ARTICLE
Addiction Education in the Undergraduate Space: A Novel Course Connecting Neurobiology of Addiction and Compassion for Individuals with Substance Use Disorder

Leslie C. Newman and Ashley T. Swisshelm
College of Pharmacy, The Ohio State University, Columbus, OH 43210

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Substance use disorder (SUD) is a chronic, relapsing disease with medical, psychological, and social complications. Sufficient knowledge of addiction mechanisms and compassion for individuals with SUD are essential for combatting the prevailing stigma associated with substance use and generating efforts for effective treatments. This article describes a unique undergraduate course on addiction where efforts to enhance understanding of the neurobiology of addiction are coordinated with an emphasis on the human element of SUD. Reinforcing the neurobiological details of addiction and their relation to SUD behaviors can humanize addiction and further motivate students to invest in learning these complex details. College students have increased exposure to and opportunities for drug use and face an increased risk of developing a SUD. Substance use among college students can contribute to physical, mental, academic, and social issues. A thorough education on the neurobiological mechanisms of addiction with emphasis on the human element can help students gain a better understanding of what happens in the brain and an appreciation for the disease nature of addiction. Ultimately, this knowledge can benefit students dealing directly or indirectly with SUD and can encourage and equip them to champion for more effective and empathetic approaches for tackling addiction. The impact of this course on student learning and motivation was measured by before and after course surveys. The results demonstrate that students developed a better understanding of addiction as a disease, gained a more compassionate view of individuals with SUD, and were inspired to learn more about how addiction affects the brain.

Key words: addiction; substance use disorder (SUD); neurobiology; stigma; undergraduate education

Substance use disorder (SUD) is a major public health concern requiring significant care and attention. The practicality and advantages of a full semester course on addiction for college students cannot be overstated. College students face increased exposure to and opportunities for substance use and considerable evidence shows that attending college is associated with increased substance-related disorders (Carter et al., 2010; Fleming et al., 2014; Welsh et al., 2019). The most recent *Monitoring the Future* report found that in the past 12 months 39.5% of college students used cannabis, 74.9% used alcohol, and 12% used other drugs (Patrick et al., 2024). Not only has substance use among college students increased in the past two decades, but negative perceptions and social attitudes toward substance users have worsened (Lu et al., 2023; Welsh et al., 2019). Additionally, college students often have a lack of awareness of the risks and severity of SUD (Caldeira et al., 2009; Welsh et al., 2019).

Undergraduates experience distinct challenges which make them vulnerable to substance use. Suddenly adapting to a new, often less structured lifestyle away from home coupled with increased exposure and access to substances can create a perfect storm for initiation of substance use. Additionally, peer substance use and acceptance as well as misconceptions about the safety and/or perceived benefits of some substances may encourage experimentation and substance misuse (Arria et al., 2018; Skidmore et al., 2016). Students may also turn to substance use to deal with mental health issues and/or academic stress or to enhance their academic performance (Pérez et al., 2023). Like some adults, students may also be compelled to use substances to lessen tension and social anxiety (Levy et al., 2005).

Compounding the increased vulnerability of college students to substance use is the fact that they rarely recognize a need for treatment or seek help (Caldeira et al., 2009, Arterberry et al., 2019). Moreover, college student concerns about confidentiality, university and/or parent involvement, and their own misgivings about the status of their mental health present challenges to pursuing adequate care (Auty et al., 2022; Caldeira et al., 2009; Welsh et al., 2019). Even when students seek treatment, retention rates for this age group are lower than when compared to older adults (Schuman-Olivier et al., 2015).

Additionally, adolescence (into the mid-to-late 20s) involves a period of rapid changes where dynamic processes affect the efficiency and organization of the developing brain. These changes foster an ability to adapt and respond to new experiences and situations, but they also make the adolescent brain more vulnerable to potentially harmful environmental influences such as substance use (Konrad et al., 2013). The adolescent brain also develops in an uneven manner where areas of emotion, motivation, and reward develop before areas responsible for impulse control, reasoning, and judgement (Casey et al., 2008; Del Piero et al., 2016). Thus, college students who experiment with substances are susceptible to deficiencies

in neurocognition and the ability to control impulsiveness, which are major contributors to initiation and continuation of substance use (De Wit, 2013; Kozak et al., 2020; Squeglia et al., 2010).

