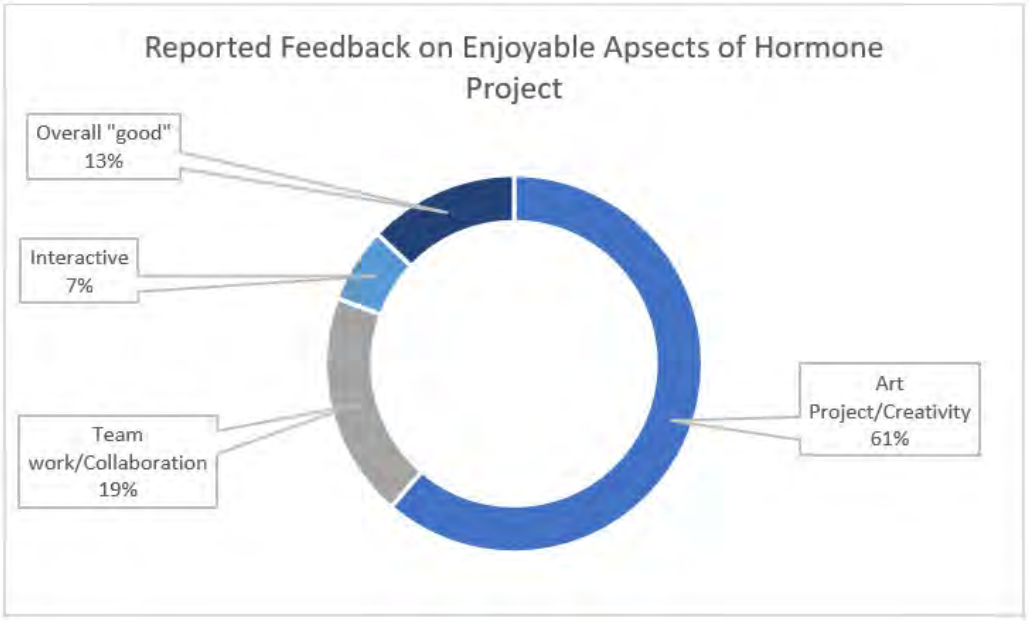

Figure 2. *Student narrative results. Narrative statements given by the students on free response to the question "Please identify one aspect you enjoyed about the Hormone Project." The top two aspects were creativity (61% of the total responses) and collaboration/ teamwork (19% of the total responses).*

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To provide a representation of the type of product which can be expected, Figure 3 is a student-made product with the full key which was submitted for the Hormone Project (provided anonymously with written consent from the group). The figure represents Addison's Disease as depicted by the students of that group.

Figure 3. *Representation of final student-created product of the Hormone Project. Figure 3 shows a representation of a student prepared submission with accompanying key for their artwork: DESTRUCTION AT PAI AIRPORT: The one where Addison eats too many tacos. KEY: 1. Clinical Presentation (and Widespread Effects) Rust Spot on the grounded airplane: Hyperpigmentation (mainly of the skin and mucous membranes) Oil Leaking from the grounded airplane: GI Upset Addison (also known as Lola) laying on the ground: Orthostatic Hypertension and Extreme Fatigue 2. Epidemiology Addison laying on the ground: Occurs more commonly in women in their 30's- 50s 3. Labs Bananas on the Runway: Hyperkalemia Salt Shaker on the Runway: Hyponatremia Trippy Smile on the Taco Truck: Metabolic Acidosis Rising Sun: Low Morning Cortisol Palm Tree: Elevated POMC Sunscreen: Elevated MSH (resulting in the hyperpigmentation) AC's Taco Hut: Elevated ACTH Candy Jar Tipped Over Off Truck: Hypoglycemia "Flight at 11 to DC is Delayed": Low 11-Deoxycortisol 4. Hormones Involved Three Triangle Signs with Arrow Pointing Down: All three major groups of steroid hormones (mineralocorticoids, glucocorticoids, and androgens) are diminished 5. Feedback Involved Healthy Individuals: Plane in the sky: cortisol (the glue) is present in these individuals that then negatively feedbacks on CRH and ACTH Those with Addison's Disease: Plane on the runway: cortisol (the glue) is not present and cannot negatively feedback on CRH and ACTH and take off 6. Common Causes Suitcase with a tag that reads "TB" and a cactus Stamp: Most common cause of Addison's in developing countries is Tuberculosis Suitcase with an immunoglobulin tag: Most common cause of Addison's in Western countries is autoimmune destruction 7. Treatments Glue bottle next to the grounded plane: Glu(e)corticoid/Mineralocorticoid replacement 8. Pathophysiology: Plane on the ground with visible mechanical issues: Destruction of the adrenal gland → decrease in cortisol and aldosterone→ plane not able to take off PAI Airport: Primary Adrenal Insufficiency 9. Genetics HLA B8, HLA D3-4 Sign: links between Addison's disease and HLA-B8, HLA-DR3, and HLA-DR4.*

