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Undergraduate Scholar: Beauty in mathematical nature

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John O'Brien, senior in mathematics, researches mathematical processes.

Beauty in mathematical nature

Musician delves into advanced algebraic research

By Dene Dryden

An undergraduate researcher and musician has found a niche studying a subset of mathematics not typically traversed by undergraduate students. For John O'Brien, Kansas State University senior in mathematics, the research process reveals the beauty in mathematical nature.

"You're seeing the structure and order behind these bizarre concepts," O'Brien said. "There's a beauty in how these things operate."

O'Brien's path to mathematics research began when Zongzhu Lin, professor of mathematics, noticed his high calculus test scores. At that time, O'Brien, who is also an accomplished pianist, was studying music education.

So Lin, who is now O'Brien's mentor, gave him a book to read on abstract algebra. From there, O'Brien dove into mathematics by reading more books and watching YouTube lectures. In the span of a year, Lin suggested that O'Brien skip some undergraduate courses and dive into graduate-level research in the fall 2017 semester.

O'Brien and Lin began their research on Soergel bimodules, a relatively new topic of research closely related to Hecke algebras, which are associated with low-rank matrices — those without clear solutions.

"If you're solving a matrix, like in high school, you can completely solve it and get a unique solution," O'Brien said. "In our case, we're trying to extend the results in this field to things that you might not necessarily get a unique solution."

The research itself, O'Brien said, looks a lot like math homework: computing equations on paper or a whiteboard. The research is in the realm of pure mathematics; unlike applied mathematics, which are processes used to find specific answers in fields like physics and chemistry, pure mathematics research is more exploratory.

"So what can you achieve? You have no clue," Lin said. "You're just curious what happens."

Mathematical processes similar to O'Brien's research do have applications. Hecke algebras have been used in physics, O'Brien said. Another related subject, geometric representation theory, is connected with quantum mechanics and quantum computing.

O'Brien and Lin are now generalizing some of their results, and they are aiming to write a paper soon.

Outside of his mathematics research, O'Brien still finds time to play the piano. He enjoys connecting the dots between abstract algebra and music theory.

"Musicians have to know a certain amount of abstract algebra, even if they won't call it that," O'Brien said. **k**