While many universities and colleges have various programs that work to support students struggling with substance use and those in recovery, there is a lack of information on the amount and depth of addiction education in the undergraduate space. Indeed, education of college students on addiction has not been extensively addressed in the literature. The importance of educating undergraduates on addiction topics has been previously noted through a strategy to integrate addiction content into undergraduate neuroscience curricula (Napier, 2018). The significance of neurobiological knowledge in addiction has also been noted through incorporation of neuroscience-informed approaches in clinical practice (Verdejo-Garcia, 2019) and in promoting individual neurobiological knowledge as a form of treatment for those experiencing SUD (Borgland, 2024).

The importance of a thorough education on the mechanisms of addiction is underscored by how society perceives individuals with SUD. In addition to dealing with the physical and mental tolls of addiction, individuals with SUD also face pervasive stigma which has profound effects on themselves, their families, and communities. SUD due to illicit drug use is often considered one of the most stigmatized health conditions, even higher than other mental health disorders (Room et al, 2001; Yang et al., 2018). It is estimated that perceived social stigma associated with substance use is as high as 78% and stigma from healthcare professionals ranges from 20-51% (Cazalis et al., 2023; Luoma et al., 2007; van Boekel et al., 2015). Additionally, stigma associated with addiction may internalize which can compromise an individual's desire and ability to seek treatment and damage their self-respect (Corrigan et al., 2015; Hammarlund et al., 2018). In addition to isolation and shame, individuals with SUD also face discrimination and limited support (Farhoudian et al, 2022). These feelings of hopelessness can be a deterrent to seeking help and can further exacerbate substance use.

There are shortcomings in addiction education, likely due to an existing gap between scientific understanding of addiction and education as well as due to an avoidance related to the stigma of addiction (Morreale, 2020; Machado Do Vale et al., 2022). Shifting views of addiction as a moral choice or weakness to that of a disease with distinct neurobiological changes requires an understanding of the brain and how it is altered by substance use. Indeed, other studies have shown that education on substances can have positive impacts on attitudes towards substance use when implemented with high school and college students as well as with the public (Harris et al., 2013; Kyzar et al., 2024; Lovecchio et al., 2010, Martin-Morris et al., 2015, Machado do Vale et al, 2022). Educating individuals in early adulthood can not only impact their lives and that of their loved ones, but this knowledge and understanding can empower them to educate and advocate for others.

A proper understanding of addiction and ultimately consideration of the individual with SUD necessitates thorough coverage of addiction neurobiology. Modern neuroscience has improved and transformed our understanding of addiction, influencing how topics related to substance use should be taught (Koob, & Le Moal, 2005; Koob, & Volkow, 2016; Uhl et al., 2019; Volkow & Morales, 2015; Volkow et al., 2016). A fundamental understanding of addiction requires examination of brain circuits involved in reward, withdrawal, and decision-making processes. Extensive addiction neuroscience information and advancements are predominantly confined to scientific endeavors and addiction education generally focuses on the reward pathway (Francesca, 2019). While the reward system is a key element of addiction which reinforces pursuing and using substances, leading to drug binging (Uhl et al., 2019; Volkow & Morales, 2015), introducing this aspect alone leaves the impression that the individual just wants to "get high" and further contributes to judgement and stigma.