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Discussion

The Hormone Project is a unique learning activity that combines art with medicine, creating an active learning activity which was engaging, enjoyable, and educational for the students. This unique team-based artistic approach was developed to respond to the unfavorable outcome from the previous iteration of the Hormone Project that ran in the previous year. In the preceding iteration, students were required to develop a 10-minute presentation on the disorder that covered the same aspects that are in the current iteration. After one trial run with the presentation style, it was quickly noted that the time allotted for a presentation where 7-8 persons had to speak was inadequate. Students had also noted in course evaluations that they did not enjoy the activity or find it useful. This reimagining of the Hormone Project served to fit in the allotted time and has provided the students with opportunities to participate in their groups in creative ways.

The Hormone Project could be adapted to use for other topics, including cancers, tumors, the reproductive system, or liver diseases as students indicated in their survey responses. Additionally, the project could be scaled down to be just one specific disease or disorder as an in-class activity for active learning during lectures. Using this style, it could be applied to almost any disease/disorder or physiological process. Additionally, though the project as described here was placed to allow the students to have some prior knowledge of the topics, it could be placed elsewhere in the curriculum, provided the students have the appropriate resources to find the information needed for the activity. It could easily be an introductory activity to a topic or a summary to incorporate prior learning.

One limitation of the Hormone Project is that each group prepared and deeply learned only one endocrine disease/disorder. This was a piece of feedback noted by the students on the annual course evaluation. As a means to help to share their products and learning tools with the class, there are plans in the next iteration to share the finished products with the entire class. While each group is still deeply learning one disease/disorder, there would be opportunities to use the learning tools for the other diseases/disorders.

A limitation to the pilot study itself was that only 75% of the students completed the survey, however reassurance came from the high reliability score. One way to address the number of survey responses in the future iterations would be to implement the survey online, immediately after they turn in their projects.

In the next implementation of the Hormone Project, feedback from this most recent iteration will be implemented. With the survey prompt asking students to identify one aspect that needs improvement in the Hormone Project, there were two points that stood out: The students wanted more time to complete the activity in class and they did not enjoy the table for part one. The next cohort of students will be given the part one table (indicated by Table 1, Part 1 above) as pre-work and they will then have a full 100 minutes to dedicate to the art project.

About the Authors

Chasity O'Malley is an Associate Professor of Medical Education and Physiology at Boonshoft School of Medicine at Wright State University. Her research goals aim to improve the learning experience for students by helping them learn to study and interact with the material in meaningful ways and for faculty by helping guide them on implementing active learning into their classrooms and is a co-principle investigator for an NSF grant related to this work. She also is actively involved in promoting diversity through her funded research projects centered around enhancing training for medical students related to the LGBTQ population.

Arkene Levy is Director of Diversity Equity and Inclusion (DEI) and Associate Professor of Medical Education at Nova Southeastern University Dr. Kiran C. Patel College of Allopathic Medicine (NSU MD). She has over fifteen years of experience in medical education and a wealth of experience with active learning exercises for multiple teaching modalities including synchronous and asynchronous online learning and face-to-face classroom activities such as problem-based and team-based learning. Dr. Levy has applied her teaching approaches to develop and implement a transformative DEI Curriculum at NSU MD and to deliver sessions related to the basic sciences for a variety of educational programs in the health professions including dentistry, optometry, and pharmacy.

Daniel P. Griffin is the Assistant Dean for Pre-Clerkship Curriculum and an Associate Professor of Medical Education at Nova Southeastern University Dr. Kiran C. Patel College of Allopathic Medicine. He has extensive experience in active learning such as problem-based learning and team-based learning. He has been fortunate to have had opportunities to take educational programs at two new medical schools to full implementation. He also has a history of and is actively involved in promoting diversity, equity, and inclusion in medical school training and processes; and executing projects designed to innovate curriculum delivery methods.

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