Once individuals develop tolerance, a diminished response to the drug, they struggle to attain the desired euphoric effect and conceivably no longer want to use the drug. However, in the absence of the drug, the individual is susceptible to withdrawal symptoms including dysphoria, anxiety, and stress sensitivity (Koob, & Le Moal, 2005; Koob, 2008; Volkow & Morales, 2015; Volkow et al., 2016). The mechanistic neurobiological details of the negative emotional and dreadful physical withdrawal symptoms give context to the enormous difficulty in refraining from substance use. In addition to the viscous cycle of less euphoria and more dysphoria, individuals become conditioned to "need" the drug. Reward circuits are activated by rewarding or reinforcing stimuli that are important for survival and drive individuals to engage in behaviors that enhance fitness (Koob, & Volkow, 2016; Volkow & Morales, 2015). Repetitive stimulation of reward circuits by repeated substance use causes the brain to perceive the drug as necessary for survival and impels the individual to seek out the substance above all else (Bommersbach et al., 2020; Koob, & Le Moal, 2001).

Furthermore, the prefrontal cortex is responsible in part for controlling the urge to use substances and in evaluating long-term consequences which enable individuals to make rational, beneficial decisions. (Koob, & Volkow, 2016) When these pathways are impaired, such as occurs in addiction, the individual's ability to resist substance use is severely diminished and the individual is confined to a viscous cycle of substance use to avoid withdrawal. Neurobiological changes and the consequent behavioral outcomes in addiction are not unlike other chronic diseases where there are defined alterations in function that the individual cannot control (DuPont et al., 2015; McLellan et al., 2000). Grasping the important neurobiological details of addiction beyond just the reward circuits is vital to appreciate the disease nature of addiction and to instill understanding and compassion for the individual impacted by SUD.

METHODS

Course Structure and Approach

"Addicting Drugs" is a 3-credit hour course which was initially offered as an elective in the College of Pharmacy's Bachelor

Variable	Category	Percentage
Rank	Freshman	37%
	Sophomore	57%
	Junior	3%
	Senior	3%
Major	Healthcare (premed, prepharm, etc.)	52%
	STEM	13%
	Business/Finance	17%
	Social Studies	17%
	Other	1%

Table 1. Course Demographics

of Science in Pharmaceutical Sciences (BSPS) program and was then expanded and offered to all students as a course in the General Education Program at The Ohio State University. The course covers an introduction to the neurobiological adaptations that occur during addiction and gives an overview of the effects, regulation, and mechanism of action of addicting drugs. It is a highly sought-after (class size ~250) and well-received course and comprises students at different stages of education from various science and non-science majors. Demographic data for the cohort used in this study is shown in Table 1.

The course consists of 7 Modules covering an Introduction to Pharmacology and Addiction (2 weeks), Neurobiology of Addiction (2 weeks), Methods to Study Addiction (2 weeks), Narcotics and Depressants (2 weeks), Psychostimulants (2 weeks), Hallucinogens (2 weeks), and Society and Addiction (2 weeks). The material, activities, and assignments in this course are set up to achieve the following learning goals:

1. Understand the basic principles of drug action
2. Gain familiarity with neuroanatomy involved in drug addiction
3. Explain the neurochemical and molecular adaptations characterizing the transition to dependence and ultimately substance use disorder
4. Describe the mechanism of action and major effects of psychostimulants, opiates, hallucinogens, alcohol, nicotine, and cannabinoids
5. Acquire basic knowledge of the behavioral models and neuroimaging studies that facilitate the study of drug addiction
6. Develop a holistic understanding of addiction by bridging emotional, behavioral, and biological /molecular elements
7. Evaluate current legal, social, and cultural impacts relative to addicting drugs

The course meets twice a week for 80 minutes and consists of approximately 45 minutes of lecture followed by an active learning activity and/or discussion. Activities and assignments focus on providing interesting, relatable, and real-world context to connect neurobiological mechanisms with the human element of addiction. Our slate of activities, discussions, and assignments comprises four themes: Media & Metaphors, Lived Experience, Personal Reflection, and Empowering Empathy. Examples in Media & Metaphors include watching videos that create imagery or relatable metaphors of the addiction cycle (Hykade, 2014), reading stories of individual's accounts of SUD experience (Pollack, 2015), and identifying and analyzing songs related to drug use (Silvia, 2020). Lived Experience involves a particularly impactful experience where students interact with a guest speaker who has battled SUD. This opportunity emphasizes the emotional impact of SUD, creating empathy and helping students connect the neurobiological stages of the addiction cycle to the decisions of an individual with SUD.

To encourage Personal Reflection on SUD, students complete a branch chain activity designed in the Canvas learning management system. Students first select whether they believe SUD is a moral choice or a medical condition and then are directed through a series of counterarguments which challenge students to think about their perceptions of and apply their knowledge towards SUD (Beck, 2017). Additionally, students complete an assignment related to the Rat Park study which helps them evaluate and reflect on the significance of neurobiological changes contributing to addiction (Gage and Sumnall, 2019). Activities and discussions in Empowering Empathy involve students considering and discussing various case scenarios that lead to SUD (such as misuse of prescription medications, self-medicating due to emotional trauma, etc.) which focus on stigma and empathy and the role of mental health issues on decisions to initiate substance use. These nontraditional methods of learning can capture student attention, offer a fresh view of the material, and give students exposure to various perspectives. In addition to activities and assignments, other assessments in the course include regular quizzes to ensure students keep up with and understand the material and two exams. More details about course structure and activities can be found in the course syllabus in Supplementary Materials 1.

Our overall approach for this course is to make it impactful and valuable to all students. Neuroscience is a complex topic and in an addiction course made up of undergraduates with various backgrounds, should be taught assuming no prior knowledge. We hope to navigate challenges in learning the complexities of addiction neurobiology by helping students appreciate the extent of changes in the brain that contribute to specific experiences and behaviors of an individual with SUD. Connecting details of brain circuits with behavioral outcomes early and often can increase student interest and retention and can enhance student appreciation for the predicament of the individual with SUD. This heightened empathy in turn can be motivating to students to further strengthen their understanding of these complex details (Figure 1). Overall, the efforts in this course are designed to help students understand and relate to individuals with SUD, assess what informs their views on addiction and towards individuals with SUD, and aid them in connecting their didactic knowledge of addiction neurobiology with real-world outcomes of SUD.

Figure 1. Illustration representing proposed effects determining student motivation and learning.

Assessment Methodology

Survey details

To explore the impact of a full-semester course on addiction with an emphasis on neurobiological mechanisms and their connection to the behaviors of an individual with SUD, we conducted a survey before and after the course. This study was determined to be exempt by The Ohio State University Institutional Review Board prior to data collection. The pre- and post-surveys consisted of demographic and Likert scale prompts gauging perceptions and knowledge relating to SUD/addiction. The surveys were designed to assess changes in these parameters resulting from participation in the course. The pre-survey was given in-class before the first lecture and elicited 171 responses (67%). The post-survey was given after the semester and generated 65 responses (25%). Students were not incentivized to fill out either survey and the lower response rate for the post-survey likely resulted from students having to remember and fill out the survey on their own time. Each participant's responses to the pre- and post-surveys were paired for analysis. To connect student responses while also keeping the survey anonymous, students were asked to provide cryptic, nonidentifying information (such as 1st letter of birth city, 1st letter of mother's/guardian's maiden name, digits of birth month) that could be included on both surveys to help pair the data. Of the responses to the post-survey, we matched 30 students to the pre-survey using the provided nonidentifying information. We evaluated the outcome of prompts related to the focus of this manuscript which included SUD knowledge and perception of individuals with SUD. The full survey questionnaire can be found in Supplementary Materials 2.

Data analysis

To assess whether this course induced a statistically significant change in responses between the pre- and post-survey, the paired Likert-derived data were treated as ordinal and were analyzed using the Wilcoxon signed rank test. Data from the pre-survey were matched to the corresponding post-survey data with a null hypothesis of no significant difference between the pre- and post-survey data. The test statistic was compared to critical values from the Wilcoxon Signed Rank distribution table, and a p-value was obtained to determine whether the null hypothesis could be rejected. A p-value less than 0.05 indicated a statistically significant difference between the pre- and post-survey responses. All statistical analyses were performed using SAS software, and the results were interpreted to evaluate the impact of the course on the participants' knowledge and perceptions of SUD/addiction.

RESULTS

This article proposes that a thorough understanding of the neurobiology of addiction can motivate students to further their knowledge on addiction and encourage empathy towards individuals with SUD. A pre- and post-survey was designed to assess student knowledge and perceptions of SUD/addiction. Figure 2 represents student knowledge and perception about the disease component of SUD/addiction. In both the pre- and post-survey, more students agreed that SUD/addiction should be considered a chronic disease, however the number of students agreeing with this statement increased after taking the course. Analysis revealed a significant difference between the pre- and post-survey scores (Z =-2.1181, p = [0.034]).

Figure 3 shows student responses relating understanding neurobiology of addiction and perception of individuals with SUD. These results were included on the post-survey only to cover the time frame after students learned about the neurobiology of addiction.

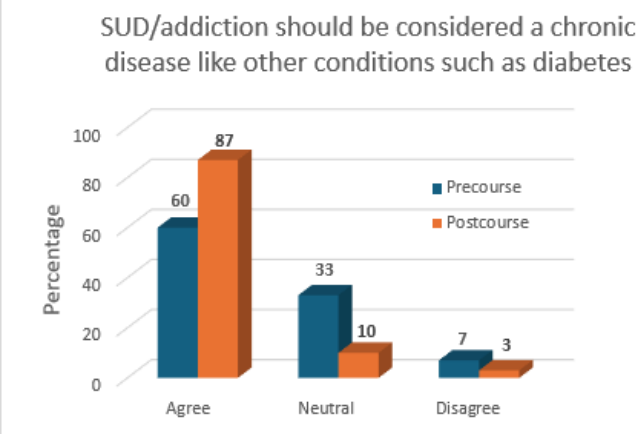

Figure 2. Student responses to pre- and post-survey prompt regarding addiction as a disease. (n=30, Z-value = -2.1811, p=0.034)

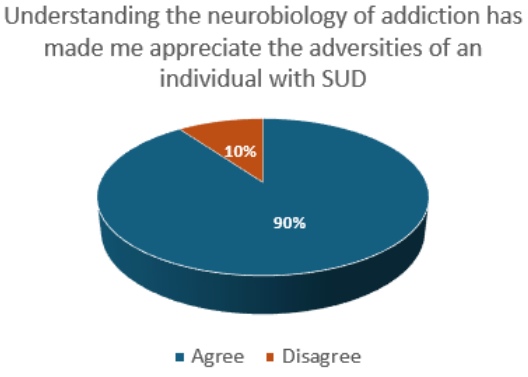

Figure 3. Student responses to the post-survey prompt regarding relation of addiction mechanism knowledge to behaviors and hardships of individuals with SUD. n=65.

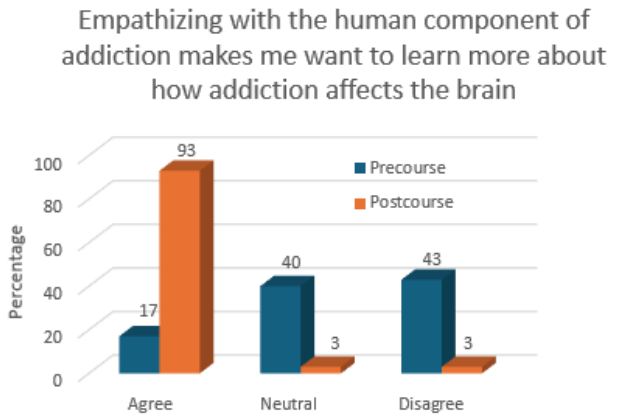

Figure 4. Student responses to pre- and post-survey prompt regarding motivation to deepen learning about addiction mechanisms as a result of appreciating the human component of addiction. (n=30, Z-value = -4.184, p<0.00001)

Figure 4 represents data regarding the impact of humanizing addiction on learning the complex details of neurobiology of addiction mechanisms. Students largely agreed that empathizing with the human component of addiction enhanced their desire to learn more. Analysis of these data revealed a significant difference in student responses between the surveys (Z =-4.184, p<0.00001).

CONCLUSION

Uncovering the biological and physiological mechanisms of addiction are important in understanding how addiction manifests and how to approach prevention and treatment, but these underlying mechanisms do not convey the emotion and experiences of an individual with SUD. Considering the element of mental health and its role in addiction, it is important is to consider the experience of the substance user and not just the addiction crisis. In this article we show that strategies to enhance education in the neurobiology of addiction can humanize addiction and increase overall understanding of the addiction process. The goal of this course is to increase student interest and motivation in learning the complex mechanisms associated with addiction as well as to enhance their understanding of the emotional complexity of the individual with SUD. Both goals are vital to addressing the physical treatment of the individual as well as their emotional well-being, components that must be addressed together to better understand, prevent, and treat substance misuse.

The prevalent stigma of addiction in our culture and how this impacts social behavior as well as personal and medical treatment of individuals with SUD is generally under-represented even in graduate and medical education (Renner, 2019, Newman & Swisshelm, 2025). Confronting the emotions and experiences of an individual with SUD contributes to a better understanding of substance use behavior and the ramifications of falling into an addiction cycle. Moreover, gaining insight into the perspective of an individual with SUD can enhance student motivation to invest in understanding the underlying science that contributes to addiction. Some students taking this course will become healthcare professionals who may address the addiction crisis directly and interact with individuals with SUD. But even students in the course not entering a healthcare field are impacted in how they view, discuss, and address SUD, which can foster an informed society where empathy prevails over judgement.

Student Experience with SUD	
Individual affected by SUD	8% (14 students)
Friend or family member affected by SUD	66% (113 students)

Table 2. Course data on student SUD experience assessed on the pre-survey (n=171).

The benefits of a full semester undergraduate course on addiction can impact all students, including those who face SUD themselves or with their loved ones, as well as those who will be inspired to make positive contributions to this complex, devastating disease. The significance of teaching and humanizing addiction in this population is evident in the number of students affected by SUD, shown in Table 2, where 8% of the class identified that they were personally dealing with SUD and 66% of the class knows a friend or family member affected by SUD. The efforts in addiction education described in this article highlight the valuable opportunity for early information and intervention for a population vulnerable to SUD. For students exposed to or contemplating substance use, knowledge of addiction neurobiology that translates into an understanding of individual behavior can help foster healthy decision-making skills regarding substance use. Considering students with personal lived experience with SUD, understanding the disease nature of addiction not only enhances student self-esteem, but can also make students more likely to seek help. For students dealing with loved ones struggling with SUD, understanding the nature of behaviors associated with SUD enhances compassion and patience and better equips them to provide support and hope (Lander et al., 2013). For students who have not faced SUD personally or with their loved ones, understanding addiction can empower them to advocate for and educate others.

While addiction is a fascinating and engaging topic for college students, learning the complex neurobiological details can be onerous. Given the diversity in maturity and education level of undergraduates, it is challenging to teach addiction in a way that is accessible, easily relatable, and ultimately meaningful to every student. A full-semester course on addiction affords ample time to properly cover addiction neurobiology and relate it to behaviors and decisions of the individual with SUD. Crafting the “neurobiological story” of addiction from euphoria and binging to withdrawal and dysphoria and finally to craving and compromised decision-making gives context to the complex but critical issues of addiction. This complete story of addiction provides the foundational knowledge necessary to adequately think about and address the addiction crisis. The multifaceted approach in this course appears to promote an increased level of interest and eagerness to learn topics that are generally considered complicated and

less interesting. The variety of unique and innovative activities to aid in understanding addiction captured student attention, mixed-up traditional expectations by the students, and resulted in significant engagement and learning. Overall, students were more likely to appreciate the disease nature of addiction (Fig 2), were more empathetic and understanding towards individuals struggling with SUD (Fig 3) and were motivated to learn complex details (Fig 4). Equipping students with this knowledge can help them make good decisions about drug use and foster future opportunities for new ideas and interventions in tackling the addiction crisis.

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Address correspondence to: Dr. Leslie Newman, College of Pharmacy, The Ohio State University, 500 W. 12th Ave, Columbus, OH 43210. Email: newman.439@osu.edu